August 2016

REPORT

SUPPLY AND DEMAND STUDY OF AGGREGATE RESOURCES SUPPLYING THE GREATER GOLDEN HORSESHOE

Submitted to:
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REPORT

Report Number: 1540982

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Golder Associates

Executive Summary

Golder Associates Ltd. (Golder), in conjunction with MHBC Planning (MHBC), Altus Group (Altus) and Dionne Bacchus and Associates (DBA), prepared this Supply and Demand Study of Aggregate Resources Supplying the Greater Golden Horseshoe (GGH). The results from the components of the work program are summarized below. Each firm is responsible for the preparation of their own section.

MATERIAL SUPPLY

A material supply analysis was completed that involved an estimation of remaining reserves quarries with Class A licences that were licensed after the preparation of the 2009 State of the Aggregate Resource in Ontario Study (SAROS) Report; an estimation of remaining reserves in selected licensed pits; and an identification and evaluation of unconstrained and unlicensed Aggregate Resources Inventory Paper (ARIP) Selected Bedrock Resources and Primary Sand and Gravel Resources.

The results of the study indicate a remaining reserves of 545 million tonnes (MT) of bedrock in quarries that have been licensed since the 2009 SAROS Study or added to the Greater Golder Horseshoe (GGH) study area. The gain in estimated reserves as a result of new licences issued is offset by ongoing production of limestone from GGH quarries.

The study reviews a number of limiting considerations that cast significant doubt on the usefulness of relying on site plan volumes as an indication of available supply. While the study estimates potential remaining reserves of 2,792 MT might be available in 123 selected licensed pits there is quite a high degree of uncertainty associated with this estimate and the results should not be taken as a very realistic indication of what resource may actually be proven and made available from these licenced sites.

While potential reserves exist in many parts of the Province there are concerns about scarcity of certain products in close to market locations that will lead to increased costs and environmental impacts associated with increased haul distance.

CONSTRAINT ANALYSIS

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 licensing an area for extraction and various challenges may need to be addressed (e.g., competing land uses).

To determine the extent of overlap between identified aggregate resource deposits and known environmental, agricultural and social constraints a Geographic Information System-based (GIS) mapping analysis was completed for the GGH and 100 km surrounding the GGH.

The mapping analysis progressively overlaid 32 known constraints on selected bedrock, primary sand and gravel and secondary sand and gravel resource areas to determine the degree to which the availability of mineral aggregate resources may be affected by known environmental, agricultural and social constraints.

Based on the analysis, the following percent (%) of the aggregate resource areas had overlapping constraints within the GGH and 100 km surrounding the GGH:

- 96.0% of the selected bedrock area;
- 97.7% of the primary sand and gravel; and
- 92.1% of the secondary sand and gravel.

The Study Region was further divided in Study Areas based on their proximity to a central growth area in the GTA. The following percent (%) of all of the aggregate resource areas had overlapping constraints within the following distances to the Vaughan Metropolitan Centre:

- 97.7% within 50 km
- 99.0% within 50 km to 100 km
- 96.7% within 100 km to 150 km
- 96.1% within 150 km to 200 km
- 87.4% within 200 km to the remainder of the study area

The results demonstrate that access to the aggregate resource areas within the Study Region (much of Southern Ontario) is severely affected by known environmental, agricultural and social constraints.

This is not to say that these resources are not available. The applied constraints are factors that have to be considered in assessing the availability of the resource; they are not all constraints that would necessarily or reasonably preclude access to the resource.

Nor should the results be interpreted to mean that the remaining resource areas (i.e., unconstrained) are available as there are numerous other site specific and unmapped factors that need to be considered before a resource can be licensed and extracted.

What the results do tell us is that the availability of aggregate resources in Ontario needs to be carefully planned for. Aggregates will not be available if it is assumed or taken for granted that there will be plentiful supply after all other planning considerations are accounted for. Planning for aggregate availability will require an integrated and balanced approach that recognizes some compromises will be required. Without this recognition it is more likely that aggregate deposits are not protected or not made available due to the potential presence of on-site and adjacent constraints.

Unconstrained and unlicensed bedrock and sand and gravel resources were identified and estimates were provided for potential resource tonnages per hectare.

DEMAND STUDY

A demand analysis for aggregates related to the GGH area was completed.

The demand analysis assesses the extent of use of aggregate in Ontario in general and the GGH specifically.

Highlights of the demand analysis include:

- Over the past 20 years, Ontario has consumed about 3.4 billion tonnes of aggregate - or about 170 MT per year on average.
- Given expected levels of economic and population growth, Ontario's consumption of aggregates is projected to average about 192 MT per year on average over the next 20 years, 13% higher than in the past 20 years.
- Despite lower per capita usage of aggregate, the GGH is expected to consume more than half of the provincial total, or about 111 MT per year over the next 20 years.
- On a per capita basis, aggregate consumption has been on a longer-term decline and this downward trend is expected to continue going forward.
- The aggregate that Ontario uses comes mainly from primary sources of material extracted from Ontario pits and quarries. Imports from other countries play only a very small role. Secondary sources of material (primarily recycled materials) have played an increasing role, and recycled material is expected to continue to gradual increase its contribution to total aggregate consumption over the next 20 years. However, the main source of aggregate supply is expected to continue to be primary aggregate from Ontario pits and quarries.
- The GTAH (Greater Toronto Area plus Hamilton) obtains approximately half of the aggregate it uses from neighbouring areas, largely from within the outer ring of the GGH.
- Aggregate is used in a wide range of applications, however the primary use is in construction work - either directly on construction sites, or in the manufacturing of concrete and other building products. Roads (provincial highways, as well as municipal and private roads), both new and repair work, account for the largest share of aggregate used in construction work.
- There are many major public infrastructure projects planned in the GGH, all of which will need aggregate:
  - MTO projects are expected to need about 20 MT in total over the next five years.
  - Transit projects are expected to need about 6 MT through completion (some of which is beyond the next five years).
  - Larger municipal infrastructure projects are expected to need about 21 MT over the next five years.

TRAFFIC ASSESSMENT

Based on the findings of the traffic assessment, it would be beneficial for individual jurisdictions without goods movement policies in place to proactively review their road networks and establish defined haul routes for the movement of aggregate through their regions. The establishment of appropriate truck routes will help ensure mobility for all road users and optimize freight capacity minimizing the impacts on sensitive areas by:

- Defining roadways that are suitable for heavy vehicle traffic;
- Ensure roadways have appropriate capacity and design to accommodate the heavy vehicles;
- Avoid residential and/or otherwise sensitive areas; and
- Reduce congestion throughout the region.

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TABLES

FIGURES

Acronyms and Units of Measure

ACRONYM/UNIT	DEFINITION
ARA	Aggregate Resources Act
ARIP	Aggregate Resources Inventory Paper
BRT	Bus Rapid Transit
CPCA	Canadian Portland Cement Association
CTM	Close to market
DEM	Digital Elevation Model
GDP	Gross domestic product (the value of all goods and services in a given time period; used as a measure of the total size of an economy; "real" GDP expresses output in constant dollar terms that is, adjusts for price inflation)
GGH	Greater Golden Horseshoe
GHG	Greenhouse gas
GIS	Geographic Information System
GP	Greenbelt Plan
GTA	Greater Toronto Area (comprised of the City of Toronto, and the Regional Municipalities of Durham, York, Peel and Halton)
GTAH	Greater Toronto Area plus Hamilton
Ha	Hectare
LCA	Life Cycle Analysis
LRT	Light Rail Transit
MNRF	Ontario Ministry of Natural Resources and Forestry
MNDM	Ontario Ministry of Northern Development and Mines
MOECC	Ministry of the Environment and Climate Change
MOF	Ontario Ministry of Finance
MT	Million Tonnes
MTO	Ministry of Transportation of Ontario
NEP	Niagara Escarpment Plan
NRVIS	Natural Resources and Values Information System
OGS	Ontario Geological Survey
ORMCP	Oak Ridges Moraine Conservation Plan
OSSGA	Ontario Stone, Sand & Gravel Association
PQOA	The Pit and Quarries Online Application
TOARC	The Ontario Aggregate Resources Corporation
SAROS	State of the Aggregate Resource in Ontario Study
StatCan	Statistics Canada
VMC	Vaughan Metropolitan Centre

1.0 INTRODUCTION

Golder Associates Ltd. (Golder), in conjunction with MHBC Planning (MHBC), Altus Group (Altus) and Dionne Bacchus and Associates (DBA), is pleased to provide this Supply and Demand Study of Aggregate Resources Supplying the Greater Golden Horseshoe (GGH). Each firm is responsible for the preparation of their own section. The proposed work program was provided by the Project Team on September 30, 2015 in Golder's Proposal Number P1540982, to address the requirements of the Ministry of Natural Resources and Forestry (MNRF) Request for Bid (RFB) No.: OSS_00539151.

The Province has the responsibility to protect aggregate resources and make them available for the long term. The Resource Development Section, Natural Resources Conservation Policy Branch of the MNRF commissioned this supply and demand study with regard to aggregate resources that supply the GGH.

This study follows up on recommendations from the 2013 Aggregate Resources Act Review Standing Committee and updates the 2010 State of the Aggregate Resource in Ontario Study (SAROS), which examined the province's aggregate consumption, demand, future availability, alternative, value, recycling, reserves and rehabilitation. The study can provide timely information relative to the 2015 Co-ordinated Provincial Plan Review.

Over the past 20 years, Ontario has consumed over 3.4 billion tonnes of aggregate - or about 170 MT per year on average. Generally speaking, Ontario is expected to consume more aggregate over the next 20 years than the past 20 years.

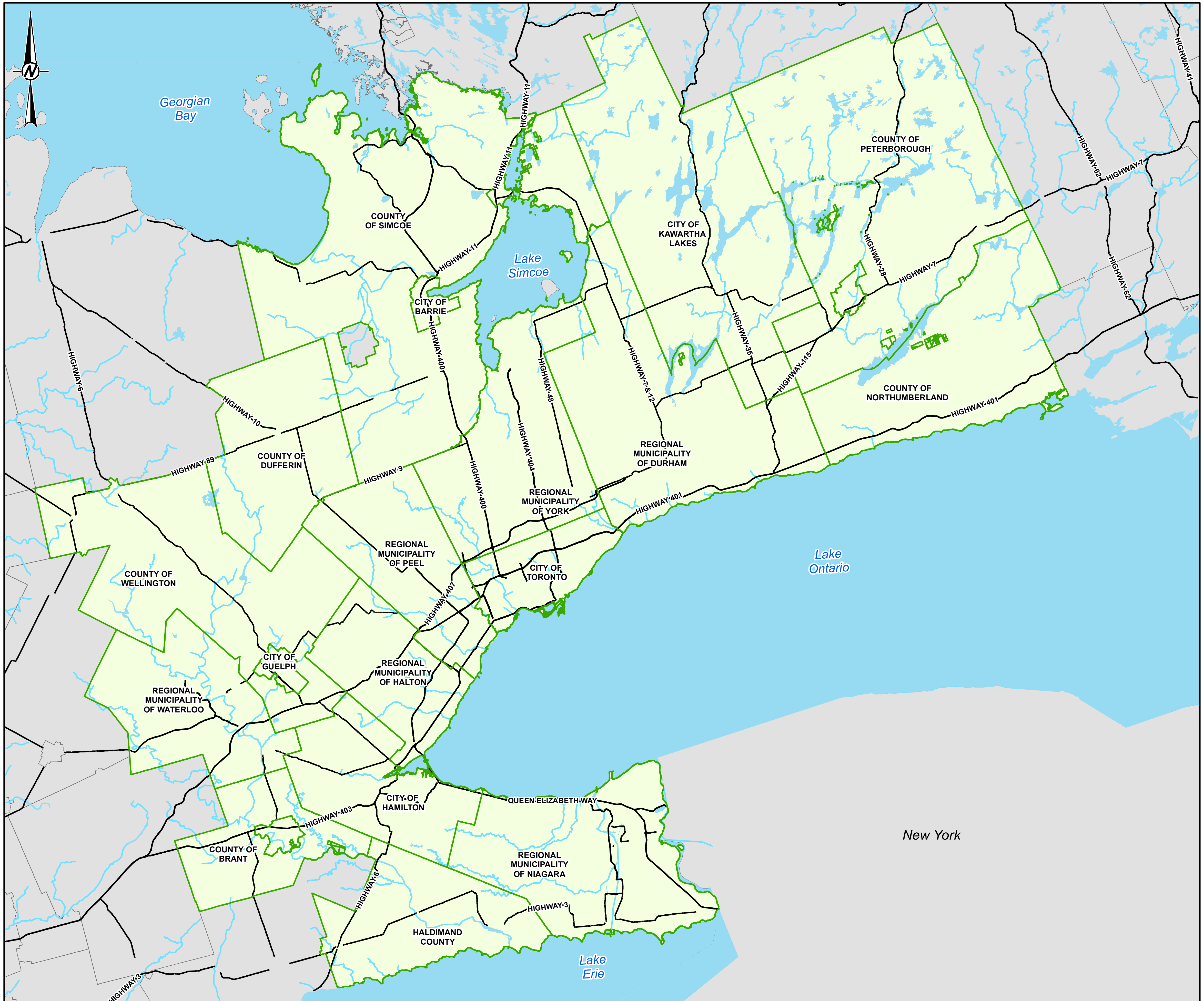
In 2013, the GGH produced almost half of all the aggregate produced in Ontario; it is anticipated that a significant portion of this material is going to supply the GTA, which only produces about half of the aggregate it needs. There is a need to ensure that areas of planned growth continue to have a supply of aggregate to fulfill infrastructure development and maintenance.

Building on the information contained in the relevant SAROS 2010 reports, this study provides detailed analysis on existing and future aggregate supply and consumption/demand within the GGH examines the planned/forecasted infrastructure projects (med– large scale) to support population growth within the study area, and the aggregate commodities required to support these projects. The study area is as shown on Figure 1-1.

This report is structured as follows:

- Section 2 provides the result of the Material Supply component of the Study, including assessment of licensed resources and unlicensed and unconstrained resources. This component builds on SAROS Paper 5 results by estimating remaining resources for quarries licensed since the 2009 study and provides estimated remaining reserves in licensed pits.
- Section 3 provides the results of the Constraint Analysis to determine the extent of overlap between environmental, agricultural and social constraints and known deposits of mineral aggregate resources.
- Section 4 presents the findings of the Demand Analysis of existing and future aggregate supply and consumption/demand within the GGH; and an examination of planned forecasted infrastructure projects to support population growth and the aggregate commodities required for these projects.
- Section 5 provides the results of the Traffic Assessment of the transportation between the supply and target demands areas.

A summary of the results of the project is provided in Section 6.



LEGEND

- Major Roads
- Watercourse
- Waterbody
- Municipal Boundary
- Study Area Boundary

0 20 40 60

1:1,000,000 Kilometers

REFERENCE(S)

LOCATIONS OF PITS AND QUARRIES, AGGREGATE SITES AUTHORIZED ACTIVE - MNRF LIO, OBTAINED 2016
ALL BASE DATA - MNRF LIO, OBTAINED 2016
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PROJECTION: ONTARIO MNR LAMBERT DATUM: NAD 83

CLIENT
MINISTRY OF NATURAL RESOURCES AND FORESTRY

PROJECT
SUPPLY AND DEMAND STUDY OF AGGREGATE RESOURCES SUPPLYING THE GREATER GOLDEN HORSESHOE

TITLE
GREATER GOLDEN HORSESHOE (GGH) STUDY AREA

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-08-18
DESIGNED	JMC/PR
PREPARED	JMC/PR
REVIEWED	SM
APPROVED	SM

PROJECT NO.	CONTROL	REV.	FIGURE
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2.0 MATERIAL SUPPLY

2.1 Introduction

This section provides the results of the Material Availability Study for addressing the requirements of the MNRF RFB No.: OSS_00539151. The study area for this portion of the Study is the GGH as shown on Figure 2-1.

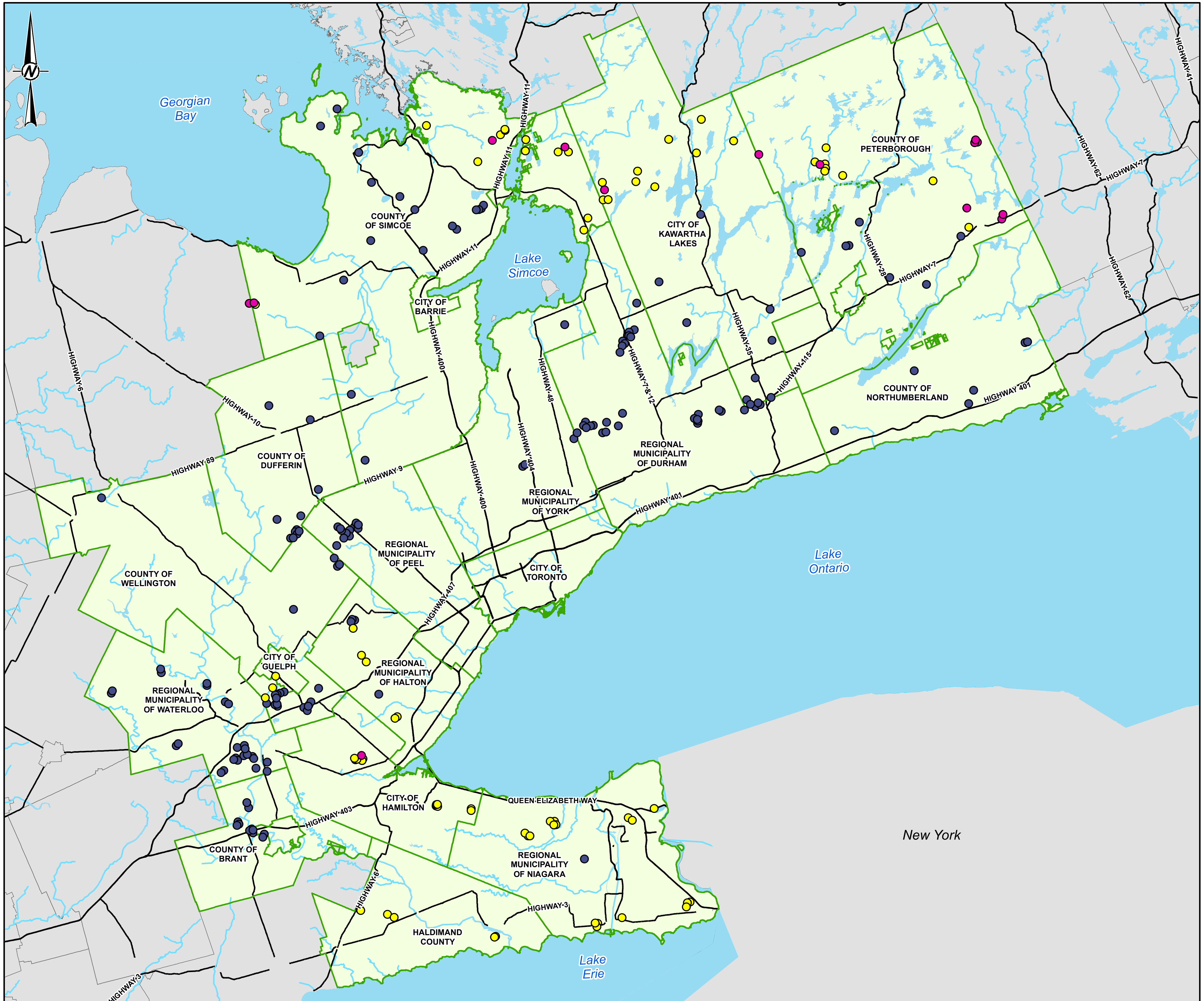
This component of the project examines the availability of materials to support growth and development and the anticipated demand for aggregate by providing information on the potential availability of materials within existing licences and future availability within unlicensed deposit areas. This includes:

- A review of previous studies and work with a focus on methods and limitations.
- Estimation of remaining licensed bedrock reserves in selected quarries supplying the GGH. Estimation of remaining licensed sand and gravel reserves in selected pits supplying the GGH.
- Identification of unconstrained and unlicensed Aggregate Resources Inventory Paper (ARIP) Selected Bedrock Areas and Primary Sand and Gravel Resources and estimation of potential resources per hectare in the GGH.

This paper builds on the papers of the 2009 SAROS study entitled, “State of the Aggregate Resource in Ontario Study (SAROS) Paper 5 – Aggregate Reserves in Existing Operations”.

This Material Availability Study is an update to the 2009 SAROS Study conducted by Golder in conjunction with MHBC presented in the report entitled “State of the Aggregate Resource in Ontario (SAROS)-Paper 5-Aggregate Reserves in Existing Operations”. A total of 97 licensed aggregate quarries were evaluated in the SAROS Study with respect to their remaining reserves of these 70 are located within the GGH study area. This Material Availability Study involves the estimation of remaining reserves in 11 additional quarries that have been licensed since the 2009 SAROS Study or added to the GGH study area, estimation of sand and gravel reserves in 123 licensed pits, and the evaluation of unlicensed and unconstrained Selected Bedrock and Primary Sand and Gravel resources in the GGH based on information in ARIP reports.

In addition to updated and expanded estimates of reserves this report includes additional background information and context in order to help interpret and understand the information that is being presented. This includes information about the nature and geology of the resource, a review of previous Ontario supply studies and a discussion about the relationship between this information and Ontario’s supply policy.



LEGEND

- Licensed Quarry Within GGH 2016 Study
- Licensed Quarry Within GGH 2009 Study
- Licensed Pit Within GGH 2016 Study
- Major Roads
- Watercourse
- Waterbody
- Municipal Boundary

0 20 40 60

1:1,000,000 Kilometers

REFERENCE(S)

LOCATIONS OF PITS AND QUARRIES, AGGREGATE SITES AUTHORIZED ACTIVE - MNRF LIO, OBTAINED 2016
ALL BASE DATA - MNRF LIO, OBTAINED 2016
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PROJECTION: ONTARIO MNR LAMBERT DATUM: NAD 83

CLIENT
MINISTRY OF NATURAL RESOURCES AND FORESTRY

PROJECT
SUPPLY AND DEMAND STUDY OF AGGREGATE RESOURCES SUPPLYING THE GREATER GOLDEN HORSESHOE

TITLE
LOCATION OF LICENSED QUARRIES AND PITS IN 2009 SAROS STUDY AND 2016 STUDY WITHIN GREATER GOLDEN HORSESHOE (GGH) STUDY AREA

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-08-18
DESIGNED	JMC/PR
PREPARED	JMC/PR
REVIEWED	SM
APPROVED	SM

PROJECT NO.	CONTROL	REV.	FIGURE
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2.1.1 Nature and Geology of Aggregate Resources

Estimating the volume of resource in an underground geological deposit requires an understanding of the nature and geology of the resource. A good starting point discussion is contained in the 1997 MNRF Non-Renewable Resources Training Manual:

Transition from Resources to Reserves

The terminology used in determining what constitutes a resource versus a reserve has created confusion for many people. This has been evident at land use planning hearings where inappropriate use has been made of ARIP data in attempts to show that there are either sufficient licensed reserves or that there are other areas where resources could be developed and that new licensing is not required in a particular area. Not all resources will be accessible or capable of being developed. Only those resources that can be readily accessed can be considered as reserves. To clarify the transition from aggregate resources to reserves, it is necessary to distinguish between the terms: resources; possible or potential resources; available resources; licensed resources; and proven aggregate reserves. The following definitions are provided to clarify the terminology.

Resource Areas

- *are broad areas identified through general geological mapping and or broad aggregate investigations by provincial surveys and private industry; and*
- *typically provide no analysis of geological, environmental or land use constraints.*

Potential Resource Areas

- *have favourable geology for the discovery of aggregate deposits (e.g., likelihood of resource verified by the presence of existing pits or quarries);*
- *have been identified by ARIPs or other equivalent surveys and studies; and*
- *may include licensed resources with an unknown reserve potential.*

Available Resource Areas

- *have favourable geology for the discovery of deposits. often shown by the presence of existing aggregate operations;*
- *do not have any quality or quantity constraints that would preclude possible development;*
- *have no known regulatory constraints due to land use. social or environmental conflicts;*
- *have no known constraints that cannot be mitigated within an operational and economic perspective; and*
- *can be acquired (purchased or leased) and are economically feasible for development.*

Licensed Resource Areas

- *are areas licensed and known to contain aggregate resources;*
- *may include some areas with no aggregate resources or resources of unacceptable quality;*

- *includes resources that may be uneconomic to extract, process, or are unmarketable due to limitations in quality or quantity of materials present; and*
- *includes reserves unavailable for extraction due to environmental restrictions.*

Proven Reserves

- *occur within a legally existing operation such as the licensed portion of the pit or quarry that is approved for extraction. as indicated on the site plans issued under the Aggregate Resources Act;*
- *have a proven quality and quantity normally demonstrated through a professional geological assessment of the property. including extensive sampling, testing, and development of quality control measures to maintain quality during production and processing;*
- *can be economically extracted and processed to meet a variety of product requirements: and*
- *can be profitably marketed to supply a ready demand area within a reasonably economic haul distance.*

Provincially, the source for mapping of unlicensed deposit areas are the Ontario Geological Survey (OGS) ARIPs. The purpose of an ARIP is to provide basic geological information on potential resource areas for planning purposes. This project's examination of unlicensed resource areas is ARIP based. What is important to understand is that an ARIP derived quantification of reserves or resources is limited by the nature of the source information. ARIPs map areas that have potential; geologic conditions that are favorable for the discovery of aggregate deposits. The ARIP methods incorporate only minimal constraints and the reports caution that many other constraints will affect resource availability. As a result, the ARIP mapped areas provide an exaggerated sense of what aggregate actually exists and only a portion of that which might become an available resource area or proven reserve based on the Training Manual terminology.

As a result, the ARIP derived information related to unlicensed deposits should be understood only as potential areas and not an accurate indication of the amount of aggregate that may exist or become available in the future. ARIP reports are not an accurate measure of reserves; they are a first approximation of possible resources.

In terms of licensed resource areas, these are areas where site plans are in place to outline the maximum potential extraction areas and depths. The examination contained in this report estimates the volume of material that may be available according to the approved site plans.

As the Training Manual discussion explains some of these licensed areas may contain no aggregate or unmarketable aggregate and some areas may not have aggregate of sufficient quality to warrant extraction or are otherwise not economically viable to extract due to other factors (e.g., insufficient thickness or a thick overburden cover).

A desktop examination of ARA site plans can estimate a volume of material that is within an area and depth approved for extraction. However, a desktop exercise cannot estimate a proven reserve (which is akin to available aggregate) because it does not:

- include a professional geological assessment with field sampling, testing etc.;

- access economics of extraction and processing to meet product requirements; or
- determine whether material can be profitably marketed to supply demand areas (reasonable economic haul distance).

A more detailed discussion of these limitations in relation to the project methodology can be found in section 2.1.5.

2.1.2 Previous Studies and Supply Estimates

To help understand some of the limitations and challenges in estimating licensed reserves it is also instructive to briefly review previous attempts to estimate availability of aggregate materials. Various studies over the years have been completed to help inform the Provincial management of mineral aggregate resources and provide information on the Provincial supply picture.

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

The 1974 Mineral Aggregate Study was prepared for the Ministry of Natural Resources to examine the aggregate industry in Central Ontario (which includes GGH) and to determine and relate the requirements of supply and demand to the year 2000. One of the central questions that led to the study was whether Central Ontario had enough aggregate reserves to meet the needs of the region up to 2001 and beyond.

The supply side of this study estimated potential available licensed supply assuming licencing of new reserves would continue. At the time licencing was just beginning under the Pits and Quarries Control Act and there was no attempt to estimate what actually existed in the early licensed areas.

The report found that due to urbanization, land use restrictions and natural features, estimated sand and gravel reserves of 10.3 billion tons in Central Ontario were reduced to a potentially available 1.9 billion tons. Similarly, estimated reserves of 83 billion tonnes of limestone were reduced to 0.8 billion tons. The report found these estimated unproven potentially available reserves were theoretically sufficient to about the end of the century. In addition, the report noted that the potentially available reserves were likely on the high side as they had not been proven as to quantity and quality, nor the probability of receiving aggregate licences in these areas.

The report noted that the challenge facing the Central Ontario Region is to significantly increase potential available supply of aggregate resources in a manner which will permit economical extraction and transportation for as far ahead as possible.

The report concluded that the potential available supply of aggregate resources cannot continue to meet the demand within the Region. There were not sufficient supplies that could be imported from outside the Region, except at great cost.

Mineral Aggregate Transportation Study (Peat Marwick & Partners, M.M. Dillon Limited 1980)

The 1980 Mineral Aggregate Transportation Study was prepared for the Ministry of Natural Resources to examine more remote, alternate sources of aggregate as possible future sources of supply to meet the projected demands in southern Ontario.

The Transportation Study included an estimate of licensed aggregate reserves that was completed through a survey of aggregate producers in four demand areas. Information was collected on total reserves broken down to fine and coarse aggregate. The results were factored up to account for non-respondents to the survey in order to represent total supply.

The report indicated current licensed reserves in the Toronto area and at locations supplying the area were estimated to be 1.1 billion tonnes. If no new licences were granted in the future, the existing licensed resources would be depleted around the year 2000 in the Toronto area. In order to ensure the continued availability of aggregate to this area, it was recommended that licensing of new sources or the provision of alternate sources of supply be considered in the near future.

The report concluded that long distance transportation of aggregate resources would increase the price of the delivered products substantially and would not be a viable alternative.

Aggregate Resources of Southern Ontario, a State of the Resource Study (Planning Initiatives Ltd. 1992)

The 1992 State of the Resource Study was prepared for the Ministry of Natural Resources to produce a comprehensive, up-to-date report on the aggregate resources of southern Ontario including reserves and production availability.

The project team worked closely with a steering committee. Calculating licence reserves was recognized as a challenging assignment:

> *"Calculations of reserves remaining within licensed areas is one of the most difficult aspects of identifying the remaining supply of aggregates. Determination of the amount of aggregate reserves remaining within a licence must take in to account a number of factors including reserves already extracted, limits to extraction created by regulatory setbacks, environmental considerations, physical constraints such as depth of overburden and waste materials."*

Recognizing the challenge, the 1992 State of the Resource Study project team considered a number of methods and sources of information for estimating reserves.

- Use of MNRF statistical information: it was determined that available information was insufficient.
- ARIPs: no detailed information regarding licensed reserves and not up-to-date.
- Detailed examination of individual site plans: not feasible due to need for on-site quantification. Selected site plans were analyzed but not sufficiently representative on which to base market area estimates.
- Identification of reserves from aggregate producer's survey data: licensees were surveyed and asked to estimate remaining reserves.

After reviewing the methods the State of the Resource Study project team determined that the most accurate estimates of remaining reserves would be from the producer surveys because they are most knowledgeable about their properties. The surveys identified area remaining to be extracted. This was then translated to a volume using average depth and density figures from ARIP reports and extrapolated (factored up) to account for the unsurveyed proportion of licence reserves.[1]

[1] Even though this was determined to be the most accurate method, it would result in an extremely rough approximation given the assumptions that need to be made in order to translate area to tonnage and account for the unsurveyed portion of the licensed properties.

The report concluded that existing licensed reserves within major market areas of southern Ontario would be depleted as early as 1995 in some areas if new reserves were not licensed. Without the continued licensing of new reserves, depletion of existing reserves would result in aggregate shortages in specific market areas. While reserves from outside the market areas would still be available, greater reliance on these sources would increase transportation costs and related environmental impacts.

The report found that shortages in the GTA of sand and gravel resources could occur as early as 1995, and for crushed stone as early as 2000.

The report concluded that in order to achieve a balanced approach to aggregate and environmental management, it was critical that the benefits and costs of planning decisions be evaluated in detail before making strategic decisions which may result in environmental impacts or loss of access to a valuable, non-renewable resource.

Oak Ridge's Moraine Aggregate Resources Study - Background Study No.10 to the Oak Ridge's Moraine Area Planning Study, Prepared by the Oak Ridge's Moraine Aggregate Committee, May 1994

During the development of the Oak Ridge's Moraine Conservation Plan, there were a number of background studies completed in order to inform the development of the Plan. Background Study No.10 examined the need for and supply of the aggregate resources of the Oak Ridge's Moraine. The study team is made up of staff from MTO, MNR and industry representation.

On the issue of existing licence reserves, the study concluded that the current supply of aggregates consists of aggregate reserves within existing licensed properties. For operations on the Oak Ridge's Moraine it was anticipated that at current rates of aggregate production many of the operations would deplete their existing reserves within about 16 years. The majority of the licences within the Oak Ridge's Moraine pre-date the introduction of regulatory controls on extraction in the early 1970's. Comparatively few licences have been issued since then such that the annual consumption of reserves has significantly exceeded replacement by new licence reserves.

These findings were based on licensee surveys. Survey respondents represent 80% of the total licensed area for the GTA portion of the moraine and the majority of the production capacity. The estimated total of proven reserves from 59 responding operators was slightly less than 159 MT. A number of limitations on the survey results and methodology are noted.

Interestingly, the responses from the Oak Ridge's Moraine operators also indicate that on average 43% of licensed area either contained no reserves, had been depleted of reserves or contained resources that were not available for extraction. Proven reserves make up only 40% of the licensed area.

Mineral Resource Planning Study Niagara Escarpment Plan Area and Surrounding Areas Prepared for MOEE by Bird and Hale Limited, 1995

This study was prepared to provide advice to the Ministry of Environment and Energy with respect to continued aggregate resource extraction in the Niagara Escarpment Plan Area. The report includes a constraint mapping exercise and a discussion of demand and supply. The Terms of Reference for the study called for an accurate estimate of reserves in licensed areas and potential resources of non-licensed areas.

To provide information on licence supply, the Bird and Hale Study relied on existing information. No data was available for licensed reserves of dolostone or sand and gravel and licensed area was used as an indicator. For sand and gravel, it was noted that licensed area under the ARA is not an accurate indicator of supply because "proven" reserves make up, on average, only 40% of the licensed area. The balance was either depleted, inaccessible or unproven. The Study reviews the 1992 State of the Resource estimated exhaustion dates noting that the forecasts may not be realizing the short term but it is likely that the GTA will face licensed aggregate reserve shortages and similar situations face most of the other markets in the Province as well.

State of the Aggregate Resources in Ontario Study – Paper 5, Aggregate Reserves in Existing Operations (Golder Associates Ltd. 2009)

The 2009 State of the Aggregate Resources in Ontario Study was prepared for the Ministry of Natural Resources to evaluate the current status of aggregate resources in Ontario. Specifically, Paper 5 addressed aggregate reserves in existing quarries in central Ontario surrounding the GTA and mapped current reserves relative to potential market demand areas.

Paper 5 included an estimate of remaining reserves in licensed limestone/dolostone quarries in the GGH study area. Ninety seven licensed sites (licensed areas greater than 20 hectares) were evaluated. Eleven quarries were field visited to validate the estimation process. The report discusses a number of limitations on reserve calculations which remain applicable to the present study.

SAROS Paper 5 was limited to an assessment of selected licensed quarries. As reported in SAROS Paper 5, there is considerable difficulty in defining reserves in sand and gravel deposits with the same degree of certainty as reserves of limestone and dolostone (which as noted in the reports has its own limitations). The highly variable nature of sand and gravel deposit is a significant impediment to calculating reserves. MNRF was advised that completing valid estimates of reserve volumes in sand and gravel pits would require a high level of field verification. Without this, broad based assumptions would render the conclusions uncertain. Additional limitations were mentioned including the difficulty in evaluating below water table reserves. Notwithstanding, the report recommended consideration of sand and gravel resources despite the difficulties identified. It was recommended that the investigation be limited to above water pit operations and that the minimum size be 40 hectares.

The report noted that aggregate consumption in the GTA remained relatively consistent over the years. However, the licensing of replacement reserves has not kept pace with this consumption, resulting in a 2.5 to 1 consumption to replacement ratio between 1991 and 2009.

The report found that the licensed reserves of stone in the 97 assessed quarries totalled approximately 3.44 billion tonnes of variable quality. The report noted that this total included the full volume of rock, both high and lower quality and did not account for unusable products that are generated through the extraction process (e.g., silt).

The report stated that although the 3.44 billion tonnes appears to be a large number, it is important to understand that the majority of these reserves are not high quality stone and are located at greater distances from the market areas, with only approximately 902 MT within 75 km of the Vaughan Corporate Centre. Of this total, only 317 MT was considered high quality reserves available for production of concrete/asphalt grade stone and manufactured sand.

Aggregate Reserve Study Prepared for the Highland Companies by Genivar Inc. January 2011

This report documented a current estimate of remaining licensed resources of high quality aggregate materials available for the GGH market. The study area was limited to a 75 km radius from the Vaughan Corporate Centre.

As the study reports: *"many of these pits and quarries have been in production for years and are becoming depleted. Some operations are restricted in the products they are able to make, and operational challenges are increasing as available resource dwindle and the environmental and planning requirements become more demanding within the industry. It recognized that many of the pits and quarries in southern Ontario today are restricted in their ability to produce a broad range of aggregate materials. The bulk of the high quality aggregate consumed in the Greater Golden Horseshoe now comes from relatively few sources."*

Two phases of work were completed consisting of an estimate of bulk resources based on general assumptions and, a focused study on high quality sources through examination of Aggregate Resources Act site plans and current topography. The following two tables reproduced from the study highlight the results:

Table 2: Aggregate Criteria Summary

	Total Sites	General Criteria	High Quality Criteria
Pits	299	242	26
Quarries	43	19	9
Both	1	1	0
Total Sites	**343**	**262**	**35**

Table 3: Study Area Licensed Aggregate Reserved Summary (MT)

	Total Sites	General Criteria	High Quality Criteria
Pits	531.3	513.9	104.1
Quarries	420	230.8	126.8
Both	12.6	12.6	0
Total Sites	**963.9**	**757.3**	**230.9**

The Future of Ontario's Close to Market Aggregate Supply: The 2015 Provincial Plan Review (MHBC & Ontario Stone Sand & Gravel Association, 2015)

The MHBC report was prepared as input on behalf of several aggregate producers through the Provincial Plan Review. The report provided an overview of aggregate production and consumption in the GTA and included recommendations for the Provincial Plans.

The report found that the GTA consumes approximately 60 MT of aggregate each year compared to producing approximately 21.2 MT in 2013. For every 2.8 tonnes of aggregate produced in the GTA, approximately one tonne is replaced through new licences in the GTA. In addition, close to market supply is heavily reliant on older licences; over 80% of the Class A licences in the GTA predate the Aggregate Resources Act (1990).

The majority of resources consumed in the GTA are imported from adjacent areas in the GGH. The report noted that the average annual decrease in aggregate production in the GTA since 2001 is approximately 1.1 MT. It concluded that resources within existing GTA licences are being rapidly depleted and are not being replaced by resources in new licences.

The report concluded 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 to the GTA market.

Supply Estimates and Public Policy

How much supply is required to meet anticipated demand? And, to what extent should estimates of supply vs. demand inform the development of public policy surrounding the management of mineral aggregate resources? These are difficult questions to answer however, some consideration is warranted in order to gain some appreciation of what the information generated by this study and previous supply demand estimates might be used for.

It is not a simple case of matching supply to demand, especially when the supply estimate is a volume of material that occurs within a licensed extraction area. That cubic metre of material in a licensed site is not a commodity sitting in a warehouse waiting to be distributed to a consumer. Apart from the geological factors that will determine if an aggregate product can or will be produced, there are economic factors that have to be considered in evaluating the capacity of estimated licensed supply to effectively meet market demand.

In order to effectively supply the market (at reasonable prices) licensed supply should be capable of producing a full range of products required by the market. Setting aside limitations regarding actual presence and quality there are many other variables that will determine if a volume or tonne of proven reserve in a licensed area can effectively meet anticipated demand such as:

- Suitability to produce the required products. While overall reserves may appear adequate there may still be shortages of reserves suitable for the production of some products.
- Reserves have to be in the right location relative to the job sites (close to market). Job sites are not fixed point meaning they are dispersed around developing areas and small increases in transportation distances for high bulk – low value products can significantly affect price and viability.
- Supply should be in competitive holdings so that many producers all have the capability to competitively bid on supply contracts.
- Any individual reserve must be large enough to justify upfront capital investment in production equipment required to produce aggregate products.
- Licensed reserves need to be held or available to companies and individuals that have the interest and capability in producing the right products. While some reserves are made available on the open market others are allocated for internal projects or products (vertical integration). Increasing costs and uncertainty regarding the licensing process will tend to reduce material available as producers manage sales to extend the life of their own reserves.
- Plant capacity and annual license limits will reduce the potential for a large reserve to satisfy annual market demand. A large portion of reserves in few licensed sites offers less capacity to effectively supply the market than the same total reserve spread among more sites.

As a result, it is overly simplistic to attempt to equate licensed supply with anticipated demand and make any evaluation of sufficiency. Certainly, it is not appropriate to calculate years of supply based on estimates of licensed supply vs. anticipated demand (e.g., 1 billion tonnes of licensed supply represents 20 years supply in a 50 million tonne per year market). It should be apparent that the inventory of licensed supply should be considerably greater (many times more) than the anticipated demand over the study period.[2]

Knowing there are adequate or plentiful licensed reserves does not guarantee the right products will be available at a reasonable price to meet demand at a specific time and place. The development and evolution of Ontario public policy for the management of mineral aggregate resources has been informed by several background studies as summarized in the previous section of this report. It is well recognized that potential reserves exist in many parts of the Province but there are concerns about scarcity that will lead to increased costs and environmental impacts associated with increased haul distance.

This understanding of a complex market and a public interest in continued availability of mineral aggregate resources is reflected in today's Provincial Policy Statement (2014 PPS) mineral aggregate supply policy:

> 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.

Public policy in Ontario aims to ensure licensed supply includes abundant reserves in competitive holdings for the full range of products in close to market locations. The Province has decided not to prescribe or control the amount of supply that should be licensed in a quantifiable way. There is an understanding that supply is constrained and impending scarcity would lead to undesirable results. The responding supply policy is qualitative and appropriate for the management of an essential non-renewable resource: as much as realistically possible.

Methodology for Estimating Remaining Licensed Reserves

This section describes the methodology for estimation of remaining licensed reserves in the quarries and pits. In the case of limestone/dolostone quarries this information will update what was presented in SAROS Paper 5. For sand and gravel pits the information is new. A secondary objective is to estimate the area of unlicensed Primary Sand and Gravel Resources and Selected Bedrock Resources that could potentially supply and serve as a source supply of aggregate materials in the GGH.

A total of 11 licensed quarries and 123 licensed pits were subject to evaluation of remaining licensed reserves. The evaluations were undertaken using the site plans for each of the quarries (as supplied by MNRF), recent ortho-photo imagery of each of the quarries. The process and the results are described in greater detail in the following sections.

[2] For further discussion on these issues the reader can refer to the 1991 InterGroup Consultants Ltd. report that was prepared for the hearings on the Niagara Escarpment Plan Review. This was part of the evidence provided relating to the economic implications of restricting supply from the Niagara Escarpment Plan Area.

The material availability analysis for this study is comprised of an assessment of both licensed and unlicensed properties for the purpose of identifying the resource potentially available to supply the GGH. These are discussed further below.

Literature and Data Review

A literature review was completed of the ARIP documents for the study area. This review was focussed primarily upon the Primary sand and gravel resources and the Selected Bedrock Resources. A review was also undertaken of the data in the GIS files in the ARIP data files including the deposit type, deposit thickness for Primary sand and gravel resources and the overburden thickness for bedrock deposits.

Resource Mapping

Mapping of resource deposits from the updated ARIP provided by the MNDM was used as an initial layer in the study area. The licensed properties within the study area were overlaid on the ARIP layer to confirm the type of resource being extracted. This helped address the location and estimated reserves based on the available material type being extracted for a given location.

Gap Analysis and Site Selection

A gap analysis was completed to identify potential licensed limestone resource sites within the current study area that were not captured during the original SAROS Paper 5 study. SAROS 2009 assessed reserves for Class A limestone/dolostone greater than 20 ha inside Canadian Portland Cement Association (CPCA) Areas 2, 3, 4 and 5.

The original SAROS Paper 5 Study Area was based on CPCA areas whereas the current study area is the GGH. The only portion of the current study area that was not covered in the CPCA Areas is a portion of Peterborough County in the north east corner of the GGH. The Pit and Quarries Online Application (PQOA) database and information from MNRF was used to identify Class A limestone and dolostone quarry sites in the GGH that were outside the CPCA Study Areas. The same 20 ha minimum size requirement was used. One quarry site was identified in the additional study area in Peterborough County. Another quarry in the original study area has been included in the update as it has been confirmed that it produces some limestone (previously thought to be only a trap rock quarry).

Additionally, the gap analysis identified Class A limestone and dolostone quarries that have been licensed since the 2009 SAROS Paper 5. The same data bases along with the Environmental Registry was used and the same size criteria was applied. It was determined that an additional nine Class A quarries have been licensed since the work for the 2009 Paper was completed.

Accordingly, there are an additional 11 quarries which were licensed during 2009 or later, or added to the GGH study area, that are being assessed as part of the current study. The results for these reserve estimates are added to the Paper 5 results.

Pit Site Selection

Considering the variable nature of sand and gravel deposits, it was determined that the minimum size of pits evaluated should increase from the 20 ha used for quarries in the 2009 SAROS Study and this 2016 update to 50 ha. Based on the LIO database this decreased the number of pits within the study area to approximately 164.

The sand and gravel resources were determined through a combination of ARIP mapping which identifies primary, secondary and tertiary resources. The 164 pits in the LIO database that were over 50 ha in size were overlain on the ARIP Primary Resource Mapping to provide an indication of whether or not they fall within the primary resource area and have the potential to produce high end products to the marketplace. After review and analyses of the actual licensed areas a total of 123 sites were identified in the study. These sites were evaluated in a similar manner to the quarries evaluated in the 2009 SAROS Study and this 2016 study.

Methods for Licensed Reserves

The estimation of remaining licensed reserves based on ARA site plans assumes that the material available is the difference between the maximum extent of extraction depicted on the site plans and the current surface topography. The difference between the two surfaces is expressed as a volume that is then converted to a tonnage based on standard density factors. As described below, the method requires interpretation of site plans to estimate the allowed areas and depths of extraction based on setback requirements, controls on depth of extraction, cross sections and rehabilitation plans. For the surface topography there are a number of available data sources of varying dates and the method includes use of aerial photography to discern pit and quarry features such as extraction faces and future reserve areas.

The process for estimating the reserves at a particular property included a detailed examination of available imagery, site plans and other information which would contribute to a relatively accurate calculation of remaining reserves on the property. The steps taken during the evaluation of the quarries is summarized below.

Recent ortho-photo imagery, the dates of which ranged from 2006 to 2008, for each of the quarries in the Study Area was supplied by MNRF in digital format. The imagery was used to capture identifiable features such as roads, boundary lines and quarry faces and was compared to the site plans for the property, which, in general, predated the date of the image supplied for the property.

The 'current' site plans, as required for each licensed aggregate property in Ontario under provisions of the ARA, are on file at MNRF District offices, and were provided by MNRF for use in the study. It should be noted that the site plans had a wide range of dates, thus resulting in a wide range of 'current' conditions as well as a range in the evolution of site planning development practices.

Where overburden depths were identified on a particular site plan, the average of such depths was used to calculate volumes. If such information was not available, other sources (i.e., drift thickness mapping, water well records, OGS mapping etc.) were used. For sites where overburden depths were not available, the OGS 'drift thickness' data (OGS 2007) was used as an approximation. This data set was created from Natural Resources and Values Information System (NRVIS) Digital Elevation Model (DEM) and OGS interpolated bedrock surfaces, and overburden thicknesses for sites within the Study Area.

The licence and limit of extraction boundaries were delineated using site plans obtained from the MNRF and other available information. Given that a majority of the existing site plans were older than 2002, the approach taken used the latest 2002\2010 DEM available through the MNRF to present the existing conditions. Where more recent DEM\contour data shown on plans were available this was digitized and\or obtained from MHBC.

The estimate of remaining reserves was similar to the methodology originally completed for SAROS Paper 5.

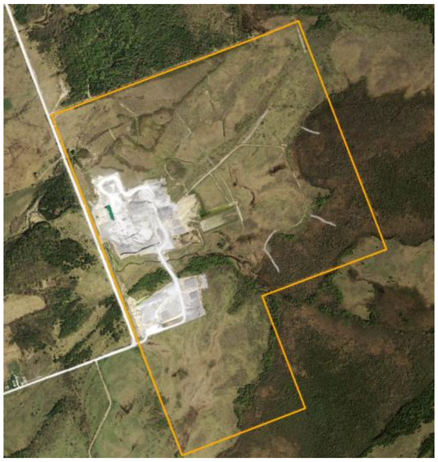
2.1.3 Remaining Resources in Licensed Quarries

The following methodology was used to evaluate the resources of the licensed limestone quarries greater than 20 ha within the study area:

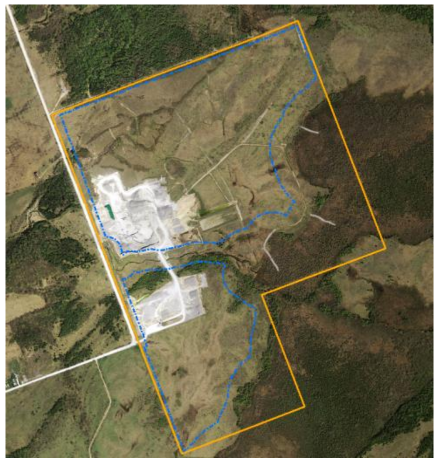
- Scanned copies of all site plans (Operational Plans, Rehabilitation Plans and Cross-sections) were received from MNRF.
- The most up to date DEM were provided by MNRF and used for site areas.
- The area that had been excavated and the remaining identified resource was based on the DEM.
- Three-dimensional models of the quarries were developed based on the DEMs and the site plans. Typically the Operational plan and Cross-Sections were used to identify the base of the resource.
- An estimate was made between the volume between the ground surface (based on the DEM) and the base of extraction (based on the site plans).
- The volume between the base of extraction and the ground surface was then calculated and multiplied by 2.75 kg/m^3 to yield the estimated remaining tonnage (this density factor was the same value used in the 2009 SAROS study).

The GIS process is described below:

- Property Boundary GIS data was provided by MNRF, and those boundaries that did not match the georeferenced site plans were adjusted accordingly, using the licensed quarry property boundary.

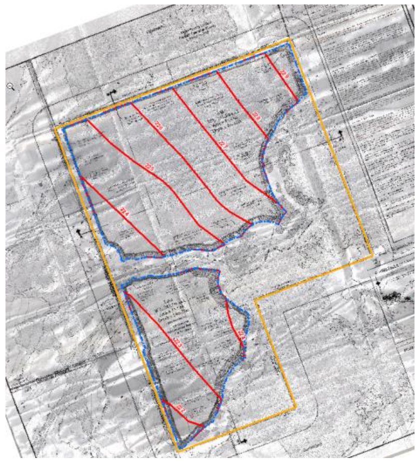


- Setbacks were captured based on the current site plan. The same boundary was used to define the modelling extents as well as the closure plan extents.

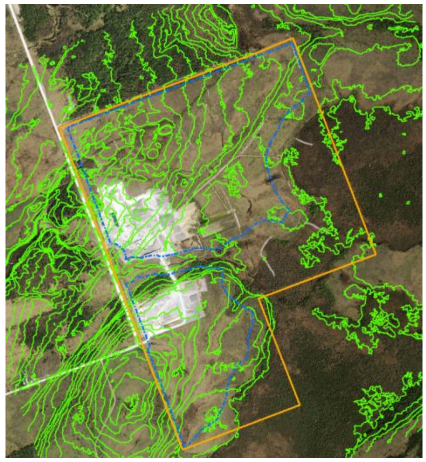


- Future stripping\overburden was captured based on the most currently available Aerial Imagery provided by MNRF. The future stripping defines the area within the setback/model extent that still is vegetated, undisturbed with no exposure to bedrock or resource surface. The overburden thickness used depth values obtained from the individual site plans or from the Aggregate Resources of Ontario—2015 dataset.

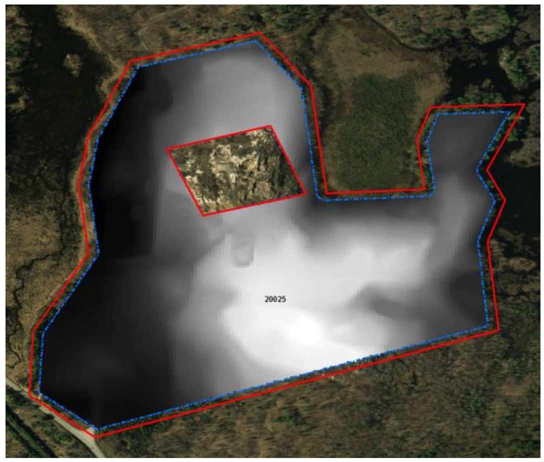
- Using the scanned site plans, point (Spot Floor Heights) and line (Final Contour) data were captured. The data was then used to develop floor elevations for the quarries. For instances where the operational or closure plans did not illustrate the final\bottom of quarry floor, the available cross sections in the site plans were considered.



- The current site plans were used to extract spot heights and/or contours.



- Where the current plan contour data was older than GTA 2002 or SWOOP 2010 DEM or there was not sufficient information to identify date, the most current available DEM, provided by MNRF, was used.



- After all the property boundary, stripping\overburden areas, current operational and closure plans were captured\digitized, the data was modelled to provide an estimated reserve volume. The volume was then multiplied by a density factor to produce a resource tonnage.

2.1.4 Remaining Sand and Gravel Resources in Licensed Pits

Quantity calculations were completed on the 123 active licensed sand and gravel pits using similar methodology to that used for the quarries (described in Section 2.1.3).

The following methodology was used in the evaluation of the sand and gravel properties discussed above:

- MNRF scanned the operational rehabilitation and cross sections.
- Property Boundary GIS data provided by MNRF used as extraction limit and adjusted based on site plans.
- The point (Spots Floor) and line (Final Contour) data was captured and processed to produce a final floor elevation using the scanned operational and closure site plans. For instances where the closure plan does not indicate the final\bottom of quarry floor, available cross sections were used.
- The DEM provided by MNRF was used with the current plan.
- Future stripping/overburden was based on the “Drift” thickness file obtained from the OGS and a 3 m overburden thickness was used generally when not available. In some instances the overburden thickness was reduced based on the information in ARIP reports. After all the stripping/overburden areas, current conditions and operational and closure plans were captured/digitized, the data was modelled to and provided an estimated reserve volume. The reserve volume was then multiplied by a density factor of 1.77 kg/m^3 to produce a reserve tonnage.

2.1.5 Uncertainty and Limitations Related to Estimation of Licensed Reserves

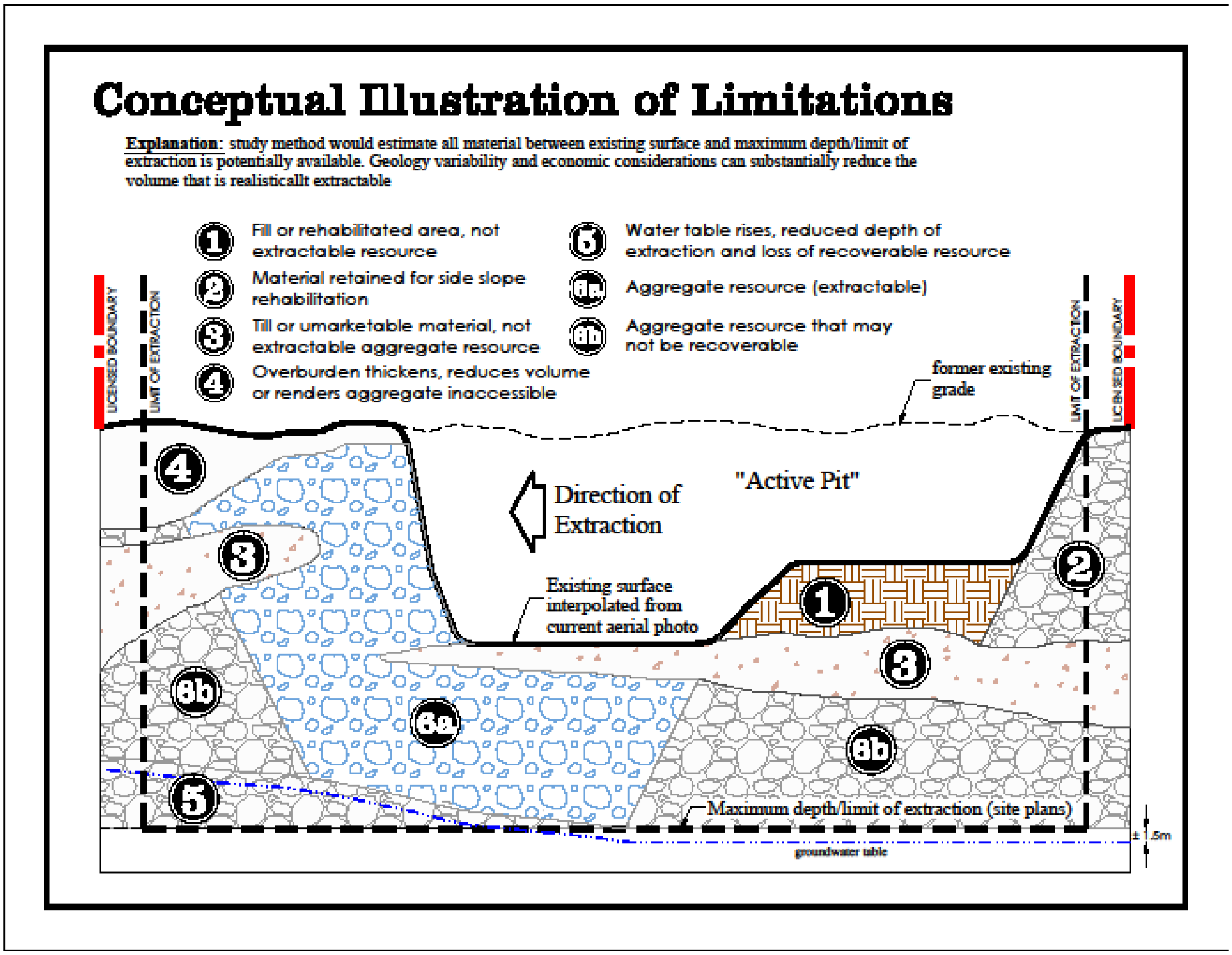
It should be noted that the unlicensed and unconstrained above bedrock and sand and gravel resources represent potential resources and the estimated tonnages would require verification through a field investigation and laboratory testing program.

There are a number of limitations that apply to desktop exercises that intend to estimate remaining licensed supply based on ARA site plans. As previously described, the method involves estimation of a volume between two surfaces: one surface is the limits of extraction depicted by the ARA site plans and the other is the existing topography. The volume between these surfaces is converted to weight (tonnes) based on an assumed density factor.

A discussion of limitations is critical to ensure a full and proper understanding of the reserve estimates produced, and how they should be treated. Many of these limitations are inherent and unavoidable in a site plan based ‘desktop’ exercise. Some are more relevant to the consideration of licensed (i.e., approved pit or quarry) versus unlicensed sites (i.e., deposit areas), or bedrock versus sand and gravel.

The first types of limitations are those that affect the accuracy of the mathematical exercise used to define the surfaces, calculate the volume and convert volume to weight. These include the requirement to interpret site plans, accuracy of topographic elevations, interpretation of aerial photography and variations in material density. Generally these factors are manageable and it is realistic to expect that the method can estimate the amount of material between two surfaces with a reasonable degree of confidence.

The more significant limitation is that the estimated volume will contain unsuitable, unextractable and unmarketable material based on both geologic and economic considerations. As discussed below, this is a particular concern for sand and gravel deposits due to their geologic variability. As a result, an estimate of the material that is within licensed extraction limits is not an estimate of a proven licensed reserve that can meet an anticipated demand for mineral aggregate products.



Conceptual Depiction of Uncertainty and Limitations

Interpretation of Site Plan Elevations and Limits

There are a number of limitations that have to be considered when calculating reserves based on a desktop review and GIS mapping process, as was conducted for this study. The varied age, formats and content of the site plans for the licensed properties that were used in the study, created a number of issues requiring resolution on an individual site basis. As well, variable imagery dates were also considered to be limiting factors.

A number of site plans for quarries and pits in the Study Area used only elevation data (spot elevations, contour lines) relative to a given benchmark, and not to an established geodetic datum (i.e., metres above sea level). This created difficulties in determining overburden depths and pit/quarry floor or post-extractive elevations, and thus volumes of reserves, particularly if the given benchmark was not at ground level. In such examples, an assumption had to be made regarding the height of the benchmark above ground level. This only occurred when the benchmark was referenced to a specific location on the property. In the absence of other, more reliable, elevation data, an approximate geodetic elevation was derived by comparing a relative spot elevation or contour line on the site plan to a NRVIS geodetic elevation, and relating the remaining relative elevations to that NRVIS elevation.

Both relative elevations and assumed benchmark elevations on the site plans used for reserve calculations served to reduce the accuracy of those calculations, particularly in comparison to other Site Plan elevation data that is based on more accurate geodetic data.

In some instances, the quarry or pit boundaries, as indicated on the site plans, did not conform to the NRVIS data provided by MNR. In these cases, a professional judgment decision was made on the basis of the source of the boundary data. In some other instances, the NRVIS boundaries were used instead of the Site Plan boundaries.

A lack of consistency in the age, format and content of the site plans leads to a level of uncertainty in the reserve calculations. Any such inconsistencies could be rectified by field verification, use of a DTM tool or a combination of both in any future reserve verification process.

Variations in Density

The conversion of volume to weight is based on standard average density factors for sand and gravel and for bedrock. While the actual density will vary depending on the specific type of mineral, moisture content, grain size and compaction the use of a generally accepted average is not a significant limitation for a study that is estimating aggregated tonnages for a number of sites across the GGH.

Geological Variability: Material may not be present or accessible

There is inherent variability in the geology of mineral aggregate deposits. For example, glacial sand and gravel deposits may contain internal layers of clay or silt that are not suitable as a source of aggregate. The highly variable nature of sand and gravel deposits is a significant impediment to calculating reserves. Within a spatially well-defined deposit, such as an outwash deposit, the mode of deposition can result in highly varied stratigraphy. The contents of an outwash deposit may vary from fine sands to cobbles, and any combination thereof. Ice contact deposits, such as kames, moraines and eskers, are highly variable in composition, often including silt and/or clay fractions in the matrix or in discrete layers or lenses. In addition, the gravel or sand layers in a deposit may pinch out as the deposit is mined. Even bedrock formations can include layers of variable rock that are not suitable based on a variety of physical or chemical characteristics. Sometimes an entire bench in a geological sequence is not suitable even though it has been included in the permitted extraction limits.

This is the most significant limitation in this method. ARA site plans are prepared to regulate extraction. One of the most basic functions of the site plans is establishing limits on areas and depths of extraction. These define the maximum permissible extent of extraction. In some cases, especially older site plans, these limits do not account for geological variability. When older licences were issued there was no requirement to prove the presence, suitability or viability of a deposit in order to obtain a licence. Even where there is some site specific geological information available the site plans will be prepared to maximize possible reserves and include portions of the deposit that may end up being marginal or unsuitable. This simply reflects the reality that extending the limits of extraction required further approval processes whereas extracting less than the volume allowed by the site plan has no practical consequence from the perspective of the licensee.

As a result, the volume based estimates generated by this method will invariably include material that is not suitable for the production of aggregate products required by the market. The presence of this material can also mean that otherwise suitable material is not accessible because it is underneath or mixed in with materials that cannot be economically mined or moved. Accordingly, this method will always exaggerate the amount of material that is actually available and the variance could be a substantial amount.

To include valid estimates of licensed supply volumes from sand and gravel pits it would be necessary to include a high level of field verification into the process. Field verification would require inclusion of sampling and analyses of all open faces within any particular pit, as well as test pits or boreholes for unextracted reserve areas. Even where this is completed at a site specific level there is still extrapolation required between data points and a continued albeit reduced level of uncertainty. Geological variability within the extraction envelope only fully becomes apparent when extraction is proceeding, either visibly at the face, or during processing or as a result of ongoing quality-control testing that may be carried out by the operator.

Economic

Additional economic and market considerations will determine whether a potential licensed reserve can be economically brought to market. Before making a contribution to meeting market demand the material that constitutes estimated licensed supply must be extracted, processed and shipped to market. In addition to existing in a licensed pit or quarry material must be economically viable in order for it to be produced for the market and not all material will be economically viable. These factors are not always accounted for when extraction limits and depths are set on older site plans.

Ability to Extract

In some cases, particularly older site plans, the potential licensed reserve includes large volumes of material that cannot be practically extracted. Some site plans include very deep extraction, both above and below water table that may be unrealistic as a result of equipment limitations (e.g., reach of an underwater dredge) or safe mining protocols (e.g., bench heights and access ramps).

Water Table Limits Depth

Elevation of the water table for pit or quarry sites can affect depths of extraction. While it is a current requirement of an above water table site plan to determine the water table and set the floor depth above it, older site plans may not have been based on as reliable information on water table elevations. Water table can sometimes be higher due to changes over time or inadequate investigation of the water table location. Site plans for above water table pits and quarries typically limit extraction to above water table. Where the water table was not previously well defined there can be material that is within the extraction envelope of the site plan that cannot be accessed because it may be found to be lying below the water table. This material will not be permitted for extraction without obtaining additional approvals from the MNRF. This material is then lost from potential supply.

Below Water Surfaces Not Visible

Pits, and in some cases quarries, may be excavated below the water table using a clamshell or dragline as part of their practice for removing the below water reserves. Some quarries with remaining reserves have been temporarily flooded. Since the extent of below water extraction cannot be determined by evaluating aerial photos or topographic maps there is additional uncertainty in evaluating licensed for below water table operations.

Depth of Overburden

Overburden depths have been accounted for and estimated using a variety of information sources as described in the methods sections of this report. The overburden depth can vary over a property, in some cases significantly. The estimation methods used may not accurately anticipate variations in overburden depth. This can affect the accuracy of the reserve estimate (i.e., if overburden is deeper than anticipated then reserve estimate includes overburden and is too high and vice versa). More significantly, there will be cases where the depth of overburden increases to the extent that extraction is no longer economically viable and a portion of the estimated reserve is not extractable.

Surface could be Imported Backfill or Rehabilitated Area

One assumption of the method is that the observed surface is the top of unextracted potential reserve. This may not be the case where backfill has been placed in a pit or quarry for the purposes of rehabilitation. Accordingly, the estimated remaining reserves could possibly include areas that have been progressively rehabilitated with non-aggregate material which introduces another element of uncertainty into the remaining reserve estimates.

Rehabilitation Requirements not Accounted For

Also, the requirement for retention of aggregate material on a property for the purpose of rehabilitation has not been addressed and has not been removed from the total reserve estimate. In many cases site plans require that creation of the rehabilitation landscape will be accomplished by using on site materials. This volume is not available and not accounted for in the potential reserves estimates.

Date of Estimate

Another significant limitation of the study is considered to be the use of 2002 and 2010 topographic mapping for the sand and gravel pits. As this mapping was used for the resource modelling it does not account for aggregate extraction that has taken place from 2002 to present, a period of 14 years. For instance when sites were licensed in 2003, this would model the site as an unextracted greenfield site, when in fact it was extracted over almost a decade and a half.

Additionally, the 2002 mapping was noted to be used for some of the large sites with high extraction rates. Review of recent air photo imagery confirmed that significant extraction had taken place since the 2002 mapping.

As a demonstration of this uncertainty the project team identified several pits that were known to be depleted and closed or nearing depletion in the short term. The desk top evaluation that was completed identified reserves that had been mined subsequent to the topographical mapping that was used for the resource evaluation GIS modelling. This provided an indication that while the resource evaluations may be mathematically correct, they reflect the resources that were in place at the time of the topographic mapping that may have been subsequently mined out. These resources would therefore be included as remaining reserves based on this but would not be remaining reserves if current topography were used. Therefore the remaining reserves reflect the conditions at the time of the topographic mapping. Many of the sites had 2002 air photo topography and therefore do not reflect the extraction of resources that took place over the 14 year period from 2002-2016. The remainder of the sites utilized 2010 mapping which does not reflect extraction during the six year period from 2010-2016. The fact that the resource evaluations do not include the 6-16 year periods of extraction results in a significant overestimate of actual remaining reserves.

The estimated potential resources therefore are considered to significantly overestimate the remaining reserves in licensed pits. It is not possible to quantify the difference in remaining resources using 2002 topographic mapping and up to date topographic mapping, without modelling the sites with more recent mapping or obtaining production data for the selected study sites.

Summary

The limitations that affect the accuracy of the mathematical exercise used to define the surfaces, calculate the volume and convert volume to weight are manageable. The potential for variations can affect the estimates in either direction (e.g., overestimate or underestimate). As a result, for a high level approximation of licensed reserves for a group of sites the margin for error seems acceptable.

However, there remain a number of other limiting considerations that cast significant doubt on the usefulness of relying on site plan volumes as an indication of available supply. An estimate of the material that is within licensed extraction limits is not an estimate of a proven licensed reserve that can meet an anticipated demand for mineral aggregate products. Most of these considerations would tend to exaggerate or overestimate the actual proven reserve that is available and the degree of overestimation could be significant on a cumulative basis.

2.2 Remaining Reserves in Licensed Quarries

An estimate of remaining tonnage was developed for the 11 quarries using the methodology described in Section 2.1.2. The results indicate a total remaining reserve of 54 MT. Of this total, over 40% of the reserves are found in one quarry which is located a considerable distance from market. Only 268 MT of the total are considered new licensed supply since 2009 (49%).

The remaining reserves for the quarries in the 2009 SAROS Study total 2,688 MT (as of the end of 2008).

The total remaining reserves from the combined 2009 and 2016 studies is 3,233 MT (see Table 2.1).

**Table 2.1: Estimated Remaining Reserves in Selected Licensed Quarries
2009 SAROS Study and 2016 Study**

2009 SAROS Study	2,688 MT[1]
2016 Update	545 MT
Total 2009 and 2016 Studies	3,233 MT

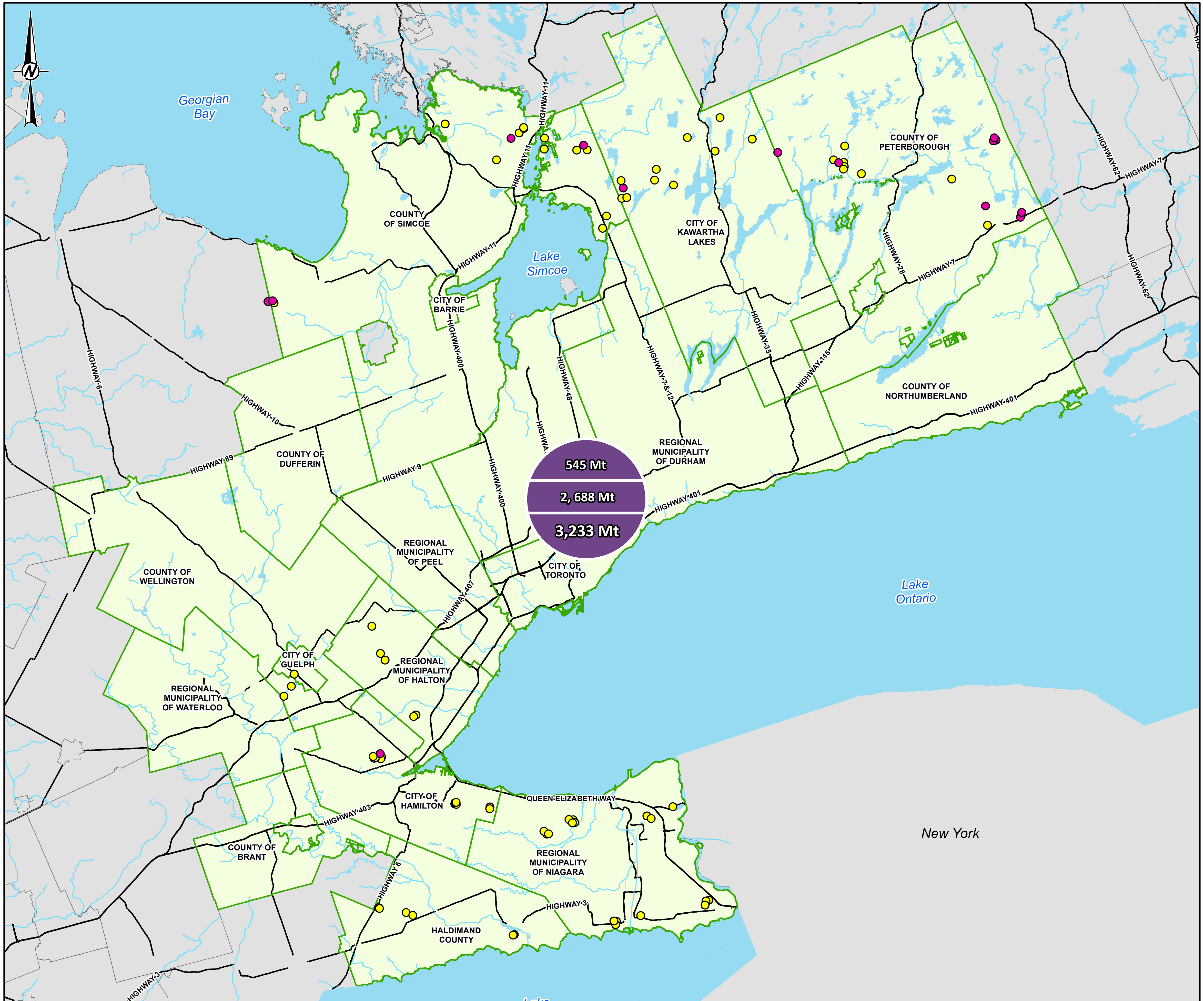
Note:

1 As at end of 2008. Not adjusted to a common date.

This gain in estimated reserves as a result of new licences issued is offset by ongoing production of limestone from GGH quarries. The estimated production from quarries is about half of the total aggregate produced in the GGH 2009 - 2015 or about 250 MT. So new licences issued over this period just kept pace with depletion rates as a result of ongoing production.

As a check on the method and reserve estimates for recently licensed sites research was completed to obtain reserve estimates that are prepared and reported by applicants as part of the licensing process. Information was found for eight of the nine new quarry licences that have been issued since 2009. The updated reserve estimates calculated through this exercise correlate well with the reserve estimates provided by the applicants and is within 5-10%. Some of this variation is explained by the production that has occurred since the quarries were licensed.

The total remaining reserves in these licensed quarries is shown on Figure 2-2.



LEGEND

- Licensed Quarry within GGH 2016 Study
- Licensed Quarry within GGH 2009 Study
- Major Roads
- Watercourse
- Waterbody
- Municipal Boundary
- Study Area Boundary

545 Mt — 2016 Estimated Stone Resource (million tonnes)

2,688 Mt — 2009 Estimated Stone Resource (million tonnes)

3,233 Mt — Total Estimated Stone Resource (million tonnes)

0 20 40 60 Kilometers

1:1,000,000

REFERENCE(S)

BASE DATA - MNRF LIO, OBTAINED 2016
PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES AND FORESTRY © QUEENS PRINTER 2016
UNLICENSED AND UNCONSTRAINED SELECTED BEDROCK REMAINING RESOURCE AREAS - ONTARIO GEOLOGICAL SURVEY 2016. AGGREGATE RESOURCES OF ONTARIO 2015; ONTARIO GEOLOGICAL SURVEY, AGGREGATE RESOURCES OF ONTARIO 2015. FEB/10/2016. MHBC, APRIL 2016
PROJECTION: ONTARIO MNR LAMBERT DATUM: NAD 83

CLIENT
MINISTRY OF NATURAL RESOURCES AND FORESTRY

PROJECT
SUPPLY AND DEMAND STUDY OF AGGREGATE RESOURCES SUPPLYING THE GREATER GOLDEN HORSESHOE

TITLE
ESTIMATED REMAINING RESERVES IN QUARRIES IN GGH STUDY AREA FROM SAROS 2009 STUDY IN 2016 STUDY

CONSULTANT: Golder Associates

YYYY-MM-DD	2016-08-18
DESIGNED	JMC/PR
PREPARED	JMC/PR
REVIEWED	SM
APPROVED	SM

PROJECT NO.	CONTROL	REV.	FIGURE
1540982		1	2-2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 0 25mm

2.2.1 Pit and Quarry Aggregate Quality

Much of the effort of the present study and previous efforts to evaluate licenced reserves has been focused on estimates of gross reserve quantities. However, the real issue is quality and it is much more difficult to get an accurate evaluation of availability of quality materials that are required to maintain and build Provincial infrastructure.

There is an increasing shortage of high quality crushed stone that is ‘close to market’. This includes high quality crushed stone for use in high strength concrete used for example in construction of major infrastructure projects using concrete. There is also an increasing shortage of ‘close to market’ crushed stone products for other uses in low to moderate strength concrete construction for use in residential, industrial, commercial and institutional developments. In addition, there is an increasing shortage in crushed stone for use in road building applications. There is a similar shortage in some areas of aggregate to produce crushed gravel products which may require stone for example of one inch or greater in diameter to permit crushing operations. This includes the shortages of gravel material in the southern portion of the GTA, with Regional Municipality of Niagara related to the depletion of the major source of gravel in the Fonthill area. There are also limited gravel resources in Haldimand County.

Aggregate reserves are required to meet a number of standardized specifications for use in such products as concrete and asphalt. Aggregate quality issues can be correlated with detailed site-specific geological information, but in many cases, such information is not generally publicly available.

A detailed differentiation of reserve quality was not made due to a lack of site-specific geological information for the limestone and dolostone quarries. Quality estimates of quarries were based on their location within known geological formations and the accompanying descriptions of those formations and their expected quality based on ARIP reports. The formation names below utilize the terminology in the ARIP reports (and not the updated OGS terminology).

In the 2009 study, the overall calculated reserves of stone may be divided into four categories including ‘high’ (concrete and asphalt stone), ‘acceptable’ (for road base), ‘low’ (backfill only), and ‘unknown’ based on stone quality (as for the 2009 SAROS Project). High quality stone was based on the proportions (or depths) of generally recognized high quality geologic strata. The following formations were considered to be high quality as to be expected as they were included in ARIP papers as a selected bedrock resource. The Amabel Formation, Bobcaygeon Formation, the upper and lower units of the Gull River Formation, (excluding the alkali reactive green beds of the middle unit), units of the Lockport Formation and units of the Bertie Formations were considered to represent high quality aggregate sources. The Guelph Formation is considered to have a variable quality in the ARIP reports. The Bois Blanc Formation, for example, is categorized as acceptable stone for aggregate use but low quality for use in concrete due to the presence of chert. However, it should be noted that blending selective extraction and/or beneficiation by further processing can enable lower quality stone to meet higher specifications in some cases. As this is an update to the 2009 SAROS Study, the quality of the formations are the same as the initial study. A general description of these formations and the quality issues associated with them is provided on the following table. More detailed descriptions can be found in the ARIP reports.

Table 2.2: Bedrock Formation Quality in Relation to Aggregate Production

Formation Name	Brief Description	Quality Issues	Expected End Products
Bertie	Medium to massive bedded brown dolostone with shale partings.	Shaley intervals are unsuitable for use as high specification aggregate because of low freeze-thaw durability. Certain units can make higher end-products.	Granular road base products and certain units can make concrete and asphalt grade aggregate.
Bois Blanc	Brownish grey, medium-crystalline, medium to thin-bedded cherty limestone, commonly fossiliferous with shaley, partings and minor interbedded dolostone.	Basically unsuitable for concrete aggregate due to high chert content.	Road base granular aggregates.
Lockport (Eramosa), Goat Island, Gosport	Bituminous dolostone with shale partings and variable chert bands and lenses.	Some areas are soft and unsuitable for use in the production of load-bearing aggregate, requiring additional testing. Certain units will make higher end products. Goat Island contains chert in Ancaster-Dundas-Hamilton Area.	Certain units suitable for concrete and asphalt grade stone while others just suitable for granular road base and lime.
Gull River	Upper Member is thin to thickly bedded, interbedded, grey argillaceous limestone and buff to green dolostone. Lower Member is dense limestone with microcrystalline, interbedded dolostone	Certain layers are considered alkali-reactive.	Concrete and asphalt grade aggregate.
Amabel	Massive, fine crystalline dolostone with reef facies and occasional shale partings and variable chert bands and lenses.	None.	Lime, concrete and asphalt aggregate, building dimension stone.
Guelph	Medium crystalline, thickly bedded to massive, porous, vuggy, fossiliferous dolostone.	Variable quality.	Lime, chemical uses.
Bobcaygeon	Thin to medium bedded, fine-grained crystalline limestone with the middle member containing numerous	Certain layers are considered alkali-reactive.	Granular road base aggregate, with some units being suitable for concrete and asphalt grade aggregate.

Formation Name	Brief Description	Quality Issues	Expected End Products
	argillaceous and shaley partings.		
Onondaga	Medium bedded, biostromal and biohermal, argillaceous and fossiliferous limestone with occasional chert nodules.	High chert content makes much of the material unsuitable for concrete aggregate, asphalt,	Granular road base, building dimension stone.

The reserve calculations that were carried out for the quarries evaluated in this study are total tonnage of stone remaining on site that is licensed within the current extraction area of each of the properties. This volume/tonnage calculation includes all ranges of quality, and does not distinguish the availability of higher quality reserves versus lower quality reserves. As such, the quality estimates for their reserves is based solely on their location with respect to available geological mapping from ARIPs, OGS mapping and the generalized description of quality with respect to aggregate production provided in those documents.

There is very little to no ‘waste’ generated in most sites that produce an asphalt grade stone. There is however a high percentage of lower value/end use by-products that result. One of the by-products resulting from this process is a ‘screening’ product that has been used by many producers to generate a manufactured sand that can also be included in the production of concrete and asphalt. Between the actual production of concrete/asphalt grade stone and manufactured sand, a maximum two-thirds (67%) of a single tonne of ‘high’ quality stone can be considered for use in higher end applications. The remaining third (33%) may be used for a lower end by-product such as granular road base.

Considering the total resource base that was calculated, it is important to understand that not all of these reserves are not comprised of high quality stone suitable for use in concrete. In addition, only a portion of higher quality reserves will be available to the GGH market.

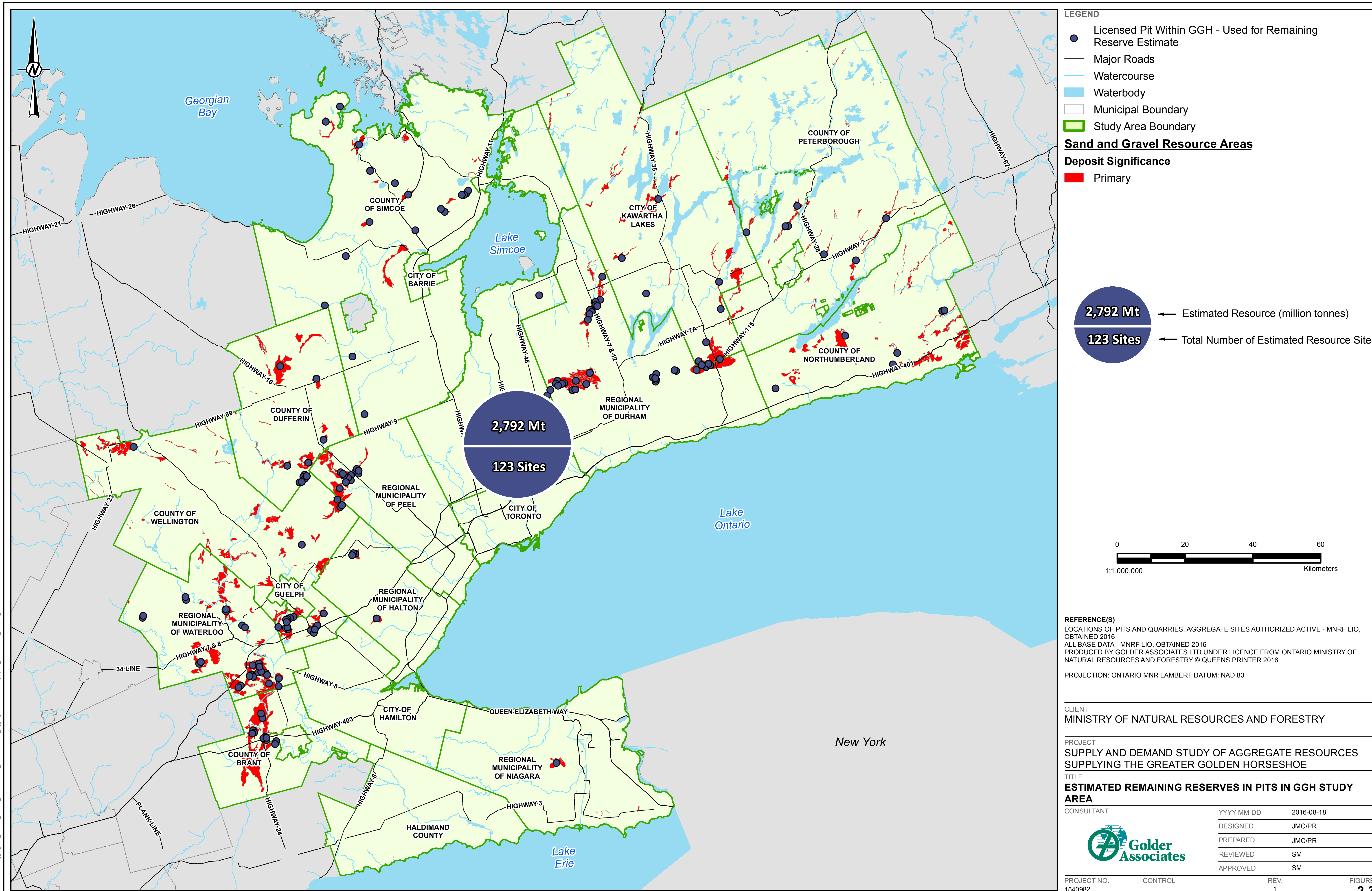
2.3 Remaining Reserves in Licensed Pits

The remaining reserves for the 123 pits were estimated using the methodology described in Section 2.1.2. The total potential estimated tonnage of resource that might be available in these pits is 2,792 MT as shown on Figure 2-3.

As noted above, there are a number of limiting considerations that cast significant doubt on the usefulness of relying on site plan volumes as an indication of available supply. Many of these considerations would tend to exaggerate or overestimate the actual proven reserve that is available and the degree of overestimation could be significant on a cumulative basis.

In an attempt to understand the significance of these limitations the study included communication with licensees for selected larger reserve pit licences to compare the study reserve estimates with the licensee’s own information. This revealed significant discrepancies that highlight the magnitude of the limitations and likelihood that this method will significantly over estimate or exaggerate the amount of resource that is actually available. In several examples the study method estimated potential resource exceeded the licensee's estimates by several times. It should also be noted that the reserve estimates from this study are considerable higher than several earlier studies as previously discussed.

Accordingly, there is quite a high degree of uncertainty associated with the licence reserve estimates provided and the results should not be taken as a very realistic indication of what resource may actually be available in licenced sites.



LEGEND
Licensed Pit Within GGH - Used for Remaining Reserve Estimate
Major Roads
Watercourse
Waterbody
Municipal Boundary
Study Area Boundary
Sand and Gravel Resource Areas
Deposit Significance
Primary
2,792 Mt
123 Sites
Estimated Resource (million tonnes)
Total Number of Estimated Resource Sites
0
20
40
60
1:1,000,000
Kilometers
Georgian Bay
Lake Simcoe
Lake Ontario
Lake Erie
New York
COUNTY OF SIMCOE
CITY OF BARRIE
CITY OF KAWARTHA LAKES
COUNTY OF PETERBOROUGH
COUNTY OF NORTHUMBERLAND
REGIONAL MUNICIPALITY OF DURHAM
COUNTY OF DUFFERIN
REGIONAL MUNICIPALITY OF PEEL
CITY OF TORONTO
COUNTY OF WELLINGTON
CITY OF GUELPH
REGIONAL MUNICIPALITY OF HALTON
REGIONAL MUNICIPALITY OF WATERLOO
COUNTY OF BRANT
CITY OF HAMILTON
REGIONAL MUNICIPALITY OF NIAGARA
HALDIMAND COUNTY
HIGHWAY-21
HIGHWAY-26
HIGHWAY-11
HIGHWAY-35
HIGHWAY-62
HIGHWAY-28
HIGHWAY-7
HIGHWAY-7-&-12
HIGHWAY-7A
HIGHWAY-115
HIGHWAY-401
HIGHWAY-48
HIGHWAY-10
HIGHWAY-89
HIGHWAY-9
HIGHWAY-23
HIGHWAY-7 & 8
34 LINE
HIGHWAY-8
HIGHWAY-403
QUEEN ELIZABETH WAY
HIGHWAY-6
HIGHWAY-3
HIGHWAY-24
PLANK LINE
REFERENCE(S)
LOCATIONS OF PITS AND QUARRIES, AGGREGATE SITES AUTHORIZED ACTIVE - MNRF LIO, OBTAINED 2016
ALL BASE DATA - MNRF LIO, OBTAINED 2016
PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES AND FORESTRY © QUEENS PRINTER 2016
PROJECTION: ONTARIO MNR LAMBERT DATUM: NAD 83
CLIENT
MINISTRY OF NATURAL RESOURCES AND FORESTRY
PROJECT
SUPPLY AND DEMAND STUDY OF AGGREGATE RESOURCES SUPPLYING THE GREATER GOLDEN HORSESHOE
TITLE
ESTIMATED REMAINING RESERVES IN PITS IN GGH STUDY AREA
CONSULTANT
YYYY-MM-DD 2016-08-18
DESIGNED JMC/PR
PREPARED JMC/PR
REVIEWED SM
APPROVED SM
Golder Associates
PROJECT NO. 1540982
CONTROL
REV. 1
FIGURE 2-3

2.4 Resources with Distance from Vaughan Metropolitan Centre Reference Point

The GGH study area has been subdivided into five areas (Areas 1-5) within concentric circles (distance areas) that are set back in increments of 50 km from the Vaughan Metropolitan Centre reference point as follows:

- Distance Ring 1 encompasses lands within 0 to 50 km from the Vaughan Metropolitan Centre;
- Distance Ring 2 encompasses lands within 50 to 100 km from the Vaughan Metropolitan Centre;
- Distance Ring 3 encompasses lands within 100 to 150 km from the Vaughan Metropolitan Centre;
- Distance Ring 4 encompasses lands within 150 to 200 km from the Vaughan Metropolitan Centre; and
- Distance Ring 5 encompasses lands within 200 km from the Vaughan Metropolitan Centre to the boundary of the Study area.

The remaining reserve tonnages for the licensed quarries and pits for each of the geographic area was calculated using GIS for:

- 2009 SAROS Study – Potential Remaining Resources for Quarries Within GGH Study Area.
- 2016 Study – Potential Remaining Resource in 11 Licensed Quarries.
- 2016 Study – Potential Remaining Resources in Selected Licensed Pits.

The remaining resources for the licensed pits and quarries in this study are summarized on Table 2.3 and shown on Figure 2-4.

LEGEND

- Vaughan Metropolitan Centre (VMC)
- Licensed Quarry Within GGH 2009 Study
- Licensed Quarry Within GGH 2016 Study
- Licensed Pit Within GGH 2016 Study
- Major Roads
- Watercourse
- Waterbody
- Municipal Boundary
- Study Area Boundary

50-100 km	Distance Ring
1,644 Mt	Total Estimated Resource for Quarries (2009 Study)
175 Mt	Total Estimated Resource for Quarries (2016 Study)
1,610 Mt	Total Estimated Resource for Pits (2016 Study)

DISTANCE FROM VAUGHAN METROPOLITAN CENTRE (VMC) AND WITHIN GGH

Distance Ring	Estimated Remaining Resource in Quarries in 2009 Study (Million Tonnes)	Estimated Remaining Resources in Quarries 2016 Study (Million Tonnes)	Estimated Remaining Resources in Pits 2016 Study (Million Tonnes)
0 - 50 km	108	-	939
50 -100 km	1,644	175	1,610
100-150 km	936	93	243
150-200 km	-	277	-
Total	2,688	545	2,792

0 20 40 60

1:1,000,000 Kilometers

REFERENCE(S)
LOCATIONS OF PITS AND QUARRIES , AGGREGATE SITES AUTHORIZED ACTIVE - MNRF LIO, OBTAINED 2016
ALL BASE DATA - MNRF LIO, OBTAINED 2016
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PROJECTION: ONTARIO MNR LAMBERT DATUM: NAD 83

CLIENT
MINISTRY OF NATURAL RESOURCES AND FORESTRY

PROJECT
SUPPLY AND DEMAND STUDY OF AGGREGATE RESOURCES SUPPLYING THE GREATER GOLDEN HORSESHOE

TITLE
ESTIMATED REMAINING RESERVES IN QUARRIES AND PITS RELATIVE TO VAUGHAN METROPOLITAN REFERENCE CENTRE

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-08-18
DESIGNED	JMC/PR
PREPARED	JMC/PR
REVIEWED	SM
APPROVED	SM

PROJECT NO.	CONTROL	REV.	FIGURE
1540982		1	2-4

Table 2.3: Remaining Reserves in Licensed Quarries and Pits with Distance from Vaughan Reference Point

Distance (km)	Potential Remaining Reserves in selected Quarries 2009 SAROS Study (MT)	Potential Remaining Reserves in additional Quarries 2016 Study (MT)	Potential Remaining Reserves in selected Pits 2016 Study (MT)
0 – 50 km	108	-	939
50 – 100 km	1,644	175	1,610
100 – 150 km	936	93	243
150 – 200 km	-	277	-
Total	**2,688**	**545**	**2,792**

Note: refers to pits and quarries including 2009 SAROS Study and this 2016 study.

As indicated in Table 2.3, there is an estimated 2,549 MT within a 100 km of the Vaughan Reference Point. There is only an estimated 108 MT of remaining reserves in quarries within 50 km of the Vaughan Reference Point. The highest amount of remaining potential reserves occurs within 50 – 100 km, comprised of an estimated 3,429 MT of which 1,819 MT is in quarries and 1,610 MT is in pits.

2.5 Unconstrained and Unlicensed Resources

The following provides an estimation of unlicensed and unconstrained Selected Bedrock Resources and Primary Sand and Gravel Resources in the GGH Study Area.

2.5.1 Unlicensed and Unconstrained Bedrock Resources

The following methodology was used to evaluate the unlicensed and unconstrained Bedrock Resource Areas and resource calculations:

The Selected Bedrock Resource areas were derived from the constraint analysis (see Section 3.0 for an explanation of these areas which may not necessarily be available as there are numerous other site specific and unmapped factors that need to be considered before a resource can be licensed and extracted).

- The Selected Bedrock Areas were overlain on the ARIP Selected Bedrock Resource Area mapping to assess their geological formations.
- A thickness was assigned based on reviewed ARIP reports, site plans and knowledge of the project team.
- A tonnage per hectare was calculated by multiplying the thickness by the area and multiplying this by a density factor of 2.75 kg/m^3 (as for the 2009 SAROS report) to yield the estimated tonnages per hectare.

The location of these areas is shown on Figure 2-5.

The total area of unlicensed and unconstrained Selected Bedrock Resources in the GGH study area is 7,607.5 ha.

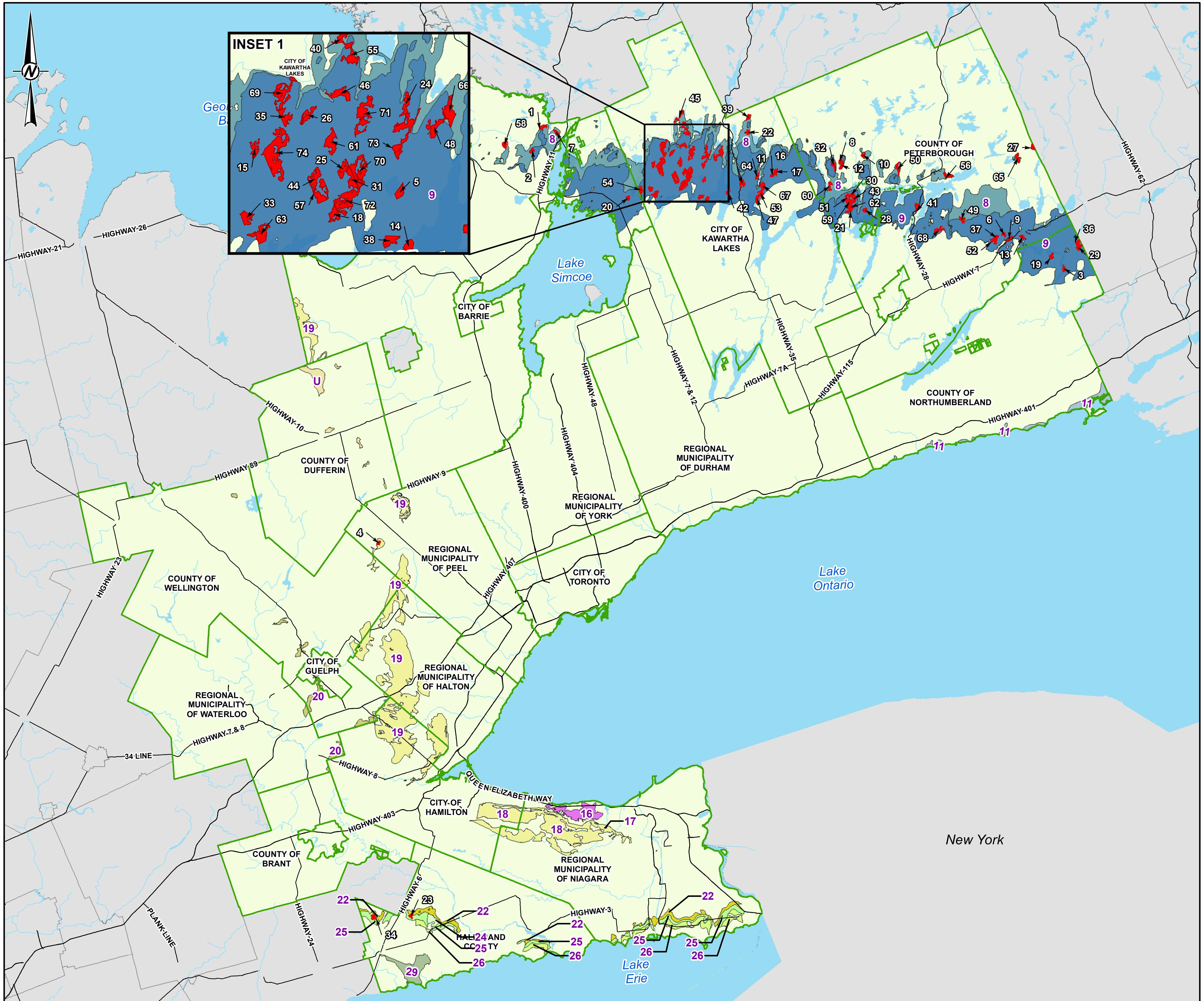
The unconstrained and unlicensed Selected Bedrock Areas are situated within the Bobcaygeon and Gull River Formations in the northeastern portion of the GGH Study Area (see Figure 2-5). There is a very small area of Amabel Formation situated in the central area of the GGH. There are also isolated exposures of the Bertie and Bois Blanc Formations in the South GGH. The approximate range in the thickness for the Selected Bedrock Resource Areas and the potential tonnage per hectare is indicated in Table 2.4.

Table 2.4: Estimated Tonnages per Hectare for Unconstrained and Unlicensed Selected Bedrock Resources

Area ID	Area (Ha)	Estimated Tonnage Per Hectare (tonnes)
1	60.24	247,500
2	60.27	742,500
3	60.30	990,000
4	60.53	825,000
5	60.89	742,500
6	61.10	495,000
7	61.14	247,500
8	61.60	495,000
9	62.32	495,000
10	64.29	495,000
11	64.65	247,500
12	65.26	495,000
13	65.58	495,000
14	66.72	990,000
15	67.09	742,500
16	67.53	990,000
17	68.31	990,000
18	68.74	990,000
19	72.19	990,000
20	72.47	990,000
21	72.91	990,000
22	73.09	247,500
23	73.23	330,000
24	74.85	990,000
25	74.99	742,500
26	75.82	742,000
27	76.96	495,000
28	77.86	990,000
29	78.78	990,000
30	80.01	990,000

Area ID	Area (Ha)	Estimated Tonnage Per Hectare (tonnes)
31	80.47	990,000
32	82.85	495,000
33	84.76	742,500
34	85.29	330,000
35	85.50	742,500
36	88.41	990,000
37	90.01	990,000
38	90.37	990,000
39	90.54	247,500
40	91.04	247,500
41	91.24	990,000
42	93.82	742,500
43	97.60	990,000
44	98.86	990,000
45	101.29	247,500
46	102.61	742,500
47	102.95	742,500
48	103.46	742,500
49	103.79	495,000
50	104.93	495,000
51	106.19	990,000
52	107.67	990,000
53	108.53	742,500
54	110.13	742,500
55	111.44	
56	112.41	
57	114.78	990,000
58	119.35	247,500
59	119.42	990,000
60	123.12	495,000
61	127.02	742,500
62	129.39	990,000
63	129.62	990,000
64	137.27	742,500
65	140.65	495,000
66	143.16	247,500

Area ID	Area (Ha)	Estimated Tonnage Per Hectare (tonnes)
67	150.28	742,500
68	153.10	990,000
69	178.59	247,500
70	180.42	742,500
71	207.49	742,500
72	220.08	742,500
73	221.42	742,500
74	436.43	742,500



LEGEND

- Major Roads
- Watercourse
- Waterbody
- Study Area Boundary
- Unlicensed and Unconstrained ARIP Selected Bedrock Remaining Resources within GGH

Paleozoic Bedrock Formation - Selected Bedrock

- 8: Gull River
- 9: Bobcaygeon
- 11: Lindsay
- 16: Queenston
- 17: Clinton-Cataract Group
- 18: Lockport
- 19: Amabel
- 20: Guelph
- 22: Bertie
- 24: Oriskany
- 25: Bois Blanc
- 26: Onondaga
- 29: Dundee
- U: Unsubdivided Goat Island and Gasport Fm

0 20 40 60
1:1,000,000 Kilometers

NOTE(S)

1. GEOLOGICAL UNIT NUMBER CAPTURED FROM SYMBOLOGY USED IN THE PALEOZOIC GEOLOGY OF SOUTHERN ONTARIO, ONTARIO MINISTRY OF NORTHERN DEVELOPMENT AND MINES, ONTARIO GEOLOGICAL SURVEY, MISCELLANEOUS RELEASE—DATA 219, JUNE 2007. UNSUBDIVIDED GOAT ISLAND AND GASPORT FM FORMATION UNIT NUMBER NOT FOUND IN SYMBOLOGY UNDER MRD219 AND SYMBOLIZED AS "U" FOR THIS FIGURE. BEDROCK FORMATION REFERENCED IN THIS FIGURE REMAINS AS ONTARIO GEOLOGICAL SURVEY 2015-2016.

REFERENCE(S)

BASE DATA - MNRF LIO, OBTAINED 2016
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PALEOZOIC BEDROCK FORMATION - ONTARIO GEOLOGICAL SURVEY 2016. AGGREGATE RESOURCES OF ONTARIO 2015; ONTARIO GEOLOGICAL SURVEY, AGGREGATE RESOURCES OF ONTARIO 2015. FEB/10/2016

UNLICENSED AND UNCONSTRAINED SELECTED BEDROCK REMAINING RESOURCE AREAS - ONTARIO GEOLOGICAL SURVEY 2016. AGGREGATE RESOURCES OF ONTARIO 2015; ONTARIO GEOLOGICAL SURVEY, AGGREGATE RESOURCES OF ONTARIO 2015. FEB/10/2016. MHBC, APRIL 2016

PROJECTION: ONTARIO MNR LAMBERT DATUM: NAD 83

CLIENT
MINISTRY OF NATURAL RESOURCES AND FORESTRY

PROJECT
SUPPLY AND DEMAND STUDY OF AGGREGATE RESOURCES SUPPLYING THE GREATER GOLDEN HORSESHOE

TITLE
UNLICENSED AND UNCONSTRAINED AREAS OF SELECTED BEDROCK REMAINING RESOURCES IN RELATION TO BEDROCK FORMATIONS IN GGH

CONSULTANT: Golder Associates

YYYY-MM-DD	2016-08-18
DESIGNED	JMC/PR
PREPARED	JMC/PR
REVIEWED	SM
APPROVED	SM

PROJECT NO.	CONTROL	REV.	FIGURE
1540982		1	**2-5**

25mm IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

2.5.2 Unlicensed and Unconstrained Sand and Gravel Resources

The following methodology was used in the evaluation of the unlicensed sand and gravel resource calculations:

The unconstrained and unlicensed ARIP Primary Sand and Gravel resources were derived from the constraint analysis (see Section 3.0 for an explanation of these areas which may not necessarily be available as there are numerous other site specific and unmapped factors that need to be considered before a resource can be licensed and extracted.

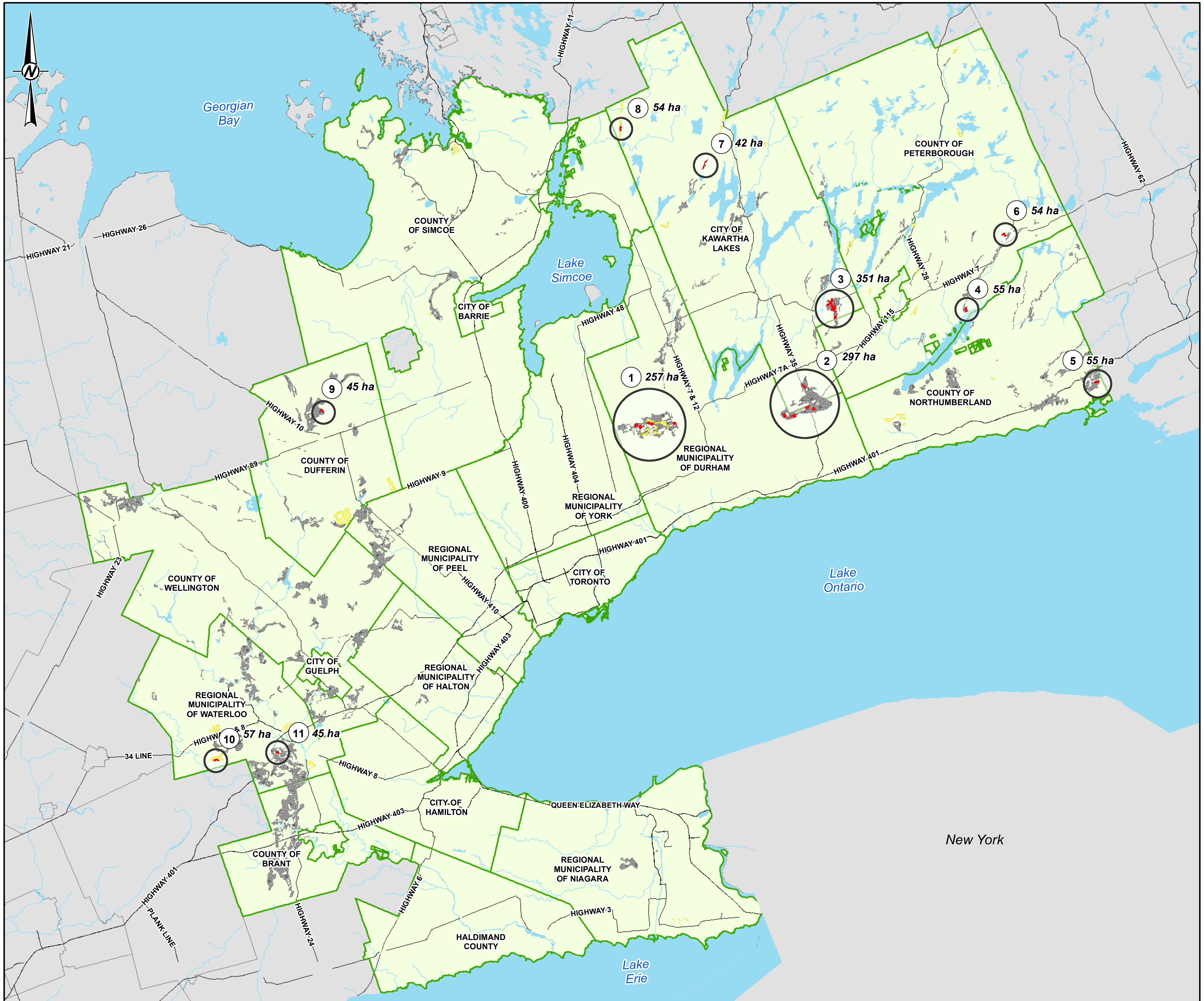
- The resource areas were identified containing larger areas of unconstrained and unlicensed deposits.
- The thickness of these resource areas were estimated based on ARIP reports, site plans as well as knowledge of the project team.
- The thickness of the resource areas was then multiplied by a density factor of 1.77 kg/m^3 to yield the estimated tonnage per hectare.

The unlicensed and unconstrained primary sand and gravel deposits are shown on Figure 2-6. The thicknesses of these resource areas was estimated using information from the ARIP reports, site plans of pits in these areas and experience of the project team with sites in these areas. The approximate thickness and estimated potential tonnage per hectare for these resource areas are indicated in Table 2.5.

Table 1: Estimated Tonnage per Hectare for Unconstrained and Unlicensed Sand and Gravel Resources

Area ID	Area (ha)	Estimated Tonnes per Hectare
Area 1	51.09	141,600 - 318,600
Area 1	54.68	141,600 - 318,600
Area 1	59.3	141,600 - 318,600
Area 1	92.22	141,600 - 318,600
Area 2	50.48	141,600 - 318,604
Area 2	50.99	141,600 - 318,600
Area 2	58.99	141,600 - 318,600
Area 2	66.99	141,600 - 318,600
Area 2	69.88	141,600 - 318,600
Area 3	42.78	354,000 - 619,500
Area 3	65.98	70,800 - 194,700
Area 3	112.06	106,200 - 177,000
Area 3	130.17	106,200 - 177,000
Area 4	54.78	106,200 - 177,000
Area 5	21.41	106,200 - 177,000

Area ID	Area (ha)	Estimated Tonnes per Hectare
Area 5	33.9	106,200 - 177,000
Area 6	53.78	106,200 - 177,000
Area 7	41.85	53,000 - 106,200
Area 8	53.68	160,200 - 177,000
Area 9	45.3	160,200 - 177,000
Area 10	57.53	160,200 - 177,000
Area 11	45.09	160,200 - 177,000



LEGEND

- Major Roads
- Watercourse
- Waterbody
- Municipal Boundary
- Study Area Boundary
- Unlicensed and Unconstrained Primary ARIP Sand and Gravel Remaining Resources within GGH
- Unlicensed and Unconstrained Primary ARIP Sand and Gravel Area with ID (1) and Area in Hectares *55 ha*

Unlicensed Primary ARIP Deposit

Deposit Material

- Unlicensed Primary Gravel Deposit
- Unlicensed Primary Sand Deposit

0 20 40 60
1:1,000,000 Kilometers

REFERENCE(S)

LOCATIONS OF PITS AND QUARRIES, AGGREGATE SITES AUTHORIZED ACTIVE - MNRF LIO, OBTAINED 2016
ALL BASE DATA - MNRF LIO, OBTAINED 2016
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SAND AND GRAVEL RESOURCE AREAS FROM ONTARIO GEOLOGICAL SURVEY 2016. AGGREGATE RESOURCES OF ONTARIO 2015; ONTARIO GEOLOGICAL SURVEY, AGGREGATE RESOURCES OF ONTARIO 2015. FEB/10/2016

PROJECTION: ONTARIO MNR LAMBERT DATUM: NAD 83

CLIENT
MINISTRY OF NATURAL RESOURCES AND FORESTRY

PROJECT
SUPPLY AND DEMAND STUDY OF AGGREGATE RESOURCES SUPPLYING THE GREATER GOLDEN HORSESHOE

TITLE
UNLICENSED AND UNCONSTRAINED AREAS OF PRIMARY SAND AND GRAVEL REMAINING RESOURCES BY DEPOSIT MATERIAL IN GGH

CONSULTANT
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DESIGNED	JMC/PR
PREPARED	JMC/PR
REVIEWED	SM
APPROVED	####

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2.6 Summary of the Material Supply

The following conclusions are provided based on the results of the study.

While potential reserves exist in many parts of the Province there are concerns about scarcity of certain products in close to market locations that will lead to increased costs and environmental impacts associated with increased haul distance.

1) The remaining reserves of the 11 licensed quarries examined in this study are 545 MT. Only 268 MT of this total are from new licences issued since 2009 (49%).

2) This gain in estimated reserves as a result of new licences issued is offset by ongoing production of limestone from GGH quarries. The estimated production from quarries is about half of the total aggregate produced in the GGH 2009 - 2015 or about 250 MT. So new licences issued over this period just kept pace with depletion rates as a result of ongoing production.

3) The remaining reserves in the quarries included in the 2009 SAROS Study that are in the GGH study area are 2,688 MT. The total remaining reserves in the quarries in the 2009 and 2016 update are 3,233 MT.

4) There are a number of limiting considerations that cast significant doubt on the usefulness of relying on site plan volumes as an indication of available supply. While the study estimates potential remaining reserves of 2,792 MT might be available in 123 selected licensed pits there is quite a high degree of uncertainty associated with this estimate and the results should not be taken as a very realistic indication of what resource may actually be proven and made available from these licenced sites.

5) The total estimated remaining reserves in pits and quarries in the distance rings relative to the Vaughan reference point are as follows:

Distance Ring	Quarries	Pits
0 – 50 km	108	939
50 – 100 km	1,819	1,610
100 – 150 km	1,029	243
150 – 200 km	277	-

2.7 Recommendations

This portion of the study has presented a thorough review of the limitations that apply to a desktop evaluation of licenced reserves based on site plans, topography and aerial photo interpretation. Some of these limitations are, in a practical sense, irresolvable. However, if the MNRF sees value in working towards further more accurate updates of licenced reserves the following recommendations for future work on material supply analysis are provided:

1) continuing the resource evaluation for the remaining pits and quarries not included in this study or the previous 2009 SAROS study to refine the estimates of remaining reserves.

2) update the resource estimates of the pits and quarries evaluated to date, when more recent topographic mapping becomes available to refine the accuracy of the estimates.

3) A field verification program to ground truth and ‘prove’ the remaining licensed reserves estimates.

3.0 CONSTRAINT 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 licensing 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, agricultural land and water features.

To determine the extent of overlap between identified aggregate resource deposits and known environmental, agricultural and social constraints a Geographic Information System-based (GIS) mapping analysis was completed for the GGH and 100 km surrounding the GGH.

The mapping analysis examined the following mineral aggregate deposits area relative to 32 identified constraints:

- selected bedrock resource area;
- primary sand and gravel resource areas; and
- secondary sand and gravel resource areas.

The 32 environmental, agricultural and social constraints were identified based on a review of existing land uses, the Provincial Policy Statement, Niagara Escarpment Plan, Greenbelt Plan, Oak Ridges Moraine Conservation Plan, Regional Official Plans, Conservation Authority Regulated Areas and were separated by:

- pre-emptive land uses / constraints;
- very serious constraints; and
- competing land uses.

The purpose of this analysis is to determine the extent of overlap between known environmental, agricultural and social constraints 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 or are not 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.

This mapping analysis builds on the work that was completed by MHBC and Golder on behalf of the Province in 2009, as part of the State of the Aggregate Resources in Ontario Study (Paper 2).

3.2 Study Region

The Study Region is composed of lands within the GGH and lands within 100 km of the GGH. This study area represents an expansive area of approximately 12,770,334 ha, and includes much of Southern Ontario. The outer boundary of the study area extends to the City of Kingston to the east, the District of Parry Sound to the north and the County of Lambton to the west.

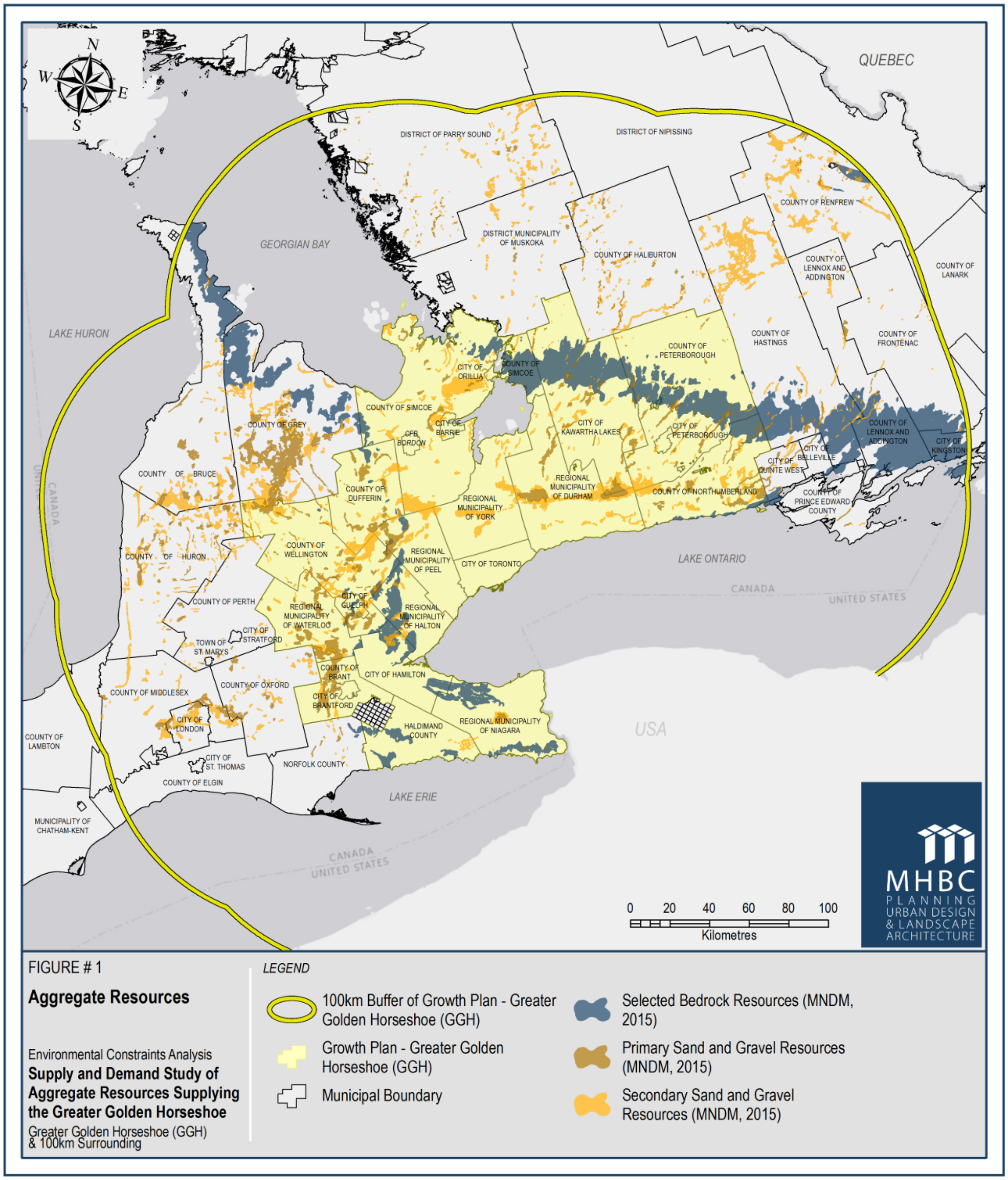


Figure 3-1: Study Region

Due to the size of the study area, the reporting has been broken down into five study areas to provide the results based on proximity to the Vaughan Metropolitan Centre. The Vaughan Metropolitan Centre was also utilized as a central location in the 2009 State of the Aggregate Resources in Ontario Study.

The five study areas are concentric circles that are setback in increments of 50 km from the Vaughan Metropolitan Centre.

- Study Area 1 encompasses lands within 0 to 50 km from the Vaughan Metropolitan Centre;
- Study Area 2 encompasses lands within 50 to 100 km from the Vaughan Metropolitan Centre;
- Study Area 3 encompasses lands within 100 to 150 km from the Vaughan Metropolitan Centre;
- Study Area 4 encompasses lands within 150 to 200 km from the Vaughan Metropolitan Centre;
- Study Area 5 encompasses lands within 200 km from the Vaughan Metropolitan Centre and the remainder of the Study Region.

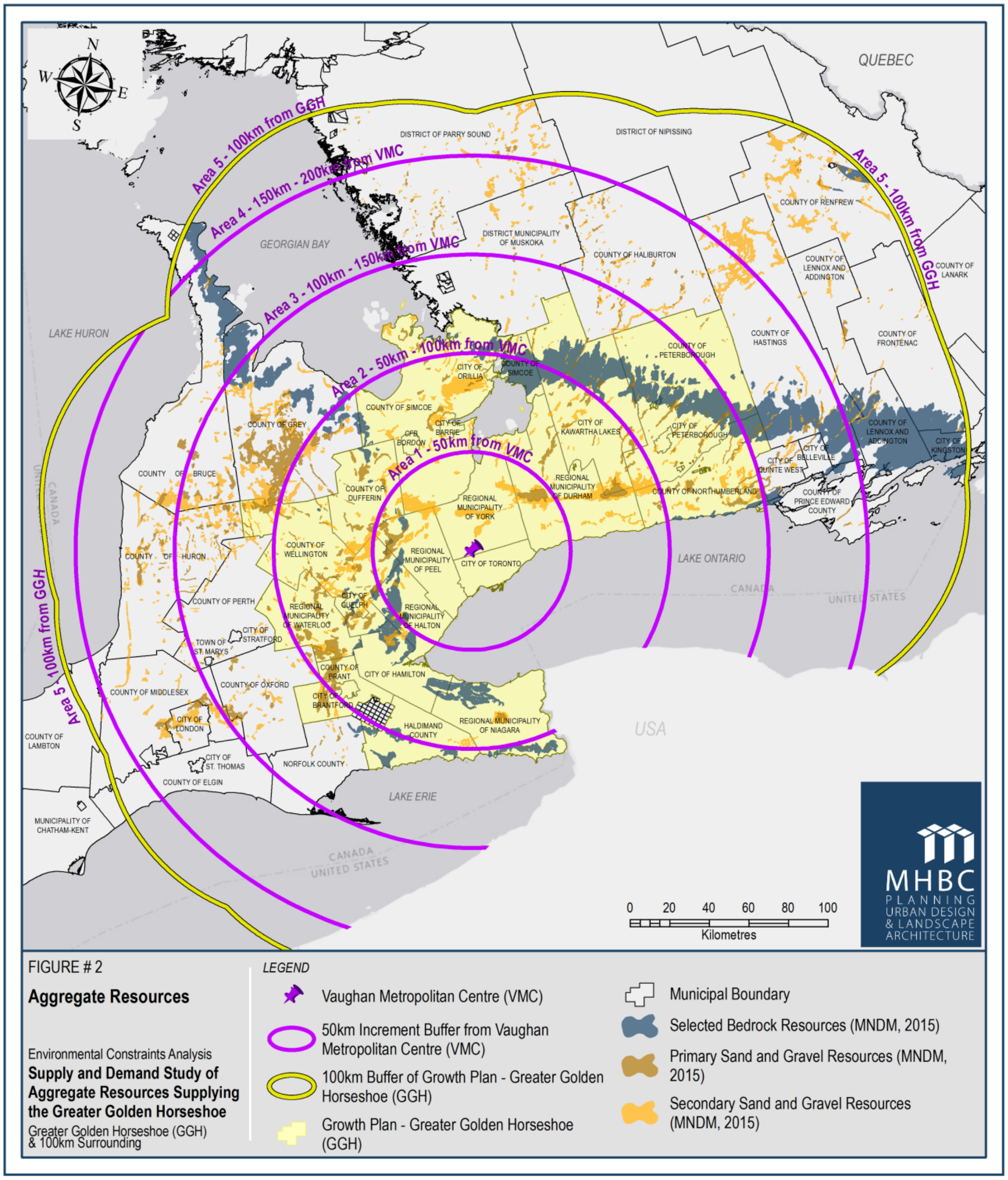


Figure 3-2: Study Areas

3.3 Methodology

A GIS-based mapping analysis was completed for the selected bedrock resources, primary sand and gravel resources, and secondary sand and gravel resources throughout the study region. The purpose of this analysis was to determine the extent of overlap between known environmental, agricultural and social constraints and the identified aggregate resource areas.

The aggregate resource area mapping used in this analysis was obtained as a consolidated dataset from the Ministry of Northern Development and Mines (MNDM), compiled from the 2015 ARIP data. The aggregate resource areas are summarized as follows:

- Selected bedrock resource areas include all bedrock formations that contain appropriate limestone/dolostone bedrock formations suitable for extraction and have less than 8 m of overburden. The quality and quantity of the aggregate within selected resource areas varies throughout Southern Ontario and the high quality bedrock is the Amabel Formation which is located primarily within the Niagara Escarpment Plan.
- Primary and secondary sand and gravel resource areas include sand and gravel deposits of sufficient quality and quantity for usefulness as a construction aggregate. The primary resource areas are typically of higher quality thickness with a greater stone content than the other two resource areas (secondary and tertiary).

These aggregate resource areas are predominately geological maps and there are numerous other factors that need to be considered to assess the viability of an aggregate area to be approved for aggregate extraction.

Based on a review of existing land uses, the Provincial Policy Statement, Niagara Escarpment Plan, Greenbelt Plan, Oak Ridges Moraine Conservation Plan, Regional Official Plans, Conservation Authority Regulated Areas 32 known constraints were identified. These constraints were separated by:

- pre-emptive land uses / constraints;
- very serious constraints; and
- competing land uses.

The constraints were applied cumulatively to the identified resource areas to avoid double counting of constraints. The order of constraints summarized below generally reflects a hierarchy starting with the more preclusive constraints to the least restrictive based on policy considerations. After applying all of the constraints fragmented resource areas were then removed and the remaining aggregate areas (i.e., unconstrained) were identified.

Pre-Emptive Land Uses / Constraints

- Existing Aggregate Licences including surrendered and revoked licences;
- Urban Areas;
- Canadian Forces Base;
- First Nations Reserves;
- Roadways (plus 30 m buffer each side);
- Railways (plus 15 m buffer each side);
- Parks and Recreation Areas (e.g., Public Lands, Conservation Area);
- NEC Escarpment Natural Area;
- NEC Escarpment Protection Area;
- ORMCP Natural Core Area;

- Specialty Crop Areas within the Greenbelt Plan between Lake Ontario and NEP; and
- Significant Wetlands / Significant Coastal Wetlands

Very Serious Constraints

- ORMCP Linkage Area (only above water extraction is permitted);
- ANSI Life Science;
- ANSI Life Science Candidates;
- ANSI Earth Science;
- ANSI Earth Science Candidates;
- Potential Significant Woodlands within EcoRegions 6E & 7E (within the GTA, Hamilton, Niagara, Haldimand, Brant, Brantford, Norfolk, Oxford, Perth, Stratford, St. Marys, Huron, Middlesex, London, St. Thomas, Elgin, and Lambton >1ha. Within the remainder of EcoRegions 6E & 7E >4ha. North of EcoRegions 6E & 7E significant woodlands are not considered a constraint);
- Alvars;
- Sand Barrens, Savannahs and Tallgrass Prairies;
- Watercourses (assumed 5 m width);
- Waterbodies;
- Wetlands that are not significant wetlands or significant coastal wetlands;
- Significant Ecological Area;
- Reserve and Wildlife Areas; and
- Regional Natural Heritage Systems, where provided and mapped beyond the above-noted constraints.

Competing Land Uses

- 30 m buffers applied to the above noted natural features;
- Conservation Authority Regulated Areas, where provided and mapped beyond the above-noted constraints;
- Other Specialty Crop Areas;
- Prime Agricultural Lands (CLI Class 1,2,3); and
- Prime Agricultural Areas in Regional Plans, where provided and mapped beyond Prime Agricultural Lands

Fragmented Aggregate Resource Areas

Fragmented aggregate resource areas are considered, resource areas that became fragmented based on the location of the above-noted constraints. The original work plan approved by the Province defined fragmented resource areas as areas smaller than 75 ha for bedrock and smaller than 50 ha for sand and gravel resource areas.

These areas were further revised to 60 ha for bedrock areas and 40 ha for sand and gravel deposits to be consistent with the 2009 State of the Aggregate Resources in Ontario Study (Paper 2). This change represents a more appropriate lower threshold since there are circumstances when applying for a smaller site is practical, taking into account other factors such as an expansion to an existing operation, market area, applicant's requirements, etc.

Remaining Resource Areas

Remaining resource areas represent aggregate resource areas that did not contain any identified social, environmental and agricultural constraint. These areas should 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 and other factors to be considered as described in Section 3.4 of this report.

3.4 Other Factors to Assess Aggregate Resource Availability

In addition to the constraints identified in Section 3.3 there are numerous other factors that need to be considered to assess the availability of the resource based on site-specific factors. These constraints have not been included in the GIS mapping analysis since the mapping layers were not available for this assessment and/or a site specific study is required to determine the extent of the constraint.

The following is a summary of these additional factors that need to be assessed.

Land Assembly

One of the most significant constraints affecting aggregate availability is land assembly. The rural landscape includes numerous rural residential lots that have fragmented rural resource areas and made property acquisitions and land assembly difficult. As a result some of the identified unconstrained aggregate areas are unavailable due to lot fragmentation (i.e., land severances and rural subdivisions).

Typically, a number of parcels need to be purchased to assemble an economically viable extraction area with appropriate buffers to protect surrounding land uses. In the event that one of these parcels is unavailable for purchase the applicant may not be able to assemble a viable extraction area.

Resource Quality/Quantity

Another factor that can affect aggregate availability is site specific assessment to confirm the quantity/quality of the resource and overburden thickness. Based on this assessment some of the resource areas that have been mapped may not contain a viable aggregate resource.

Proximity to Residents and Other Sensitive Land Uses

Even when a viable site for extraction is assembled there is still the requirement to ensure impacts to adjacent sensitive receptors are minimized.

For quarries (bedrock resource area) the area of influence for potential air, noise and blasting impacts is 500 m and influences to groundwater levels can extend up to 1.5 km from the site. For gravel pits (primary and secondary sand and gravel) the area of influence is typically much smaller and is approximately 300 m.

To ensure that impacts to sensitive land uses within these area of influences are minimized typically additional setbacks and or mitigation measures are required to protect these land uses and meet Ministry of the Environment and Climate Change (MOECC) air, noise and blasting limits. Based on the new MOECC Noise Guidelines an applicant for a new aggregate operation not only has to design for existing sensitive receptors but also has to design the site to protect vacant parcels that have the ability to accommodate a resident based on the zoning for the property.

Based on the lot fabric within the study area and general knowledge of licensing new mineral aggregate operations there are always going to be sensitive land use within the area of influence for a quarry or a gravel pit. Depending on the extent of the setbacks and the mitigation measures required some of these unconstrained aggregate resources will no longer be available for extraction.

Haul Routes

Another factor to determine the viability of a potential resource area is the suitability of the haul route to transfer the aggregate resource to market.

Some of the aggregate resource areas may be located on a road that is not suitable for truck traffic or would require substantial upgrades that could impact the viability of the project. This is another significant constraint that can affect aggregate availability.

Endangered Species Act

The Endangered Species Act includes protection for 104 Endangered Species and 57 Threatened Species and their associated habitat. The habitat for these species can only be mapped once site specific studies are completed to identify the presence of the species and map the habitat for the species. The habitat mapping can include extensive areas depending upon the species habitat requirements and migratory movements and can include active agricultural lands, hedgerows, etc.

Due to the size of the site required for potential aggregate operations and the number of species that are protected under the Endangered Spices Act the majority of sites proposed for extraction now have a least one endangered or threatened species. Protecting the habitat for these species either requires additional setbacks or mitigation/compensation in accordance with the Endangered Species Act.

Other On-Site Environmental Features

There are numerous other factors that are not accounted for in the GIS analysis because they rely on site specific studies such as:

- Numerous data layers were not available for use in this analysis, including: significant valleylands, significant wildlife habitat, special concern species, seepage areas, springs, and recharge areas.
- Typically, additional environmental features that were not previously mapped are identified during site specific studies.
- Conservation Authority Mapping - As part of Ontario Regulation 97/04, local conservation authorities prepared updated wetland and watercourse mapping. This mapping has identified additional environmental features within the study area. This information was only available for areas generally within the GGH but not for areas outside 100 km of the GGH.

- Regional Natural Heritage System – Regional Municipalities are mapping Natural Heritage Systems for inclusion in Official Plans. These Natural Heritage Systems result in additional features and linkage areas being identified for protection. This information was not made available for the majority of the study area.
- Other Environmental Legislation - Other pieces of environmental legislation must be also considered, such as the, Migratory Birds Convention Act, Environmental Protection Act, and Fisheries Act.

Environmental studies are required to identify which environmental features warrant protection and the setbacks required to protect these features. A single environmental feature can have a significant impact on the availability of the resource area if the feature must be protected.

Figure 3-3: Potential Impact

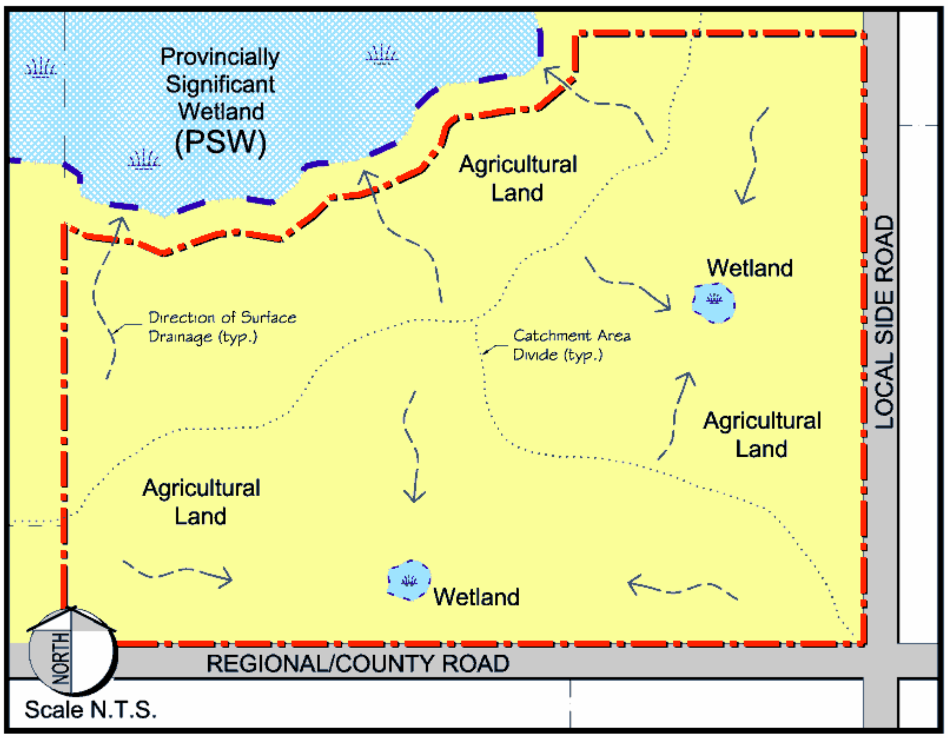


Figure 3-3 illustrates an example of the potential impact that an environmental feature could have on the availability of an aggregate area. This figure represents a 60 ha agricultural site containing two small wetlands that total 1.0 ha and an adjacent Provincially Significant Wetland. In this scenario, 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).

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 if it is determined that the feature has to be protected.

Protection of Adjacent Environmental Features

The mapping analysis completed in Section 3.3 identified that there are numerous environmental features overlapping the aggregate resource area and / or directly adjacent to the unconstrained areas such as:

- Significant Wetlands;
- ANSI Life Science;
- ANSI Earth Science;
- Significant Woodlands;
- Alvars;
- Sand Barrens, Savannahs and Tallgrass Prairies;
- Watercourses;
- Waterbodies;
- Local Wetlands;
- Significant Ecological Areas;
- Reserve and Wildlife Areas; or
- Regional Natural Heritage System, where provided. This information was not provided for the majority of the study area.

The constraint analysis did assume a 30 m buffer from these known environmental constraints however, site specific environmental studies are required to identify each feature and determine the setback required to protect these features. As noted above, a single feature can have a significant impact on the availability of the resource area if the feature must be protected.

Water Resources Studies to Protect Environmental Features, Residential / Agricultural Wells and Well Head Protection Areas

Site specific studies are also needed 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), wellhead protection areas and residential wells. Each of these considerations could result in the requirement for additional setbacks that can impact the availability of the resource area.

Cultural Heritage Resources

Provincial policy requires conservation of significant archeological, significant built heritage and significant cultural heritage landscapes however mapping of these potential constraints are not available.

Site-specific studies need to be completed to identify any significant cultural heritage resources and some of these cultural heritage resources may require protection and additional setbacks that can impact the availability of the resource area.

Utilities, Hydro Lines and Pipelines

Within Southern Ontario, the rural area contains corridors for public utilities, hydro lines and pipelines. These features could overlap a resource area and impact the viability of a site or require setbacks that could impact the availability of the resource area.

Aggregate Resources Act (ARA) Prescribed Setbacks and Sidesloping Requirements

The ARA requires 15 m setbacks from property lines and 30 m setbacks from all roadways, residential properties and bodies of water. The constraint analysis considered 30 m setbacks from existing roadways and bodies of water but did not consider setbacks from unopened road allowances and setbacks from property lines. These prescribed setbacks will further constrain identified aggregate resource areas.

In addition, within an approved extraction area, aggregate operators are required to slope the overburden to the top of the aggregate resource to create stable side slopes and this results in additional setbacks that impact the amount of aggregate that is available within an approved extraction area.

3.5 Results

In accordance with Sections 3.2 and 3.3 of this report, a GIS-based mapping analysis was completed by applying the 32 identified environmental, agricultural and social constraint by:

- Selected bedrock resource areas;
- Primary Sand and gravel areas; and
- Secondary sand and gravel areas

for the five study areas.

The following is a summary of the results:

3.5.1 Selected Bedrock Resource Areas

3.5.1.1 Study Region - GGH and 100 km Buffer

The Study Region contains 626,133 ha of selected bedrock resource areas**.** See Figure 3-4.

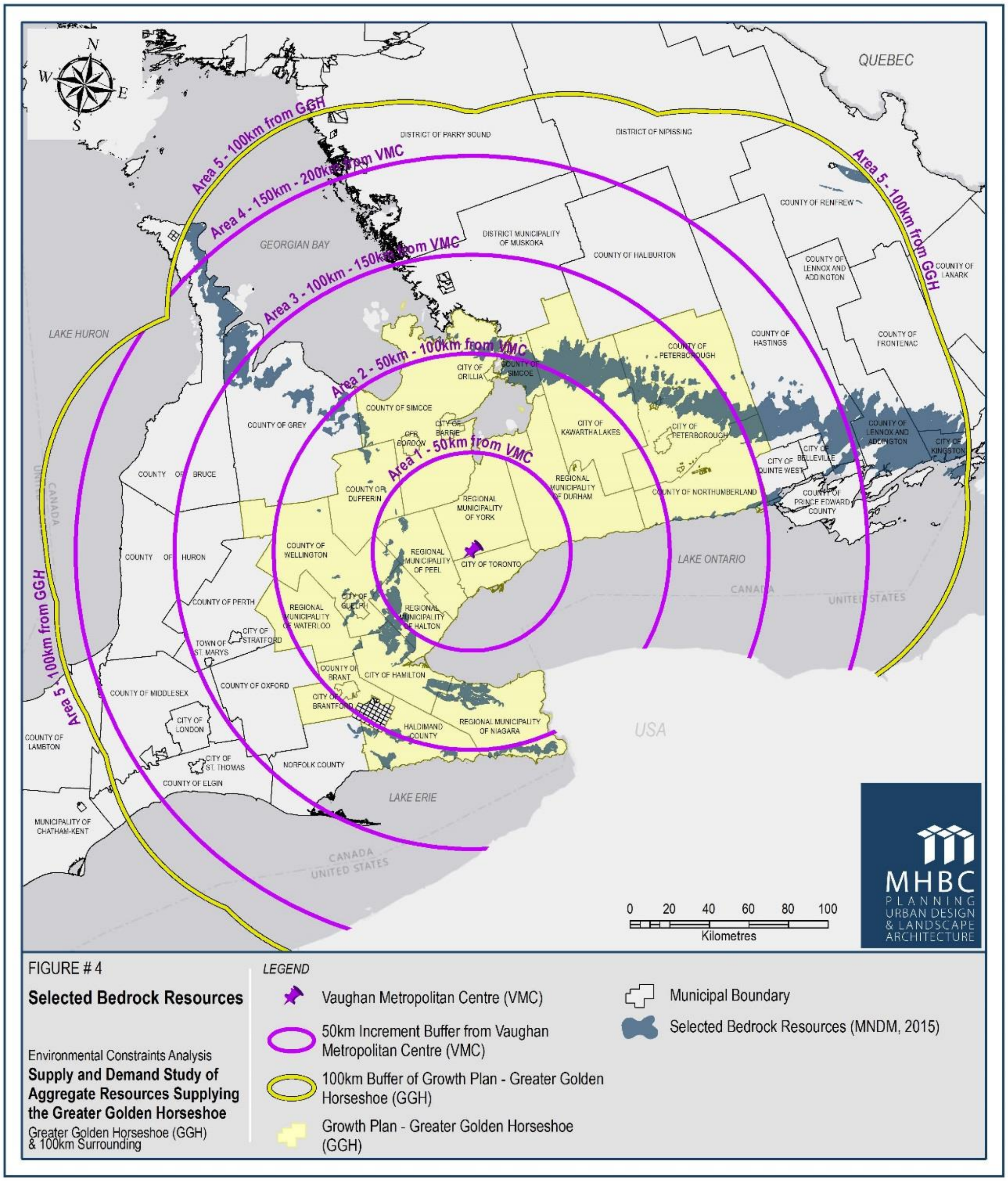


Figure 3-4: Selected Bedrock Resource Areas

After applying the 32 constraints to the selected bedrock resource area mapping, 24,923 ha of the aggregate resource remained, and 601,211 ha of the aggregate resource had overlapping constraints. **This results in 3.98% of the bedrock resource base remaining, and 96.02%% of the bedrock resource base being constrained. See Table 3.1 and Figure 3-5.**

Table 3.1: Study Region - Selected Bedrock Deposits

		Constraint	Area of constraint located within Remaining Bedrock Deposits (ha)*	Remaining Selected Bedrock Resource (ha)
Preemptive Land Uses/Constraints	1	Selected Bedrock Resource Areas		626,133
	2	Existing Aggregate Licences including surrendered and revoked licences	12,047	614,087
	3	Urban Areas	32,588	581,499
	4	Canadian Forces Bases and other Federal Protected Lands	560	580,940
	5	First Nations Reserves	2,353	578,586
	6	Roadways (plus 30 m buffer each side)	31,155	547,431
	7	Railways (plus 15 m buffer each side)	568	546,863
	8	Parks and Recreation Areas (e.g., Public Lands, Conservation Area)	8,601	538,262
	9	NEC Natural Area	13,434	524,828
	10	NEC Protection Area	14,352	510,476
	11	ORMCP Natural Core Area	-	510,476
	12	Specialty Crop Areas within the Greenbelt Plan between Lake Ontario and NEP	1,653	508,823
	13	Significant Wetlands / Significant Coastal Wetlands	39,499	469,325
Very Serious Constraints	14	ORMCP Linkage Area (only above water extraction is permitted)	-	469,325
	15	ANSI Life Science	12,938	456,386
	16	ANSI Life Science Candidates	35	456,351
	17	ANSI Earth Science	3,281	453,070
	18	ANSI Earth Science Candidates	0	453,070
	19	Potential Significant Woodlands within EcoRegions 6E & 7E (within the GTA, Hamilton, Niagara, Haldimand, Brant, Brantford, Norfolk, Oxford, Perth, Stratford, St. Marys, Huron, Middlesex, London, St. Thomas, Elgin, and Lambton >1ha. Within the remainder of EcoRegions 6E & 7E >4 ha, North of EcoRegions 6E & 7E significant woodlands are not considered a constraint)	178,667	274,403
	20	Alvars	77	274,326
	21	Sand Barrens, Savannahs and Tallgrass Prairies	0	274,326
	22	Watercourses	1,432	272,894
	23	Waterbodies	16,586	256,308
	24	Wetlands that are not significant wetlands or significant coastal wetlands	11,954	244,353
	25	Significant Ecological Area	0	244,353
	26	Reserve and Wildlife Areas	0	244,353
	27	Regional Natural Heritage Systems, where provided and mapped beyond the above-noted constraints	7,553	236,801

		Constraint	Area of constraint located within Remaining Bedrock Deposits (ha)*	Remaining Selected Bedrock Resource (ha)
Competing Land Uses	28	30 m buffers applied to Constraints 13 and 15-26	58,014	178,786
	29	Conservation Authority Regulated Areas, where provided and mapped beyond the above-noted constraints	4,773	174,013
	30	Specialty Crop Areas (not included in Constraint 12)	2,923	171,089
	31	Prime Agricultural Lands (CLI Class 1,2,3)	96,281	74,808
	32	Prime Agricultural Areas, where provided and mapped beyond Prime Agricultural Lands	4,093	70,716
	33	Fragmented Bedrock Areas (less than 60 ha)	45,793	24,923
		REMAINING BEDROCK RESOURCE AREA (HA)		24,923

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

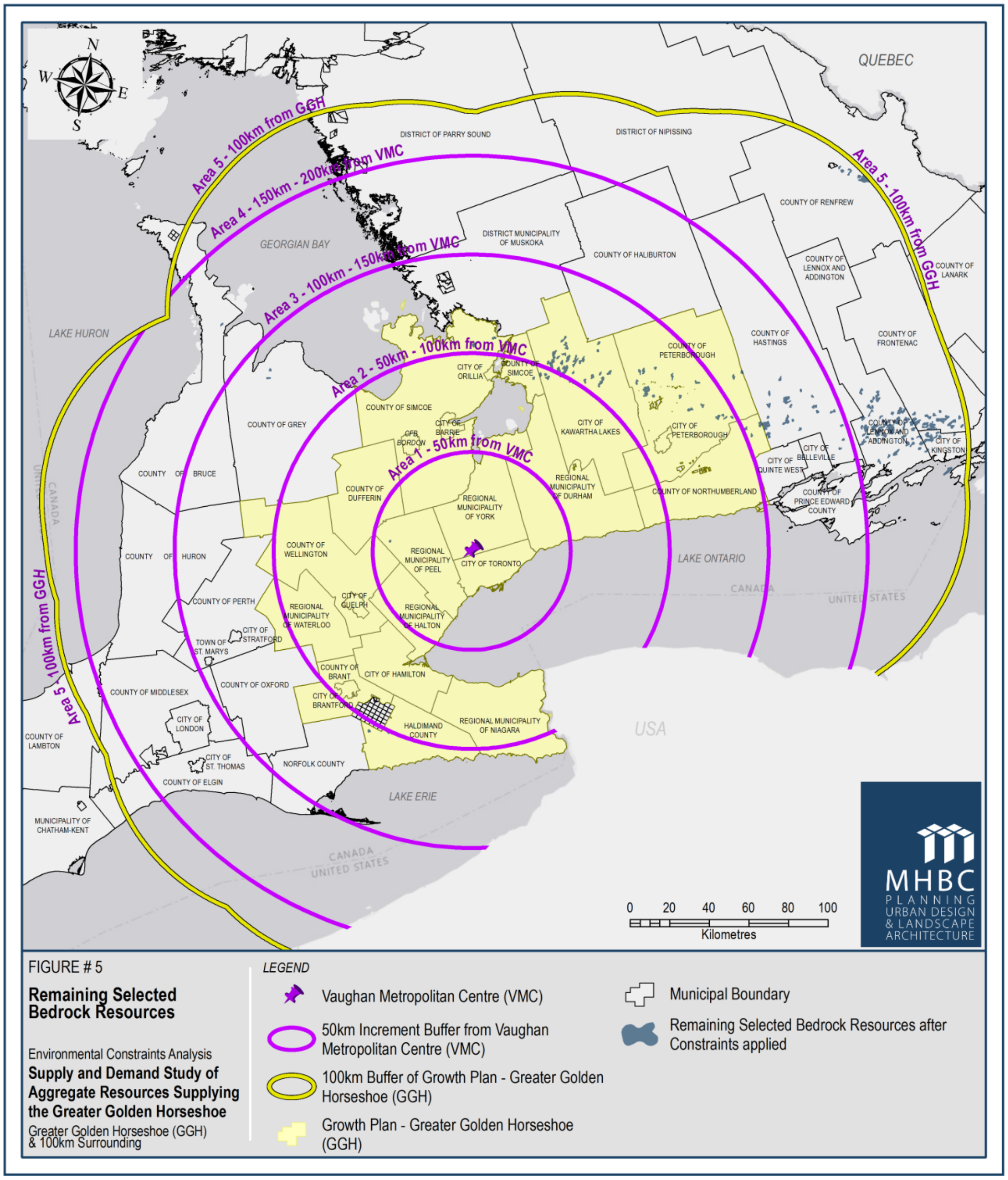


Figure 3-5: Remaining Selected Bedrock Resources

3.5.1.2 Study Area 1 – 0 - 50 km from the Vaughan Metropolitan Centre

Area 1 contains approximately 17,067 ha of bedrock resource. After applying the 32 constraints, 61 ha of the aggregate resource remained, and 17,007 ha of the aggregate resource had overlapping constraints. **This results in 0.35% of the bedrock resource base remaining, and 99.65% of the bedrock resource base being constrained.**

Table 3.2: Study Area 1 - Selected Bedrock Deposits

		Constraint	Area of constraint located within Remaining Bedrock Deposits (ha)*	Remaining Selected Bedrock Resource (ha)
Preemptive Land Uses/Constraints	1	Selected Bedrock Resource Areas		17,067
	2	Existing Aggregate Licences including surrendered and revoked licences	965	16102
	3	Urban Areas	679	15,423
	4	Canadian Forces Bases and other Federal Protected Lands	-	15,423
	5	First Nations Reserves	-	15,423
	6	Roadways (plus 30 m buffer each side)	920	14,503
	7	Railways (plus 15 m buffer each side)	3	14,500
	8	Parks and Recreation Areas (e.g., Public Lands, Conservation Area)	0	14,500
	9	NEC Natural Area	3,351	11,150
	10	NEC Protection Area	1,140	10,010
	11	ORMCP Natural Core Area	-	10,010
	12	Specialty Crop Areas within the Greenbelt Plan between Lake Ontario and NEP	-	10,010
	13	Significant Wetlands / Significant Coastal Wetlands	1,433	8,577
Very Serious Constraints	14	ORMCP Linkage Area (only above water extraction is permitted)	-	8,577
	15	ANSI Life Science	425	8,153
	16	ANSI Life Science Candidates	-	8,153
	17	ANSI Earth Science	0	8,153
	18	ANSI Earth Science Candidates	-	8,153
	19	Potential Significant Woodlands within EcoRegions 6E & 7E (within the GTA, Hamilton, Niagara, Haldimand, Brant, Brantford, Norfolk, Oxford, Perth, Stratford, St. Marys, Huron, Middlesex, London, St. Thomas, Elgin, and Lambton >1ha. Within the remainder of EcoRegions 6E & 7E >4 ha, North of EcoRegions 6E & 7E significant woodlands are not considered a constraint)	2,726	5,427
	20	Alvars	-	5,427
	21	Sand Barrens, Savannahs and Tallgrass Prairies	-	5,427
	22	Watercourses	21	5,406
	23	Waterbodies	10	5,396
	24	Wetlands that are not significant wetlands or significant coastal wetlands	49	5,348
	25	Significant Ecological Area	0	5,348
	26	Reserve and Wildlife Areas	-	5,348
	27	Regional Natural Heritage Systems, where provided and mapped beyond the above-noted constraints	366	4,981

		Constraint	Area of constraint located within Remaining Bedrock Deposits (ha)*	Remaining Selected Bedrock Resource (ha)
Competing Land Uses	28	30 m buffers applied to Constraints 13 and 15-26	1,585	3,396
	29	Conservation Authority Regulated Areas, where provided and mapped beyond the above-noted constraints	948	2,448
	30	Specialty Crop Areas (not included in Constraint 12)	-	2,448
	31	Prime Agricultural Lands (CLI Class 1,2,3)	1,281	1,167
	32	Prime Agricultural Areas, where provided and mapped beyond Prime Agricultural Lands	171	996
	33	Fragmented Bedrock Areas (less than 60 ha)	936	61
		REMAINING BEDROCK RESOURCE AREA (HA)		61

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

3.5.1.3 Study Area 2 – 50 km to 100 km from the Vaughan Metropolitan Centre

Area 2 contains approximately 94,870 ha of bedrock resource. After applying the 32 constraints, 594 ha of the aggregate resource remained, and 94,275 ha of the aggregate resource had overlapping constraints. **This results in 0.63% of the bedrock resource base remaining, and 99.37% of the bedrock resource base being constrained.**

Table 3.3: Study Area 2 - Selected Bedrock Deposits

		Constraint	Area of constraint located within Remaining Bedrock Deposits (ha)*	Remaining Selected Bedrock Resource (ha)
Preemptive Land Uses/Constraints	1	Selected Bedrock Resource Areas		94,870
	2	Existing Aggregate Licences including surrendered and revoked licences	2,821	92,049
	3	Urban Areas	8,054	83,994
	4	Canadian Forces Bases and other Federal Protected Lands	0	83,994
	5	First Nations Reserves	6	83,989
	6	Roadways (plus 30 m buffer each side)	5,339	78,650
	7	Railways (plus 15 m buffer each side)	193	78,457
	8	Parks and Recreation Areas (e.g., Public Lands, Conservation Area)	941	77,516
	9	NEC Natural Area	2,963	74,553
	10	NEC Protection Area	4,071	70,482
	11	ORMCP Natural Core Area	-	70,482
	12	Specialty Crop Areas within the Greenbelt Plan between Lake Ontario and NEP	1,653	68,830
	13	Significant Wetlands / Significant Coastal Wetlands	12,000	56,830
Very Serious Constraints	14	ORMCP Linkage Area (only above water extraction is permitted)	-	56,830
	15	ANSI Life Science	635	56,195
	16	ANSI Life Science Candidates	-	56,195
	17	ANSI Earth Science	900	55,295
	18	ANSI Earth Science Candidates	-	55,295
	19	Potential Significant Woodlands within EcoRegions 6E & 7E (within the GTA, Hamilton, Niagara, Haldimand, Brant, Brantford, Norfolk, Oxford, Perth, Stratford, St. Marys, Huron, Middlesex, London, St. Thomas, Elgin, and Lambton >1ha. Within the remainder of EcoRegions 6E & 7E >4 ha, North of EcoRegions 6E & 7E significant woodlands are not considered a constraint)	11,717	43,579
	20	Alvars	0	43,579
	21	Sand Barrens, Savannahs and Tallgrass Prairies	0	43,579
	22	Watercourses	245	43,334
	23	Waterbodies	1,354	41,980
	24	Wetlands that are not significant wetlands or significant coastal wetlands	1,126	40,854
	25	Significant Ecological Area	0	40,854
	26	Reserve and Wildlife Areas	-	40,854
	27	Regional Natural Heritage Systems, where provided and mapped beyond the above-noted constraints	1,784	39,071

		Constraint	Area of constraint located within Remaining Bedrock Deposits (ha)*	Remaining Selected Bedrock Resource (ha)
Competing Land Uses	28	30 m buffers applied to Constraints 13 and 15-26	7,962	31,109
	29	Conservation Authority Regulated Areas, where provided and mapped beyond the above-noted constraints	2,753	28,356
	30	Specialty Crop Areas (not included in Constraint 12)	2,923	25,433
	31	Prime Agricultural Lands (CLI Class 1,2,3)	20,852	4,581
	32	Prime Agricultural Areas, where provided and mapped beyond Prime Agricultural Lands	772	3,809
	33	Fragmented Bedrock Areas (less than 60 ha)	3,215	594
		REMAINING BEDROCK RESOURCE AREA (HA)		594

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

3.5.1.4 Study Area 3 – 100 km to 150 km from the Vaughan Metropolitan Centre

Area 3 contains approximately 189,842 ha of bedrock resource. After applying the 32 constraints, 6,583 ha of the aggregate resource remained, and 183,259 ha of the aggregate resource had overlapping constraints. **This results in 3.47% of the bedrock resource base remaining, and 96.53% of the bedrock resource base being constrained.**

Table 3.4: Study Area 3 - Selected Bedrock Deposits

		Constraint	Area of constraint located within Remaining Bedrock Deposits (ha)*	Remaining Selected Bedrock Resource (ha)
Preemptive Land Uses/Constraints	1	Selected Bedrock Resource Areas		189,842
	2	Existing Aggregate Licences including surrendered and revoked licences	5,198	184,644
	3	Urban Areas	8,584	176,060
	4	Canadian Forces Bases and other Federal Protected Lands	53	176,007
	5	First Nations Reserves	497	175,509
	6	Roadways (plus 30 m buffer each side)	8,780	166,729
	7	Railways (plus 15 m buffer each side)	102	166,627
	8	Parks and Recreation Areas (e.g., Public Lands, Conservation Area)	2,854	163,773
	9	NEC Natural Area	2,003	161,770
	10	NEC Protection Area	3,147	158,624
	11	ORMCP Natural Core Area	-	158,624
	12	Specialty Crop Areas within the Greenbelt Plan between Lake Ontario and NEP	0	158,624
	13	Significant Wetlands / Significant Coastal Wetlands	10,621	148,003
Very Serious Constraints	14	ORMCP Linkage Area (only above water extraction is permitted)	-	148,003
	15	ANSI Life Science	4,491	143,512
	16	ANSI Life Science Candidates	0	143,512
	17	ANSI Earth Science	1,066	142,446
	18	ANSI Earth Science Candidates	0	142,446
	19	Potential Significant Woodlands within EcoRegions 6E & 7E (within the GTA, Hamilton, Niagara, Haldimand, Brant, Brantford, Norfolk, Oxford, Perth, Stratford, St. Marys, Huron, Middlesex, London, St. Thomas, Elgin, and Lambton >1ha. Within the remainder of EcoRegions 6E & 7E >4 ha, North of EcoRegions 6E & 7E significant woodlands are not considered a constraint)	61,225	81,221
	20	Alvars	0	81,221
	21	Sand Barrens, Savannahs and Tallgrass Prairies	0	81,221
	22	Watercourses	398	80,823
	23	Waterbodies	11,435	69,389
	24	Wetlands that are not significant wetlands or significant coastal wetlands	4,593	64796
	25	Significant Ecological Area	0	64,796
	26	Reserve and Wildlife Areas	0	64,796
	27	Regional Natural Heritage Systems, where provided and mapped beyond the above-noted constraints	920	63,876

		Constraint	Area of constraint located within Remaining Bedrock Deposits (ha)*	Remaining Selected Bedrock Resource (ha)
Competing Land Uses	28	30 m buffers applied to Constraints 13 and 15-26	16,577	47,299
	29	Conservation Authority Regulated Areas, where provided and mapped beyond the above-noted constraints	1,073	46,226
	30	Specialty Crop Areas (not included in Constraint 12)	-	46,226
	31	Prime Agricultural Lands (CLI Class 1,2,3)	25,028	21,199
	32	Prime Agricultural Areas, where provided and mapped beyond Prime Agricultural Lands	1,717	19,482
	33	Fragmented Bedrock Areas (less than 60 ha)	12,899	6,583
		REMAINING BEDROCK RESOURCE AREA (HA)		6,583

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

3.5.1.5 Study Area 4 – 150 km to 200 km from the Vaughan Metropolitan Centre

Area 4 contains approximately 149,241 ha of bedrock resource. After applying the 32 constraints, 3,842 ha of the aggregate resource remained, and 145,399 ha of the aggregate resource had overlapping constraints. **This results in 2.57% of the bedrock resource base remaining, and 97.43% of the bedrock resource base being constrained.**

Table 3.5: Study Area 4 - Selected Bedrock Deposits

		Constraint	Area of constraint located within Remaining Bedrock Deposits (ha)*	Remaining Selected Bedrock Resource (ha)
Preemptive Land Uses/Constraints	1	Selected Bedrock Resource Areas		149,241
	2	Existing Aggregate Licences including surrendered and revoked licences	1,465	147,776
	3	Urban Areas	2,566	145,210
	4	Canadian Forces Bases and other Federal Protected Lands	0	145,210
	5	First Nations Reserves	1,811	143,399
	6	Roadways (plus 30 m buffer each side)	7,153	136,246
	7	Railways (plus 15 m buffer each side)	61	136,184
	8	Parks and Recreation Areas (e.g., Public Lands, Conservation Area)	1,040	135,144
	9	NEC Natural Area	3,691	131,453
	10	NEC Protection Area	4,556	126,897
	11	ORMCP Natural Core Area	-	126,897
	12	Specialty Crop Areas within the Greenbelt Plan between Lake Ontario and NEP	-	126,897
	13	Significant Wetlands / Significant Coastal Wetlands	8,097	118,800
Very Serious Constraints	14	ORMCP Linkage Area (only above water extraction is permitted)	-	118,800
	15	ANSI Life Science	3,993	114,807
	16	ANSI Life Science Candidates	34	114,773
	17	ANSI Earth Science	398	114,375
	18	ANSI Earth Science Candidates	-	114,375
	19	Potential Significant Woodlands within EcoRegions 6E & 7E (within the GTA, Hamilton, Niagara, Haldimand, Brant, Brantford, Norfolk, Oxford, Perth, Stratford, St. Marys, Huron, Middlesex, London, St. Thomas, Elgin, and Lambton >1ha. Within the remainder of EcoRegions 6E & 7E >4 ha, North of EcoRegions 6E & 7E significant woodlands are not considered a constraint)	57,744	56,631
	20	Alvars	35	56,597
	21	Sand Barrens, Savannahs and Tallgrass Prairies	-	56,597
	22	Watercourses	273	56,597
	23	Waterbodies	1,688	54,635
	24	Wetlands that are not significant wetlands or significant coastal wetlands	3,044	51,591
	25	Significant Ecological Area	0	51,591
	26	Reserve and Wildlife Areas	-	51,591
	27	Regional Natural Heritage Systems, where provided and mapped beyond the above-noted constraints	375	36,475

		Constraint	Area of constraint located within Remaining Bedrock Deposits (ha)*	Remaining Selected Bedrock Resource (ha)
Competing Land Uses	28	30 m buffers applied to Constraints 13 and 15-26	14,741	36,475
	29	Conservation Authority Regulated Areas, where provided and mapped beyond the above-noted constraints	0	36,475
	30	Specialty Crop Areas (not included in Constraint 12)	-	36,475
	31	Prime Agricultural Lands (CLI Class 1,2,3)	20,426	16,049
	32	Prime Agricultural Areas, where provided and mapped beyond Prime Agricultural Lands	1,063	14,986
	33	Fragmented Bedrock Areas (less than 60 ha)	11,143	3,842
		REMAINING BEDROCK RESOURCE AREA (HA)		3.842

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

3.5.1.6 Study Area 5 – 200 km to the Remainder of the Study from the Vaughan Metropolitan Centre

Area 5 contains approximately 175,113 ha of bedrock resource. After applying the 32 constraints, 13,842 ha of the aggregate resource remained, and 161,270 ha of the aggregate resource had overlapping constraints. **This results in 7.90% of the bedrock resource base remaining, and 92.1% of the bedrock resource base being constrained.**

Table 3.6: Study Area 5 - Selected Bedrock Deposits

		Constraint	Area of constraint located within Remaining Bedrock Deposits (ha)*	Remaining Selected Bedrock Resource (ha)
Preemptive Land Uses/Constraints	1	Selected Bedrock Resource Areas		175,113
	2	Existing Aggregate Licences including surrendered and revoked licences	1,597	173,516
	3	Urban Areas	12,703	160,812
	4	Canadian Forces Bases and other Federal Protected Lands	506	160,306
	5	First Nations Reserves	39	160,267
	6	Roadways (plus 30 m buffer each side)	8,963	151,304
	7	Railways (plus 15 m buffer each side)	210	151,094
	8	Parks and Recreation Areas (e.g., Public Lands, Conservation Area)	3,766	147,328
	9	NEC Natural Area	1,426	145,902
	10	NEC Protection Area	1,439	144,463
	11	ORMCP Natural Core Area	-	144,463
	12	Specialty Crop Areas within the Greenbelt Plan between Lake Ontario and NEP	-	144,463
	13	Significant Wetlands / Significant Coastal Wetlands	7,348	137,114
Very Serious Constraints	14	ORMCP Linkage Area (only above water extraction is permitted)	-	137,114
	15	ANSI Life Science	3,395	133,719
	16	ANSI Life Science Candidates	1	133,718
	17	ANSI Earth Science	918	132,800
	18	ANSI Earth Science Candidates	-	132,800
	19	Potential Significant Woodlands within EcoRegions 6E & 7E (within the GTA, Hamilton, Niagara, Haldimand, Brant, Brantford, Norfolk, Oxford, Perth, Stratford, St. Marys, Huron, Middlesex, London, St. Thomas, Elgin, and Lambton >1ha. Within the remainder of EcoRegions 6E & 7E >4 ha, North of EcoRegions 6E & 7E significant woodlands are not considered a constraint)	45,255	87,545
	20	Alvars	43	87,503
	21	Sand Barrens, Savannahs and Tallgrass Prairies	-	87,503
	22	Watercourses	496	87,006
	23	Waterbodies	2,099	84,907
	24	Wetlands that are not significant wetlands or significant coastal wetlands	3,143	81,764
	25	Significant Ecological Area	0	81,764
	26	Reserve and Wildlife Areas	-	81,764
	27	Regional Natural Heritage Systems, where provided and mapped beyond the above-noted constraints	4,107	77,657

		Constraint	Area of constraint located within Remaining Bedrock Deposits (ha)*	Remaining Selected Bedrock Resource (ha)
Competing Land Uses	28	30 m buffers applied to Constraints 13 and 15-26	17,150	60,507
	29	Conservation Authority Regulated Areas, where provided and mapped beyond the above-noted constraints	0	60,507
	30	Specialty Crop Areas (not included in Constraint 12)	-	60,507
	31	Prime Agricultural Lands (CLI Class 1,2,3)	28,694	31,813
	32	Prime Agricultural Areas, where provided and mapped beyond Prime Agricultural Lands	371	31,442
	33	Fragmented Bedrock Areas (less than 60 ha)	17,600	13,842
		REMAINING BEDROCK RESOURCE AREA (HA)		13,842

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

3.5.2 Primary Sand and Gravel Resource Areas

3.5.2.1 Study Region – GGH and 100 km Buffer

The Study Region contains 162,349 ha of primary sand and gravel resource areas. See Figure 3-6.

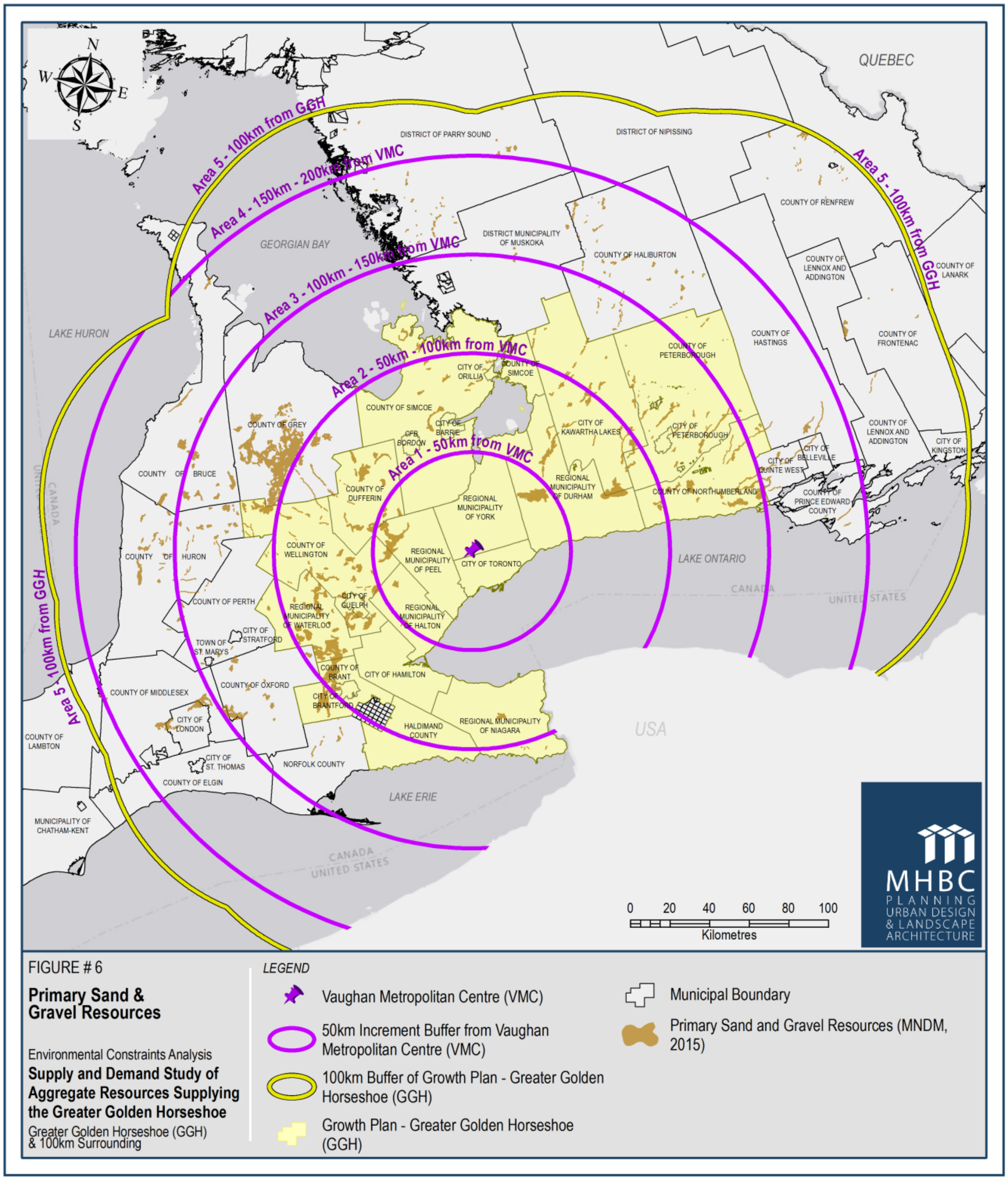


Figure 3-6: Primary Sand & Gravel Resources

After applying the 32 constraints to the selected primary sand and gravel resource area mapping, 3,798 ha of the aggregate resource remained, and 158,551 ha of the aggregate resource had overlapping constraints. **This results in 2.34% of the primary sand and gravel resource base remaining, and 97.66% of the primary sand and gravel resource base being constrained. See Table 3.7 and Figure 3-7.**

Table 3.7: Study Region - Primary Sand & Gravel Resource

		Constraint	Area of constraint located within Remaining Sand & Gravel Resource Areas (ha)*	Remaining Primary Sand & Gravel Resource (ha)
Preemptive Land Uses/Constraints	1	Primary Sand & Gravel Resource Areas		162,349
	2	Existing Aggregate Licences including surrendered and revoked licences	25,558	136,791
	3	Urban Areas	12,719	124,072
	4	Canadian Forces Bases and other Federal Protected Lands	0	124,072
	5	First Nations Reserves	-	124,072
	6	Roadways (plus 30 m buffer each side)	9,758	114,314
	7	Railways (plus 15 m buffer each side)	156	114,159
	8	Parks and Recreation Areas (e.g., Public Lands, Conservation Area)	329	113,830
	9	NEC Natural Area	727	113,103
	10	NEC Protection Area	1,136	111,103
	11	ORMCP Natural Core Area	4,706	107,261
	12	Specialty Crop Areas within the Greenbelt Plan between Lake Ontario and NEP	0	107,261
	13	Significant Wetlands / Significant Coastal Wetlands	4,288	102,973
Very Serious Constraints	14	ORMCP Linkage Area (only above water extraction is permitted)	1,774	101,199
	15	ANSI Life Science	2,042	99,157
	16	ANSI Life Science Candidates	120	99,037
	17	ANSI Earth Science	3,446	95,591
	18	ANSI Earth Science Candidates	614	94,977
	19	Potential Significant Woodlands within EcoRegions 6E & 7E (within the GTA, Hamilton, Niagara, Haldimand, Brant, Brantford, Norfolk, Oxford, Perth, Stratford, St. Marys, Huron, Middlesex, London, St. Thomas, Elgin, and Lambton >1ha. Within the remainder of EcoRegions 6E & 7E >4 ha, North of EcoRegions 6E & 7E significant woodlands are not considered a constraint)	23,497	71,480
	20	Alvars	0	71,480
	21	Sand Barrens, Savannahs and Tallgrass Prairies	27	71,453
	22	Watercourses	261	71,192
	23	Waterbodies	909	70,283
	24	Wetlands that are not significant wetlands or significant coastal wetlands	1,572	68,711
	25	Significant Ecological Area	0	68,711
	26	Reserve and Wildlife Areas	0	68,711
	27	Regional Natural Heritage Systems, where provided and mapped beyond the above-noted constraints	4,971	63,740

		Constraint	Area of constraint located within Remaining Sand & Gravel Resource Areas (ha)*	Remaining Primary Sand & Gravel Resource (ha)
Competing Land Uses	28	30 m buffers applied to Constraints 13 and 15-26	8,466	55,274
	29	Conservation Authority Regulated Areas, where provided and mapped beyond the above-noted constraints	1,973	53,301
	30	Specialty Crop Areas (not included in Constraint 12)	150	53,150
	31	Prime Agricultural Lands (CLI Class 1,2,3)	31,334	21,816
	32	Prime Agricultural Areas, where provided and mapped beyond Prime Agricultural Lands	4,155	17,661
	33	Fragmented Primary Sand & Gravel Resource Areas (less than 40 ha)	13,863	3,798
		REMAINING PRIMARY SAND & GRAVEL RESOURCE AREAS (HA)		3,798

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

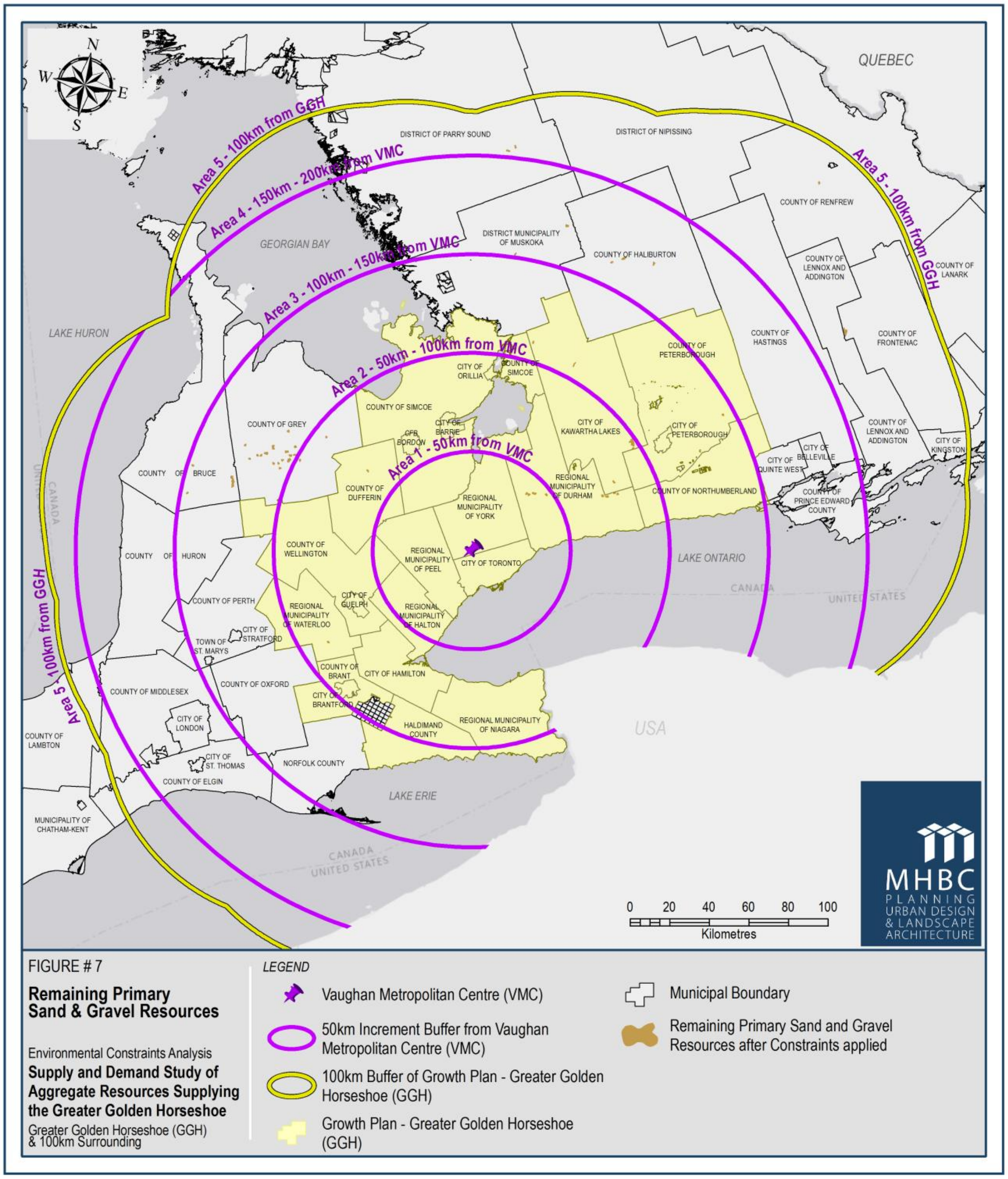


Figure 3-7: Remaining Primary Sand & Gravel Resources

3.5.2.2 Study Area 1 – 0 - 50 km from the Vaughan Metropolitan Centre

Area 1 contains approximately 14,066 ha of primary sand and gravel resource. After applying 32 constraints, 257 ha of the aggregate resource remained, and 13,809 ha of the aggregate resource had overlapping constraints. **This results in 1.83% of the primary sand and gravel resource base remaining, and 98.17% of the primary sand and gravel resource base being constrained.**

Table 3.8: Study Area 1 - Primary Sand & Gravel Resource

		Constraint	Area of constraint located within Remaining Primary Sand & Gravel Resource Areas (ha)*	Remaining Primary Sand & Gravel Resource (ha)
Preemptive Land Uses/Constraints	1	Primary Sand & Gravel Resource Areas		162,349
	2	Existing Aggregate Licences including surrendered and revoked licences	25,558	136,791
	3	Urban Areas	12,719	124,072
	4	Canadian Forces Bases and other Federal Protected Lands	0	124,072
	5	First Nations Reserves	-	124,072
	6	Roadways (plus 30 m buffer each side)	9,758	114,314
	7	Railways (plus 15 m buffer each side)	156	114,159
	8	Parks and Recreation Areas (e.g., Public Lands, Conservation Area)	329	113,830
	9	NEC Natural Area	727	113,103
	10	NEC Protection Area	1,136	111,968
	11	ORMCP Natural Core Area	4,706	107,261
	12	Specialty Crop Areas within the Greenbelt Plan between Lake Ontario and NEP	0	107,261
	13	Significant Wetlands / Significant Coastal Wetlands	4,288	102,973
Very Serious Constraints	14	ORMCP Linkage Area (only above water extraction is permitted)	1,774	101,199
	15	ANSI Life Science	2,042	99,157
	16	ANSI Life Science Candidates	120	99,037
	17	ANSI Earth Science	3,446	95,591
	18	ANSI Earth Science Candidates	614	94,977
	19	Potential Significant Woodlands within EcoRegions 6E & 7E (within the GTA, Hamilton, Niagara, Haldimand, Brant, Brantford, Norfolk, Oxford, Perth, Stratford, St. Marys, Huron, Middlesex, London, St. Thomas, Elgin, and Lambton >1ha. Within the remainder of EcoRegions 6E & 7E >4 ha, North of EcoRegions 6E & 7E significant woodlands are not considered a constraint)	23,497	71,480
	20	Alvars	0	71,480
	21	Sand Barrens, Savannahs and Tallgrass Prairies	27	71,453
	22	Watercourses	261	71,192
	23	Waterbodies	909	70,283
	24	Wetlands that are not significant wetlands or significant coastal wetlands	1,572	68,711
	25	Significant Ecological Area	0	68,711
	26	Reserve and Wildlife Areas	0	68,711
	27	Regional Natural Heritage Systems, where provided and mapped beyond the above-noted constraints	4,971	63,740

		Constraint	Area of constraint located within Remaining Primary Sand & Gravel Resource Areas (ha)*	Remaining Primary Sand & Gravel Resource (ha)
Competing Land Uses	28	30 m buffers applied to Constraints 13 and 15-26	8,466	55,274
	29	Conservation Authority Regulated Areas, where provided and mapped beyond the above-noted constraints	1,973	53,301
	30	Specialty Crop Areas (not included in Constraint 12)	150	53,150
	31	Prime Agricultural Lands (CLI Class 1,2,3)	31,334	21,816
	32	Prime Agricultural Areas, where provided and mapped beyond Prime Agricultural Lands	4,155	17,661
	33	Fragmented Primary Sand & Gravel Resource Areas (less than 40 ha)	13,863	3,798
		REMAINING PRIMARY SAND & GRAVEL RESOURCE AREAS (HA)		3,798

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

3.5.2.3 Study Area 2 - 50 km to 100 km from the Vaughan Metropolitan Centre

Area 2 contains approximately 57,599 ha of primary sand and gravel resource. After applying 32 constraints, 873 ha of the aggregate resource remained, and 56,726 ha of the aggregate resource had overlapping constraints. **This results in 1.52% of the primary sand and gravel resource base remaining, and 98.48% of the primary sand and gravel resource base being constrained.**

Table 3.9: Study Area 2 - Primary Sand & Gravel Resource

		Constraint	Area of constraint located within Remaining Primary Sand & Gravel Resource Areas (ha)*	Remaining Primary Sand & Gravel Resource (ha)
Preemptive Land Uses/Constraints	1	Primary Sand & Gravel Resource Areas		57,599
	2	Existing Aggregate Licences including surrendered and revoked licences	9,934	47,665
	3	Urban Areas	7,003	40,662
	4	Canadian Forces Bases and other Federal Protected Lands	0	40,662
	5	First Nations Reserves	-	40,662
	6	Roadways (plus 30 m buffer each side)	3,016	37,646
	7	Railways (plus 15 m buffer each side)	74	37,572
	8	Parks and Recreation Areas (e.g., Public Lands, Conservation Area)	48	37,524
	9	NEC Natural Area	483	37,041
	10	NEC Protection Area	480	36,562
	11	ORMCP Natural Core Area	1,505	35,057
	12	Specialty Crop Areas within the Greenbelt Plan between Lake Ontario and NEP	0	35,057
	13	Significant Wetlands / Significant Coastal Wetlands	2,208	32,848
Very Serious Constraints	14	ORMCP Linkage Area (only above water extraction is permitted)	1,219	31,629
	15	ANSI Life Science	637	30,992
	16	ANSI Life Science Candidates	82	30,911
	17	ANSI Earth Science	1,473	29,438
	18	ANSI Earth Science Candidates	12	29,426
	19	Potential Significant Woodlands within EcoRegions 6E & 7E (within the GTA, Hamilton, Niagara, Haldimand, Brant, Brantford, Norfolk, Oxford, Perth, Stratford, St. Marys, Huron, Middlesex, London, St. Thomas, Elgin, and Lambton >1ha. Within the remainder of EcoRegions 6E & 7E >4 ha, North of EcoRegions 6E & 7E significant woodlands are not considered a constraint)	5,373	24,053
	20	Alvars	-	24,053
	21	Sand Barrens, Savannahs and Tallgrass Prairies	0	24,053
	22	Watercourses	69	23,983
	23	Waterbodies	126	23,857
	24	Wetlands that are not significant wetlands or significant coastal wetlands	542	23,315
	25	Significant Ecological Area	0	23,315
	26	Reserve and Wildlife Areas	-	23,315
	27	Regional Natural Heritage Systems, where provided and mapped beyond the above-noted constraints	2,402	20,913

		Constraint	Area of constraint located within Remaining Primary Sand & Gravel Resource Areas (ha)*	Remaining Primary Sand & Gravel Resource (ha)
Competing Land Uses	28	30 m buffers applied to Constraints 13 and 15-26	124	20,789
	29	Conservation Authority Regulated Areas, where provided and mapped beyond the above-noted constraints	1,659	19,130
	30	Specialty Crop Areas (not included in Constraint 12)	151	18,979
	31	Prime Agricultural Lands (CLI Class 1,2,3)	14,133	4,846
	32	Prime Agricultural Areas, where provided and mapped beyond Prime Agricultural Lands	1,477	3,370
	33	Fragmented Primary Sand & Gravel Resource Areas (less than 40 ha)	2,496	873
		REMAINING PRIMARY SAND & GRAVEL RESOURCE AREAS (HA)		873

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

3.5.2.4 Study Area 3 - 100 km to 150 km from the Vaughan Metropolitan Centre

Area 3 contains approximately 67,144 ha of primary sand and gravel resource. After applying 32 constraints, 1,814 ha of the aggregate resource remained, and 65,330 ha of the aggregate resource had overlapping constraints. **This results in 2.70% of the primary sand and gravel resource base remaining, and 97.30% of the primary sand and gravel resource base being constrained.**

Table 3.10: Study Area 3 - Primary Sand & Gravel Resource

		Constraint	Area of constraint located within Remaining Primary Sand & Gravel Resource Areas (ha)*	Remaining Primary Sand & Gravel Resource (ha)
Preemptive Land Uses/Constraints	1	Primary Sand & Gravel Resource Areas		67,144
	2	Existing Aggregate Licences including surrendered and revoked licences	7,102	60,042
	3	Urban Areas	3,247	56,795
	4	Canadian Forces Bases and other Federal Protected Lands	-	56,795
	5	First Nations Reserves	-	56,795
	6	Roadways (plus 30 m buffer each side)	3,987	52,808
	7	Railways (plus 15 m buffer each side)	24	52,784
	8	Parks and Recreation Areas (e.g., Public Lands, Conservation Area)	2	52,783
	9	NEC Natural Area	-	52,783
	10	NEC Protection Area	-	52,783
	11	ORMCP Natural Core Area	1,350	51,433
	12	Specialty Crop Areas within the Greenbelt Plan between Lake Ontario and NEP	-	51,433
	13	Significant Wetlands / Significant Coastal Wetlands	1,411	50,022
Very Serious Constraints	14	ORMCP Linkage Area (only above water extraction is permitted)	447	49,575
	15	ANSI Life Science	932	48,643
	16	ANSI Life Science Candidates	5	48,648
	17	ANSI Earth Science	1,110	47,527
	18	ANSI Earth Science Candidates	58	47,469
	19	Potential Significant Woodlands within EcoRegions 6E & 7E (within the GTA, Hamilton, Niagara, Haldimand, Brant, Brantford, Norfolk, Oxford, Perth, Stratford, St. Marys, Huron, Middlesex, London, St. Thomas, Elgin, and Lambton >1ha. Within the remainder of EcoRegions 6E & 7E >4 ha, North of EcoRegions 6E & 7E significant woodlands are not considered a constraint)	14,746	32,723
	20	Alvars	0	32,723
	21	Sand Barrens, Savannahs and Tallgrass Prairies	0	32,723
	22	Watercourses	113	32,610
	23	Waterbodies	401	32,209
	24	Wetlands that are not significant wetlands or significant coastal wetlands	877	31,333
	25	Significant Ecological Area	0	31,333
	26	Reserve and Wildlife Areas	-	31,333
	27	Regional Natural Heritage Systems, where provided and mapped beyond the above-noted constraints	2,057	29,276

		Constraint	Area of constraint located within Remaining Primary Sand & Gravel Resource Areas (ha)*	Remaining Primary Sand & Gravel Resource (ha)
Competing Land Uses	28	30 m buffers applied to Constraints 13 and 15-26	5,754	23,522
	29	Conservation Authority Regulated Areas, where provided and mapped beyond the above-noted constraints	119	23,403
	30	Specialty Crop Areas (not included in Constraint 12)	-	23,403
	31	Prime Agricultural Lands (CLI Class 1,2,3)	13,101	10,302
	32	Prime Agricultural Areas, where provided and mapped beyond Prime Agricultural Lands	2,528	7,774
	33	Fragmented Primary Sand & Gravel Resource Areas (less than 40 ha)	5,950	1,814
		REMAINING PRIMARY SAND & GRAVEL RESOURCE AREAS (HA)		1,814

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

3.5.2.5 Study Area 4 - 150 km to 200 km from the Vaughan Metropolitan Centre

Area 4 contains approximately 19,969 ha of primary sand and gravel resource. After applying 32 constraints, 398 ha of the aggregate resource remained, and 19,571 ha of the aggregate resource had overlapping constraints. **This results in 1.99% of the primary sand and gravel resource base remaining, and 98.01% of the primary sand and gravel resource base being constrained.**

Table 3.11: Study Area 4 - Primary Sand & Gravel Resource

		Constraint	Area of constraint located within Remaining Primary Sand & Gravel Resource Areas (ha)*	Remaining Primary Sand & Gravel Resource (ha)
Preemptive Land Uses/Constraints	1	Primary Sand & Gravel Resource Areas		19,969
	2	Existing Aggregate Licences including surrendered and revoked licences	4,343	15,626
	3	Urban Areas	1,340	14,286
	4	Canadian Forces Bases and other Federal Protected Lands	-	14,286
	5	First Nations Reserves	-	14,286
	6	Roadways (plus 30 m buffer each side)	1,540	12,746
	7	Railways (plus 15 m buffer each side)	23	12,723
	8	Parks and Recreation Areas (e.g., Public Lands, Conservation Area)	93	12,630
	9	NEC Natural Area	10	12,620
	10	NEC Protection Area	33	12,587
	11	ORMCP Natural Core Area	-	12,587
	12	Specialty Crop Areas within the Greenbelt Plan between Lake Ontario and NEP	-	12,587
	13	Significant Wetlands / Significant Coastal Wetlands	354	12,233
Very Serious Constraints	14	ORMCP Linkage Area (only above water extraction is permitted)	-	12,233
	15	ANSI Life Science	404	11,829
	16	ANSI Life Science Candidates	25	11,804
	17	ANSI Earth Science	579	11,225
	18	ANSI Earth Science Candidates		11,225
	19	Potential Significant Woodlands within EcoRegions 6E & 7E (within the GTA, Hamilton, Niagara, Haldimand, Brant, Brantford, Norfolk, Oxford, Perth, Stratford, St. Marys, Huron, Middlesex, London, St. Thomas, Elgin, and Lambton >1ha. Within the remainder of EcoRegions 6E & 7E >4 ha, North of EcoRegions 6E & 7E significant woodlands are not considered a constraint)	2,407	8,818
	20	Alvars	0	8,818
	21	Sand Barrens, Savannahs and Tallgrass Prairies	27	8,791
	22	Watercourses	45	8,746
	23	Waterbodies	229	8,518
	24	Wetlands that are not significant wetlands or significant coastal wetlands	187	8,330
	25	Significant Ecological Area	-	8,330
	26	Reserve and Wildlife Areas	-	8,330
	27	Regional Natural Heritage Systems, where provided and mapped beyond the above-noted constraints	280	8,050

		Constraint	Area of constraint located within Remaining Primary Sand & Gravel Resource Areas (ha)*	Remaining Primary Sand & Gravel Resource (ha)
Competing Land Uses	28	30 m buffers applied to Constraints 13 and 15-26	1,571	6,480
Competing Land Uses	29	Conservation Authority Regulated Areas, where provided and mapped beyond the above-noted constraints	-	6,480
Competing Land Uses	30	Specialty Crop Areas (not included in Constraint 12)	-	6,480
Competing Land Uses	31	Prime Agricultural Lands (CLI Class 1,2,3)	2,609	3,870
Competing Land Uses	32	Prime Agricultural Areas, where provided and mapped beyond Prime Agricultural Lands	144	3,726
	33	Fragmented Primary Sand & Gravel Resource Areas (less than 40 ha)	3,328	398
		REMAINING PRIMARY SAND & GRAVEL RESOURCE AREAS (HA)		398

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

3.5.2.6 Study Area 5 - 200 km to the Remainder of the Study from the Vaughan Metropolitan Centre

Area 5 contains approximately 3,571 ha of primary sand and gravel resource. After applying 32 constraints, 455 ha of the aggregate resource remained, and 3,115 ha of the aggregate resource had overlapping constraints. **This results in 12.74% of the primary sand and gravel resource base remaining, and 87.26% of the primary sand and gravel resource base being constrained.**

Table 3.12: Study Area 5 - Primary Sand & Gravel Resource

		Constraint	Area of constraint located within Remaining Primary Sand & Gravel Resource Areas (ha)*	Remaining Primary Sand & Gravel Resource (ha)
Preemptive Land Uses/Constraints	1	Primary Sand & Gravel Resource Areas		3,571
	2	Existing Aggregate Licences including surrendered and revoked licences	282	3,288
	3	Urban Areas	12	3,276
	4	Canadian Forces Bases and other Federal Protected Lands	-	3,276
	5	First Nations Reserves	-	3,276
	6	Roadways (plus 30 m buffer each side)	416	2,860
	7	Railways (plus 15 m buffer each side)	0	2,860
	8	Parks and Recreation Areas (e.g., Public Lands, Conservation Area)	2	2,858
	9	NEC Natural Area	-	2,858
	10	NEC Protection Area	-	2,858
	11	ORMCP Natural Core Area	-	2,858
	12	Specialty Crop Areas within the Greenbelt Plan between Lake Ontario and NEP	-	2,858
	13	Significant Wetlands / Significant Coastal Wetlands	11	2,847
Very Serious Constraints	14	ORMCP Linkage Area (only above water extraction is permitted)	-	2,847
	15	ANSI Life Science	34	2,813
	16	ANSI Life Science Candidates	2	2,811
	17	ANSI Earth Science	-	2,811
	18	ANSI Earth Science Candidates	2	2,809
	19	Potential Significant Woodlands within EcoRegions 6E & 7E (within the GTA, Hamilton, Niagara, Haldimand, Brant, Brantford, Norfolk, Oxford, Perth, Stratford, St. Marys, Huron, Middlesex, London, St. Thomas, Elgin, and Lambton >1ha. Within the remainder of EcoRegions 6E & 7E >4 ha, North of EcoRegions 6E & 7E significant woodlands are not considered a constraint)	19	2,790
	20	Alvars	-	2,790
	21	Sand Barrens, Savannahs and Tallgrass Prairies	0	2,790
	22	Watercourses	26	2,764
	23	Waterbodies	147	2,617
	24	Wetlands that are not significant wetlands or significant coastal wetlands	117	2,500
	25	Significant Ecological Area	-	2,500
	26	Reserve and Wildlife Areas	-	2,500
	27	Regional Natural Heritage Systems, where provided and mapped beyond the above-noted constraints	12	2,488

		Constraint	Area of constraint located within Remaining Primary Sand & Gravel Resource Areas (ha)*	Remaining Primary Sand & Gravel Resource (ha)
Competing Land Uses	28	30 m buffers applied to Constraints 13 and 15-26	416	2,072
	29	Conservation Authority Regulated Areas, where provided and mapped beyond the above-noted constraints	-	2,072
	30	Specialty Crop Areas (not included in Constraint 12)	-	2,0722
	31	Prime Agricultural Lands (CLI Class 1,2,3)	64	2,008
	32	Prime Agricultural Areas, where provided and mapped beyond Prime Agricultural Lands	-	2,008
	33	Fragmented Primary Sand & Gravel Resource Areas (less than 40 ha)	1,553	455
		REMAINING PRIMARY SAND & GRAVEL RESOURCE AREAS (HA)		455

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

3.5.3 Secondary Sand and Gravel Resource Areas

3.5.3.1 Study Region - GGH and 100 km Buffer

The Study Region contains 289,463 ha of secondary sand and gravel resource areas. See Figure 3-8.

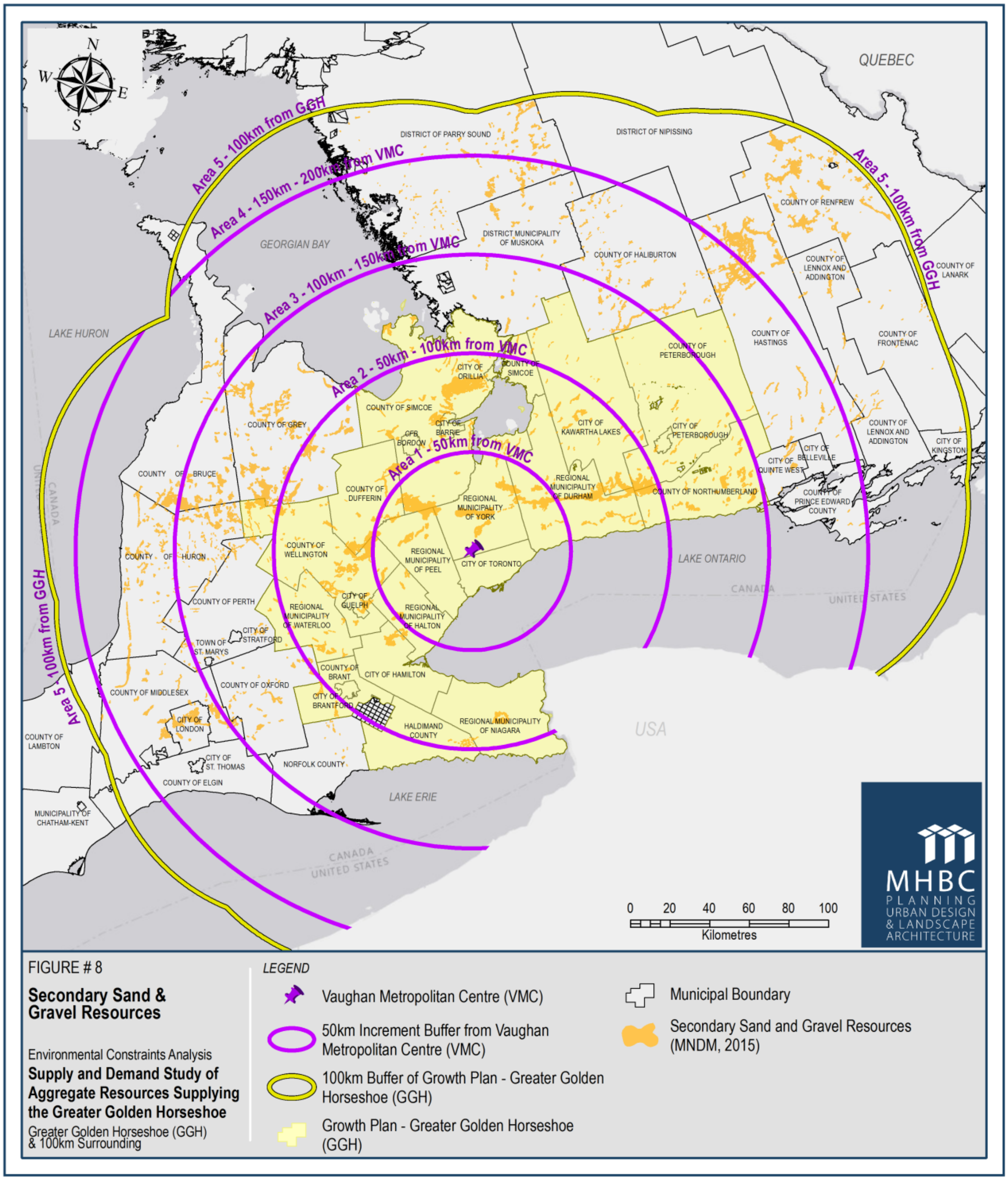


Figure 3-8: Secondary Sand & Gravel Resources

After applying the 32 constraints to the secondary sand and gravel resource area mapping, 23,002 ha of the aggregate resource remained, and 266,461 ha of the aggregate resource had overlapping constraints. **This results in 7.95% of the secondary sand and gravel resource base remaining, and 92.05% of the secondary sand and gravel resource base being constrained. See Table 3.13 and Figure 3-9.**

Table 3.13: Study Region - Secondary Sand & Gravel Resource

		Constraint	Area of constraint located within Remaining Secondary Sand & Gravel Resource Areas (ha)*	Remaining Secondary Sand & Gravel Resource (ha)
Preemptive Land Uses/Constraints	1	Secondary Sand & Gravel Resource Areas		289,463
	2	Existing Aggregate Licences including surrendered and revoked licences	13,922	275,541
	3	Urban Areas	22,035	253,506
	4	Canadian Forces Bases and other Federal Protected Lands	293	253,213
	5	First Nations Reserves	1	253,212
	6	Roadways (plus 30 m buffer each side)	19,077	234,134
	7	Railways (plus 15 m buffer each side)	237	233,898
	8	Parks and Recreation Areas (e.g., Public Lands, Conservation Area)	955	232,943
	9	NEC Natural Area	1,108	231,835
	10	NEC Protection Area	1,706	230,130
	11	ORMCP Natural Core Area	21,235	208,894
	12	Specialty Crop Areas within the Greenbelt Plan between Lake Ontario and NEP	0	208,894
	13	Significant Wetlands / Significant Coastal Wetlands	5,642	203,253
Very Serious Constraints	14	ORMCP Linkage Area (only above water extraction is permitted)	10,924	192,328
	15	ANSI Life Science	3,321	189,008
	16	ANSI Life Science Candidates	394	188,613
	17	ANSI Earth Science	2,063	186,550
	18	ANSI Earth Science Candidates	379	186,171
	19	Potential Significant Woodlands within EcoRegions 6E & 7E (within the GTA, Hamilton, Niagara, Haldimand, Brant, Brantford, Norfolk, Oxford, Perth, Stratford, St. Marys, Huron, Middlesex, London, St. Thomas, Elgin, and Lambton >1ha. Within the remainder of EcoRegions 6E & 7E >4 ha, North of EcoRegions 6E & 7E significant woodlands are not considered a constraint)	32,225	153,946
	20	Alvars	0	153,946
	21	Sand Barrens, Savannahs and Tallgrass Prairies	0	153,946
	22	Watercourses	927	153,019
	23	Waterbodies	2,666	150,353
	24	Wetlands that are not significant wetlands or significant coastal wetlands	4,079	146,274
	25	Significant Ecological Area	0	146,274
	26	Reserve and Wildlife Areas	0	146,274
	27	Regional Natural Heritage Systems, where provided and mapped beyond the above-noted constraints	3,761	142,513

		Constraint	Area of constraint located within Remaining Secondary Sand & Gravel Resource Areas (ha)*	Remaining Secondary Sand & Gravel Resource (ha)
Competing Land Uses	28	30 m buffers applied to Constraints 13 and 15-26	24,829	117,685
	29	Conservation Authority Regulated Areas, where provided and mapped beyond the above-noted constraints	2,761	114,923
	30	Specialty Crop Areas (not included in Constraint 12)	475	114,448
	31	Prime Agricultural Lands (CLI Class 1,2,3)	48,466	65,982
	32	Prime Agricultural Areas, where provided and mapped beyond Prime Agricultural Lands	4,832	61,149
	33	Fragmented Secondary Sand & Gravel Resource Areas (less than 40 ha)	38,147	23,002
		REMAINING SECONDARY SAND & GRAVEL RESOURCE AREAS (HA)		23,002

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

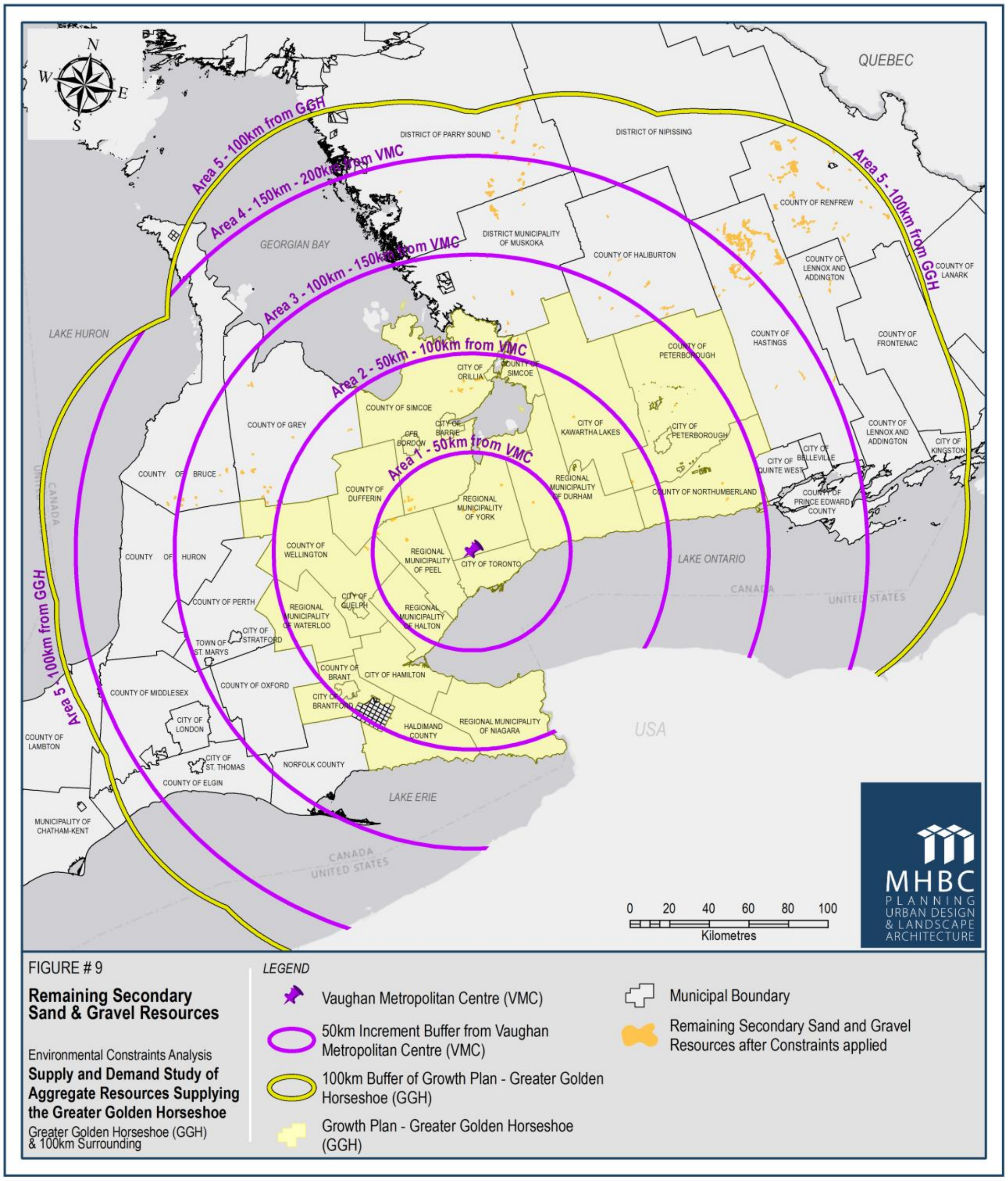


Figure 3-9: Remaining Secondary Sand & Gravel Resources

3.5.3.2 Study Area 1 – 0 - 50 km from the Vaughan Metropolitan Centre

Area 1 contains approximately 36,183 ha of secondary sand and gravel resource. After applying 32 constraints, 1,235 ha of the aggregate resource remained, and 34,948 ha of the aggregate resource had overlapping constraints. **This results in 3.41% of the secondary sand and gravel resource base remaining, and 96.59% of the secondary sand and gravel resource base being constrained.**

Table 3.14: Study Area 1 - Secondary Sand & Gravel Resource

		Constraint	Area of constraint located within Remaining Secondary Sand & Gravel Resource Areas (ha)*	Remaining Secondary Sand & Gravel Resource (ha)
Preemptive Land Uses/Constraints	1	Secondary Sand & Gravel Resource Areas		36,183
	2	Existing Aggregate Licences including surrendered and revoked licences	1,516	34,667
	3	Urban Areas	5,092	29,575
	4	Canadian Forces Bases and other Federal Protected Lands	-	29,575
	5	First Nations Reserves	-	29,575
	6	Roadways (plus 30 m buffer each side)	1,930	27,645
	7	Railways (plus 15 m buffer each side)	51	27,595
	8	Parks and Recreation Areas (e.g., Public Lands, Conservation Area)	40	27,554
	9	NEC Natural Area	424	27,130
	10	NEC Protection Area	580	26,551
	11	ORMCP Natural Core Area	9,419	17,132
	12	Specialty Crop Areas within the Greenbelt Plan between Lake Ontario and NEP	-	17,132
	13	Significant Wetlands / Significant Coastal Wetlands	420	16,712
Verv Serious Constraints	14	ORMCP Linkage Area (only above water extraction is permitted)	7,203	9,509
	15	ANSI Life Science	54	9,455
	16	ANSI Life Science Candidates	96	9,359
	17	ANSI Earth Science	52	9,307
	18	ANSI Earth Science Candidates	125	9,182
	19	Potential Significant Woodlands within EcoRegions 6E & 7E (within the GTA, Hamilton, Niagara, Haldimand, Brant, Brantford, Norfolk, Oxford, Perth, Stratford, St. Marys, Huron, Middlesex, London, St. Thomas, Elgin, and Lambton >1ha. Within the remainder of EcoRegions 6E & 7E >4 ha, North of EcoRegions 6E & 7E significant woodlands are not considered a constraint)	1,542	7,640
	20	Alvars	0	7,640
	21	Sand Barrens, Savannahs and Tallgrass Prairies	-	7,640
	22	Watercourses	28	7,612
	23	Waterbodies	38	7,574
	24	Wetlands that are not significant wetlands or significant coastal wetlands	60	7,514
	25	Significant Ecological Area	-	7,514
	26	Reserve and Wildlife Areas	-	7,514
	27	Regional Natural Heritage Systems, where provided and mapped beyond the above-noted constraints	177	7,337

		Constraint	Area of constraint located within Remaining Secondary Sand & Gravel Resource Areas (ha)*	Remaining Secondary Sand & Gravel Resource (ha)
Competing Land Uses	28	30 m buffers applied to Constraints 13 and 15-26	1,543	5,794
	29	Conservation Authority Regulated Areas, where provided and mapped beyond the above-noted constraints	679	5,115
	30	Specialty Crop Areas (not included in Constraint 12)	-	5,115
	31	Prime Agricultural Lands (CLI Class 1,2,3)	2,280	2,835
	32	Prime Agricultural Areas, where provided and mapped beyond Prime Agricultural Lands	91	2,744
	33	Fragmented Secondary Sand & Gravel Resource Areas (less than 40 ha)	1,510	1,235
		REMAINING SECONDARY SAND & GRAVEL RESOURCE AREAS (HA)		1,235

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

3.5.3.3 Study Area 2 - 50 km to 100 km from the Vaughan Metropolitan Centre

Area 2 contains approximately 87,540 ha of secondary sand and gravel resource. After applying 32 constraints, 954 ha of the aggregate resource remained, and 86,585 ha of the aggregate resource had overlapping constraints. **This results in 1.09% of the secondary sand and gravel resource base remaining, and 98.91% of the secondary sand and gravel resource base being constrained.**

Table 3.15: Study Area 2 - Secondary Sand & Gravel Resource

		Constraint	Area of constraint located within Remaining Secondary Sand & Gravel Resource Areas (ha)*	Remaining Secondary Sand & Gravel Resource (ha)
Preemptive Land Uses/Constraints	1	Secondary Sand & Gravel Resource Areas		87,540
	2	Existing Aggregate Licences including surrendered and revoked licences	4,252	83,288
	3	Urban Areas	8,214	75,074
	4	Canadian Forces Bases and other Federal Protected Lands	34	75,040
	5	First Nations Reserves	-	75,040
	6	Roadways (plus 30 m buffer each side)	4,754	70,286
	7	Railways (plus 15 m buffer each side)	87	70,199
	8	Parks and Recreation Areas (e.g., Public Lands, Conservation Area)	293	69,906
	9	NEC Natural Area	607	69,299
	10	NEC Protection Area	566	68,733
	11	ORMCP Natural Core Area	10,887	57,846
	12	Specialty Crop Areas within the Greenbelt Plan between Lake Ontario and NEP	0	57,846
	13	Significant Wetlands / Significant Coastal Wetlands	2,226	55,620
Very Serious Constraints	14	ORMCP Linkage Area (only above water extraction is permitted)	3,505	52,115
	15	ANSI Life Science	680	51,435
	16	ANSI Life Science Candidates	62	51,373
	17	ANSI Earth Science	494	50,879
	18	ANSI Earth Science Candidates	4	50,875
	19	Potential Significant Woodlands within EcoRegions 6E & 7E (within the GTA, Hamilton, Niagara, Haldimand, Brant, Brantford, Norfolk, Oxford, Perth, Stratford, St. Marys, Huron, Middlesex, London, St. Thomas, Elgin, and Lambton >1ha. Within the remainder of EcoRegions 6E & 7E >4 ha, North of EcoRegions 6E & 7E significant woodlands are not considered a constraint)	13,655	37,220
	20	Alvars	-	37,220
	21	Sand Barrens, Savannahs and Tallgrass Prairies	-	37,220
	22	Watercourses	132	37,087
	23	Waterbodies	173	36,914
	24	Wetlands that are not significant wetlands or significant coastal wetlands	1,077	35,837
	25	Significant Ecological Area	-	35,837
	26	Reserve and Wildlife Areas	0	35,837
	27	Regional Natural Heritage Systems, where provided and mapped beyond the above-noted constraints	921	34,916

		Constraint	Area of constraint located within Remaining Secondary Sand & Gravel Resource Areas (ha)*	Remaining Secondary Sand & Gravel Resource (ha)
Competing Land Uses	28	30 m buffers applied to Constraints 13 and 15-26	6,358	28,558
	29	Conservation Authority Regulated Areas, where provided and mapped beyond the above-noted constraints	2,028	26,530
	30	Specialty Crop Areas (not included in Constraint 12)	336	26,195
	31	Prime Agricultural Lands (CLI Class 1,2,3)	19,348	6,846
	32	Prime Agricultural Areas, where provided and mapped beyond Prime Agricultural Lands	1,827	5,019
	33	Fragmented Secondary Sand & Gravel Resource Areas (less than 40 ha)	4,065	954
		REMAINING SECONDARY SAND & GRAVEL RESOURCE AREAS (HA)		954

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

3.5.3.4 Study Area 3 - 100 km to 150 km from the Vaughan Metropolitan Centre

Area 3 contains approximately 67,107 ha of secondary sand and gravel resource. After applying 32 constraints, 2,457 ha of the aggregate resource remained, and 64,650 ha of the aggregate resource had overlapping constraints. **This results in 3.66% of the secondary sand and gravel resource base remaining, and 96.34% of the secondary sand and gravel resource base being constrained.**

Table 3.16: Study Area 3 - Secondary Sand & Gravel Resource

		Constraint	Area of constraint located within Remaining Secondary Sand & Gravel Resource Areas (ha)*	Remaining Secondary Sand & Gravel Resource (ha)
Preemptive Land Uses/Constraints	1	Secondary Sand & Gravel Resource Areas		67,107
	2	Existing Aggregate Licences including surrendered and revoked licences	3,408	63,699
	3	Urban Areas	2,566	61,133
	4	Canadian Forces Bases and other Federal Protected Lands	-	61,133
	5	First Nations Reserves	1	61,132
	6	Roadways (plus 30 m buffer each side)	4,004	57,128
	7	Railways (plus 15 m buffer each side)	26	57,102
	8	Parks and Recreation Areas (e.g., Public Lands, Conservation Area)	79	57,023
	9	NEC Natural Area	77	56,946
	10	NEC Protection Area	560	56,387
	11	ORMCP Natural Core Area	929	55,457
	12	Specialty Crop Areas within the Greenbelt Plan between Lake Ontario and NEP	-	55,457
	13	Significant Wetlands / Significant Coastal Wetlands	1,639	53,818
Very Serious Constraints	14	ORMCP Linkage Area (only above water extraction is permitted)	217	53,601
	15	ANSI Life Science	1,367	52,234
	16	ANSI Life Science Candidates	226	52,008
	17	ANSI Earth Science	764	51,244
	18	ANSI Earth Science Candidates	69	51,174
	19	Potential Significant Woodlands within EcoRegions 6E & 7E (within the GTA, Hamilton, Niagara, Haldimand, Brant, Brantford, Norfolk, Oxford, Perth, Stratford, St. Marys, Huron, Middlesex, London, St. Thomas, Elgin, and Lambton >1ha. Within the remainder of EcoRegions 6E & 7E >4 ha, North of EcoRegions 6E & 7E significant woodlands are not considered a constraint)	12,047	39,127
	20	Alvars	0	39,127
	21	Sand Barrens, Savannahs and Tallgrass Prairies	-	39,127
	22	Watercourses	168	38,959
	23	Waterbodies	229	38,730
	24	Wetlands that are not significant wetlands or significant coastal wetlands	672	38,058
	25	Significant Ecological Area	-	38,058
	26	Reserve and Wildlife Areas	-	38,058
	27	Regional Natural Heritage Systems, where provided and mapped beyond the above-noted constraints	1,316	36,742

		Constraint	Area of constraint located within Remaining Secondary Sand & Gravel Resource Areas (ha)*	Remaining Secondary Sand & Gravel Resource (ha)
Competing Land Uses	28	30 m buffers applied to Constraints 13 and 15-26	6,658	30,084
	29	Conservation Authority Regulated Areas, where provided and mapped beyond the above-noted constraints	53	30,031
	30	Specialty Crop Areas (not included in Constraint 12)	139	29,892
	31	Prime Agricultural Lands (CLI Class 1,2,3)	17,824	12,068
	32	Prime Agricultural Areas, where provided and mapped beyond Prime Agricultural Lands	2,480	9,588
	33	Fragmented Secondary Sand & Gravel Resource Areas (less than 40 ha)	7,130	2,457
		REMAINING SECONDARY SAND & GRAVEL RESOURCE AREAS (HA)		2,457

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

3.5.3.5 Study Area 4 - 150 km to 200 km from the Vaughan Metropolitan Centre

Area 4 contains approximately 54,914 ha of secondary sand and gravel resource. After applying 32 constraints, 4,512 ha of the aggregate resource remained, and 50,402 ha of the aggregate resource had overlapping constraints. **This results in 8.22% of the secondary sand and gravel resource base remaining, and 91.78% of the secondary sand and gravel resource base being constrained.**

Table 3.17: Study Area 4 - Secondary Sand & Gravel Resource

		Constraint	Area of constraint located within Remaining Secondary Sand & Gravel Resource Areas (ha)*	Remaining Secondary Sand & Gravel Resource (ha)
Preemptive Land Uses/Constraints	1	Secondary Sand & Gravel Resource Areas		54,914
	2	Existing Aggregate Licences including surrendered and revoked licences	3,108	51,806
	3	Urban Areas	5,851	45,954
	4	Canadian Forces Bases and other Federal Protected Lands	-	45,954
	5	First Nations Reserves	-	45,954
	6	Roadways (plus 30 m buffer each side)	4,489	41,465
	7	Railways (plus 15 m buffer each side)	67	41,399
	8	Parks and Recreation Areas (e.g., Public Lands, Conservation Area)	110	41,289
	9	NEC Natural Area	0	41,289
	10	NEC Protection Area	0	41,289
	11	ORMCP Natural Core Area	0	41,289
	12	Specialty Crop Areas within the Greenbelt Plan between Lake Ontario and NEP	0	41,289
	13	Significant Wetlands / Significant Coastal Wetlands	1,219	40,070
Very Serious Constraints	14	ORMCP Linkage Area (only above water extraction is permitted)	0	40,070
	15	ANSI Life Science	1,067	39,003
	16	ANSI Life Science Candidates	4	38,998
	17	ANSI Earth Science	634	38,364
	18	ANSI Earth Science Candidates	179	38,185
	19	Potential Significant Woodlands within EcoRegions 6E & 7E (Within the GTA, Hamilton, Niagara, Haldimand, Brant, Brantford, Norfolk, Oxford, Perth, Stratford, St. Marys, Huron, Middlesex, London, St. Thomas, Elgin, and Lambton >1ha. Within the remainder of EcoRegions 6E & 7E >4 ha, North of EcoRegions 6E & 7E significant woodlands are not considered a constraint)	4,768	33,417
	20	Alvars	-	33,417
	21	Sand Barrens, Savannahs and Tallgrass Prairies	-	33,417
	22	Watercourses	269	33,149
	23	Waterbodies	1,270	31,879
	24	Wetlands that are not significant wetlands or significant coastal wetlands	681	31,198
	25	Significant Ecological Area	-	31,198
	26	Reserve and Wildlife Areas	-	31,198
	27	Regional Natural Heritage Systems, where provided and mapped beyond the above-noted constraints	482	30,716

		Constraint	Area of constraint located within Remaining Secondary Sand & Gravel Resource Areas (ha)*	Remaining Secondary Sand & Gravel Resource (ha)
Competing Land Uses	28	30 m buffers applied to Constraints 13 and 15-26	5,435	25,281
	29	Conservation Authority Regulated Areas, where provided and mapped beyond the above-noted constraints	0	25,281
	30	Specialty Crop Areas (not included in Constraint 12)	0	25,281
	31	Prime Agricultural Lands (CLI Class 1,2,3)	8,616	16,664
	32	Prime Agricultural Areas, where provided and mapped beyond Prime Agricultural Lands	434	16,230
	33	Fragmented Secondary Sand & Gravel Resource Areas (less than 40 ha)	11,718	4,512
		REMAINING SECONDARY SAND & GRAVEL RESOURCE AREAS (HA)		4,512

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

3.5.3.6 Study Area 5 - 200 km to the Remainder of the Study from the Vaughan Metropolitan Centre

Area 5 contains approximately 43,719 ha of secondary sand and gravel resource. After applying 32 constraints, 13,844 ha of the aggregate resource remained, and 29,875 ha of the aggregate resource had overlapping constraints. **This results in 31.67% of the secondary sand and gravel resource base remaining, and 68.33% of the secondary sand and gravel resource base being constrained.**

Table 3.18: Study Area 5 - Secondary Sand & Gravel Resource

		Constraint	Area of constraint located within Remaining Secondary Sand & Gravel Resource Areas (ha)*	Remaining Secondary Sand & Gravel Resource (ha)
Preemptive Land Uses/Constraints	1	Secondary Sand & Gravel Resource Areas		43,719
	2	Existing Aggregate Licences including surrendered and revoked licences	1,638	42,081
	3	Urban Areas	311	41,770
	4	Canadian Forces Bases and other Federal Protected Lands	259	41,511
	5	First Nations Reserves	1	41,510
	6	Roadways (plus 30 m buffer each side)	3,900	37,610
	7	Railways (plus 15 m buffer each side)	6	37,604
	8	Parks and Recreation Areas (e.g., Public Lands, Conservation Area)	433	37,171
	9	NEC Natural Area	0	37,171
	10	NEC Protection Area	0	37,171
	11	ORMCP Natural Core Area	0	37,171
	12	Specialty Crop Areas within the Greenbelt Plan between Lake Ontario and NEP	0	37,171
	13	Significant Wetlands / Significant Coastal Wetlands	138	37,033
Very Serious Constraints	14	ORMCP Linkage Area (only above water extraction is permitted)	0	37,033
	15	ANSI Life Science	152	36,881
	16	ANSI Life Science Candidates	6	36,875
	17	ANSI Earth Science	119	36,756
	18	ANSI Earth Science Candidates	0	36,756
	19	Potential Significant Woodlands within EcoRegions 6E & 7E (within the GTA, Hamilton, Niagara, Haldimand, Brant, Brantford, Norfolk, Oxford, Perth, Stratford, St. Marys, Huron, Middlesex, London, St. Thomas, Elgin, and Lambton >1ha. Within the remainder of EcoRegions 6E & 7E >4 ha, North of EcoRegions 6E & 7E significant woodlands are not considered a constraint)	213	36,542
	20	Alvars	-	36,542
	21	Sand Barrens, Savannahs and Tallgrass Prairies	-	36,542
	22	Watercourses	330	36,212
	23	Waterbodies	955	35,256
	24	Wetlands that are not significant wetlands or significant coastal wetlands	2,206	33,051
	25	Significant Ecological Area	0	33,051
	26	Reserve and Wildlife Areas	-	33,051
	27	Regional Natural Heritage Systems, where provided and mapped beyond the above-noted constraints	248	32,802

		Constraint	Area of constraint located within Remaining Secondary Sand & Gravel Resource Areas (ha)*	Remaining Secondary Sand & Gravel Resource (ha)
Competing Land Uses	28	30 m buffers applied to Constraints 13 and 15-26	4,835	27,967
	29	Conservation Authority Regulated Areas, where provided and mapped beyond the above-noted constraints	1	27,966
	30	Specialty Crop Areas (not included in Constraint 12)	0	27,966
	31	Prime Agricultural Lands (CLI Class 1,2,3)	398	27,568
	32	Prime Agricultural Areas, where provided and mapped beyond Prime Agricultural Lands	0	27,568
	33	Fragmented Secondary Sand & Gravel Resource Areas (less than 40 ha)	13,724	13,844
		REMAINING SECONDARY SAND & GRAVEL RESOURCE AREAS (HA)		13,844

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

3.5.4 Summary of the Constraint Analysis

The following is a summary of the constraint analysis by resource type and study area.

Table 3.19: Aggregate Resource Areas - No Constraints Applied (ha)

	Area 1	Area 2	Area 3	Area 4	Area 5	Total
Selected Bedrock Resource Area	17,067	94,870	189,842	149,241	175,113	626,133
Primary Sand and Gravel Area	14,066	57,599	67,144	19,969	3,571	162,349
Secondary Sand and Gravel Area	36,183	87,540	67,107	54,914	43,719	289,463
Total	67,316	240,009	324,093	224,124	222,403	1,077,945

Table 3.20: Unconstrained Aggregate Areas - After Constraint Applied (ha)

	Area 1	Area 2	Area 3	Area 4	Area 5	Total
Selected Bedrock Resource Area	61	594	6,583	3,842	13,842	24,923
Primary Sand and Gravel Area	257	873	1,814	398	455	3,798
Secondary Sand and Gravel Area	1,235	954	2,457	4,512	13,844	23,002
Total	1,553	2,421	10,854	8,752	28,141	51,723

*Total values are rounded

Table 3.21: % of Aggregate Area with an Overlapping Constraint (%)

	Area 1	Area 2	Area 3	Area 4	Area 5	Total
Selected Bedrock Resource Area	99.65	99.37	96.53	97.43	92.1	96.02
Primary Sand and Gravel Area	98.17	98.48	97.30	98.01	87.26	97.66
Secondary Sand and Gravel Area	96.59	98.91	96.34	91.78	68.33	92.05
Total	97.70	98.99	96.65	96.1	87.35	95.2

3.6 Conclusion

This assessment of unlicensed aggregate resource areas has examined the extent of overlap between identified aggregate resource deposits and known environmental, agricultural and social constraints. A GIS mapping analysis has the capability to progressively overlay constraints and determine the degree to which the availability of mineral aggregate resources may be affected by other mapped land uses, features and resources.

The results demonstrate that access to aggregate resources within the Study Area (much of Southern Ontario) is severely affected by known environmental, agricultural and social constraints. On average 95% of the ARIP selected bedrock and primary and secondary sand and gravel deposits have overlapping constraints.

This is not to say that these resources are not available. The applied constraints are factors that have to be considered in assessing the availability of the resource; they are not all constraints that would necessarily or reasonably preclude access to the resource.

Nor should the results be interpreted to mean that the remaining resource areas (i.e., unconstrained) are available as there are numerous other site specific and unmapped factors that need to be considered before a resource can be licensed and extracted.

What the results do tell us is that the availability of aggregate resources in Ontario needs to be carefully planned for. Aggregates will not be available if it is assumed or taken for granted that there will be plentiful supply after all other planning considerations are accounted for. Planning for aggregate availability will require an integrated and balanced approach that recognizes some compromises will be required. Without this recognition it is more likely that aggregate deposits are not protected or made available given the likelihood of on-site and adjacent constraints.

4.0 DEMAND STUDY

4.1 Introduction

This report presents the findings from the **Demand Analysis** component of the Study.

4.1.1 Study Approach

The demand analysis in this report uses two separate, but connected streams:

- **"Macro" demand analysis** – this approach assesses future aggregate consumption based on **underlying growth** prospects for the economy and population.
- **"Micro" demand analysis** – this approach assesses the aggregate quantities that will be needed in the GGH related to specific major infrastructure projects that are currently planned for the GGH.

Note that while the micro demand analysis helps to confirm the results of the macro demand analysis, the micro demand analysis is only conducted for key major public infrastructure spending in the GGH; as such the resulting aggregate need is only part of the total amount of aggregate that will be needed in the GGH.

4.1.2 Section Outline

In addition to this Introduction, this Section contains the following sub-sections:

- Aggregate Consumption Patterns in Ontario and the GGH
- The Use of Aggregate
- The Future Consumption of Aggregate in Ontario and the GGH
- Aggregate Quantities Needed for Major Planned Infrastructure Projects in the GGH

4.1.3 Geographic Scope

The study examines aggregate consumption for the following geographic areas:

- The province as a whole.
- The eight geographic areas for the province that were examined in the previous SAROS (2009) and State of the Aggregate Resource (1989) studies; these are provided for consistency with previous analyses, as well as to provide cross-province coverage. These eight geographic areas, and their constituent upper or single tier municipalities, are shown Figure 4-1.

- The GGH, in total and with results for the GTAH and Outer Ring combined areas. Figure 4-1 also shows for each of the zones, what proportion of that zone is contained in the GGH, both on an aggregate production and population (2014) basis, as well as which upper tier municipalities are in the GGH (GTAH vs Outer Ring).

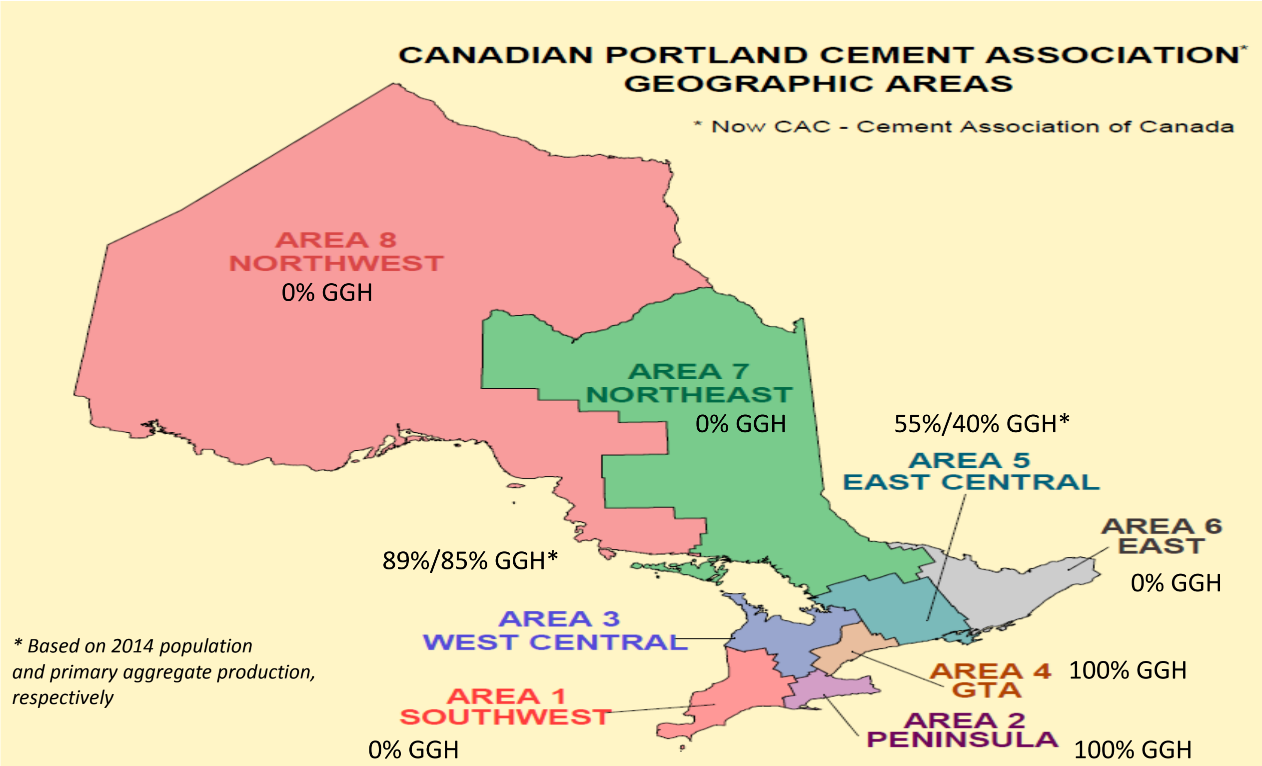


Figure 4-1: Geographic Areas

Area 1 Southwest	Area 2 Peninsula	Area 3 West Central	Area 4 GTA
Essex Chatham-Kent Lambton Elgin Middlesex Huron Perth Oxford	Niagara **OR** Brant **OR** Haldimand- Norfolk **OR*** Hamilton- Wentworth **GTAH**	Bruce Grey Simcoe **OR** Dufferin **OR** Wellington **OR** Waterloo **OR**	Toronto **GTAH** Peel **GTAH** York **GTAH** Durham **GTAH** Halton **GTAH**
Area 5 East Central	**Area 6 East**	**Area 7 Northeast**	**Area 8 Northwest**
Kawartha Lakes **OR** Peterborough **OR** Haliburton Northumberland **OR** Hastings Prince Edward Muskoka	Prescott & Russell Leeds & Grenville Stormont, Dundas, & Glengarry Frontenac Ottawa Lanark Renfrew Lennox & Addington	Nipissing Parry Sound Timiskaming Cochrane Sudbury District Sudbury Region Manitoulin	Algoma Thunder Bay Kenora Rainy River

OR = Outer Ring; * Note that Norfolk is not part of the GGH, however it is included in this study due to historical data limitations in separating data for Haldimand and Norfolk

4.1.4 Definitions

This section provides definitions for some terms for the demand analysis.

4.1.4.1 Aggregate related terms

- **Aggregate** - includes sand, gravel, limestone, dolostone, crushed stone, rock other than metallic ores, and other prescribed material. In this section, aggregate is considered in total, as well as broken into two main groups:
  - Sand and gravel
  - crushed stone and other (primarily limestone and dolostone)
- **Aggregate consumption** – the number of tonnes of aggregate (from both primary and secondary sources, see additional definitions below) used in various applications in a given geographic area during a given time period. As discussed in the report, aggregate consumption in a particular area of Ontario may derive from a variety of sources, including new locally produced aggregate, imports from other provinces and countries, aggregate produced in other areas of Ontario, and recycled product.
- **Aggregate demand –** in this study the term "demand" is used interchangeably with consumption. Technically, "demand for aggregate" is a related, but somewhat different, concept. Demand is an economics term which essentially measures how much of a product or service would be purchased/consumed at varying price points (this relationship is the "demand curve"). The scope of required "demand" work as indicated in the Request for Proposal was primarily related to the "consumption" definition – that is, how much aggregate has been used in the past, and might be expected to be used in the future.
- **Per capita aggregate consumption** – total consumption divided by total population.
- **Primary aggregate production** – newly produced aggregate, taken directly from pits and quarries (sometimes also referred to as "virgin" aggregate to differentiate it from recycled and substitute materials). In Ontario, high quality data on primary aggregate production is compiled and reported each year by The Ontario Aggregate Resources Corporation (TOARC).
- **Secondary aggregate** – recycled aggregate and substitute materials. Data on secondary sources of aggregate are less readily available than for primary aggregate production. In this report, recycling estimates rely largely on work conducted by LVM Jegel as part of the 2009 SAROS study (**Paper 4: Re-use and Recycling**), as this is still the most comprehensive information available on the topic.

4.1.5 Note

This section relies on information from a variety of secondary sources. While every effort is made to ensure the accuracy of the data, we cannot guarantee the complete accuracy of the information used in this report from these secondary sources.

In addition, due to the lack of comprehensive data for some of the series analyzed, it was necessary as part of this exercise to prepare estimates based on more limited available information.

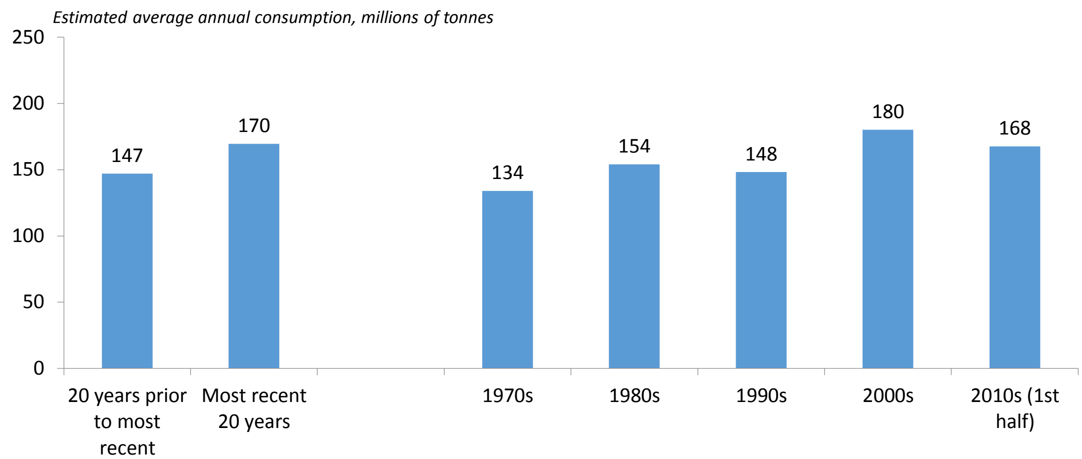
4.2 Aggregate Consumption Patterns in Ontario and the GGH

This section examines past consumption patterns for aggregate in Ontario.

4.2.1 Ontario-wide Historical Trends

- Over the past 20 years (1995-2014), Ontario has consumed approximately 170 MT of aggregate per year (a total of about 3.4 billion tonnes), up from an average of about 147 MT per year in the previous 20 year period (Figure 4-2).[3]

Ontario's total consumption of aggregate has been on a generally upward path



Source: Estimates by Altus Group based on information from MNRF, TOARC and StatCan

Figure 4-2 Average Annual Historical Aggregate Consumption, Ontario

- During the 2010-2014 period, average annual consumption was lower than during the decade of the 2000s, reflecting the relatively more sluggish economic growth.
- Consumption of aggregate can fluctuate significantly from year-to-year (Figure 4-3). Over the period since 1981, aggregate consumption has ranged from an estimated low of just over 100 MT in recession-ravaged 1982, to over 200 MT in the strong building days of the latter 1980s.

[3] These consumption estimates are based on data on primary local aggregate production (as measured by TOARC, and previously MNR and MNDM, production data), as well as estimates of international trade in aggregates (imports and exports) from Statistics Canada data and estimated use of recycled material. Note that 2014 was the latest year for which actual TOARC production data was available at the time of this study.

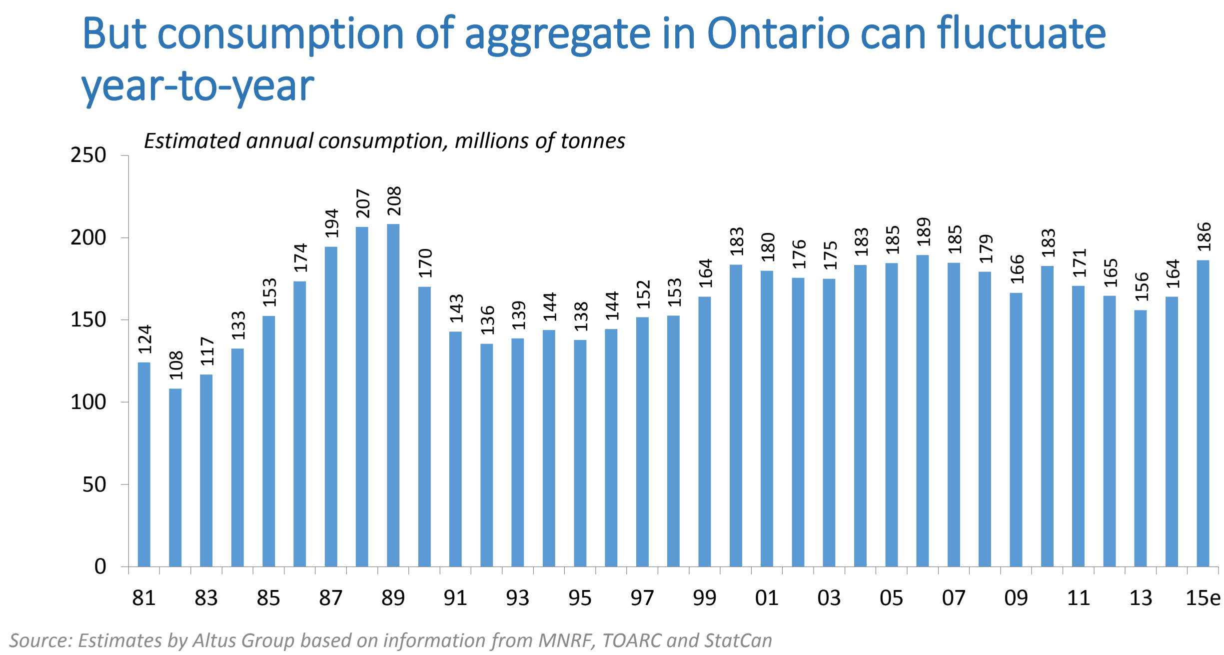


Figure 4-3 Aggregate Consumption by Year, Ontario

- The annual level ramped up in the latter 1980s – almost doubling in the space of only six years – before dropping back down in the early 1990s.
- After being on a generally upward path since the early 1990s, aggregate consumption was negatively impacted by the recession of the latter 2000s, but has picked up again in recent years.
- Over the past 20 years, the total amount of aggregate consumed in the Province of Ontario has been equivalent to just under 14 tonnes per capita on average per year (Figure 4-4) – about 12% lower than during the previous 20 year period.

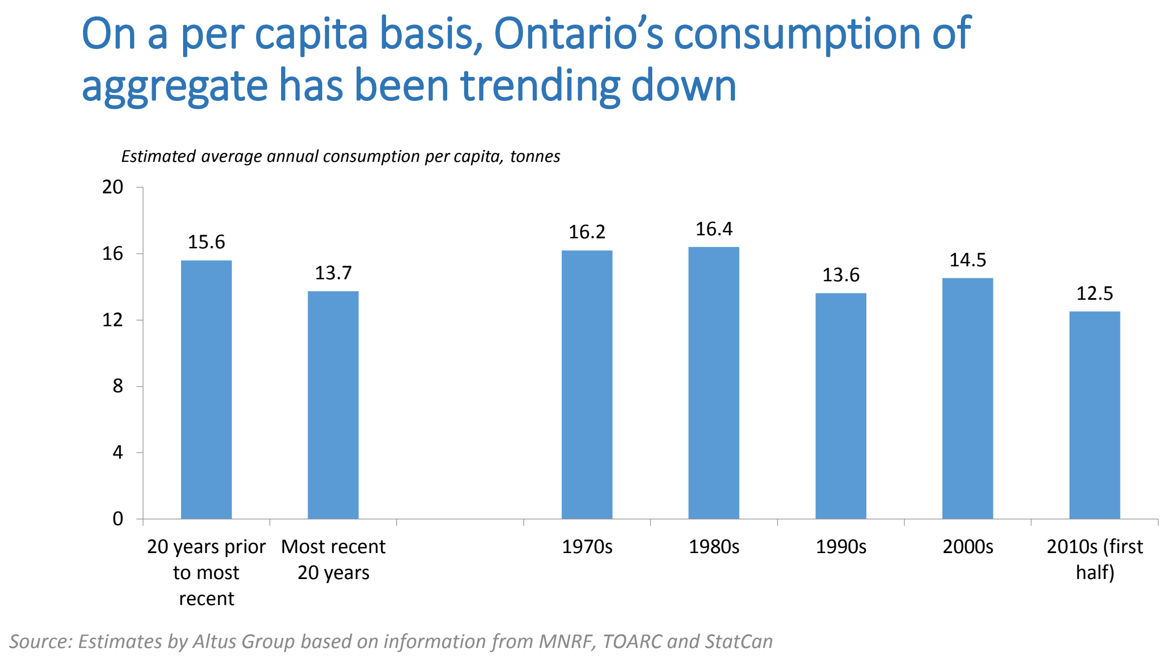


Figure 4-4 Average Annual Aggregate Consumption per Capita, Ontario

- The per capita pattern, however, has not been consistently downward. During the recessionary period of the early 1990s for example, per capita aggregate consumption saw a significant decline but was followed by a period of upturn, before declining again in conjunction with the slower economic growth of the latter 2000s/early 2010s.

4.2.2 Where the Aggregate Ontario Uses Comes From?

- Ontario's aggregate consumption is filled by two general types of material:
  - **Primary aggregate:** Newly produced sand and gravel, and crushed stone, taken directly from pits and quarries (sometimes referred to as "virgin" aggregate); and
  - **Secondary aggregate:** Recycled aggregate and substitute materials.
- Most of the aggregate used in Ontario is primary aggregate (Figure 4-5). Of the 168 MT of aggregate used on average each year over the 2010-2014 period, it is estimated that about 92% was comprised of primary aggregate.
- While still only a modest contributor to Ontario's overall aggregate use, the proportion of demand filled by secondary material (essentially recycled material) has grown, up from about 4% in the early 1990s to the current estimate of about 8%.[4]

[4] Based on extrapolation of trends shown in SAROS Paper 4: Recycling and Re-use.

- Primary materials can be either produced locally, or imported from other provinces or countries. However, given the nature of the product, and transportation costs, there is little trade in aggregate between Ontario and other areas.
- Imports to Ontario during the 2010-2014 period accounted for only about 2% of the primary aggregate consumed (or roughly 3 MT per year).[5] The majority of the imports are from the U.S., in particular the states bordering the Great Lakes region (primarily Michigan and Ohio).

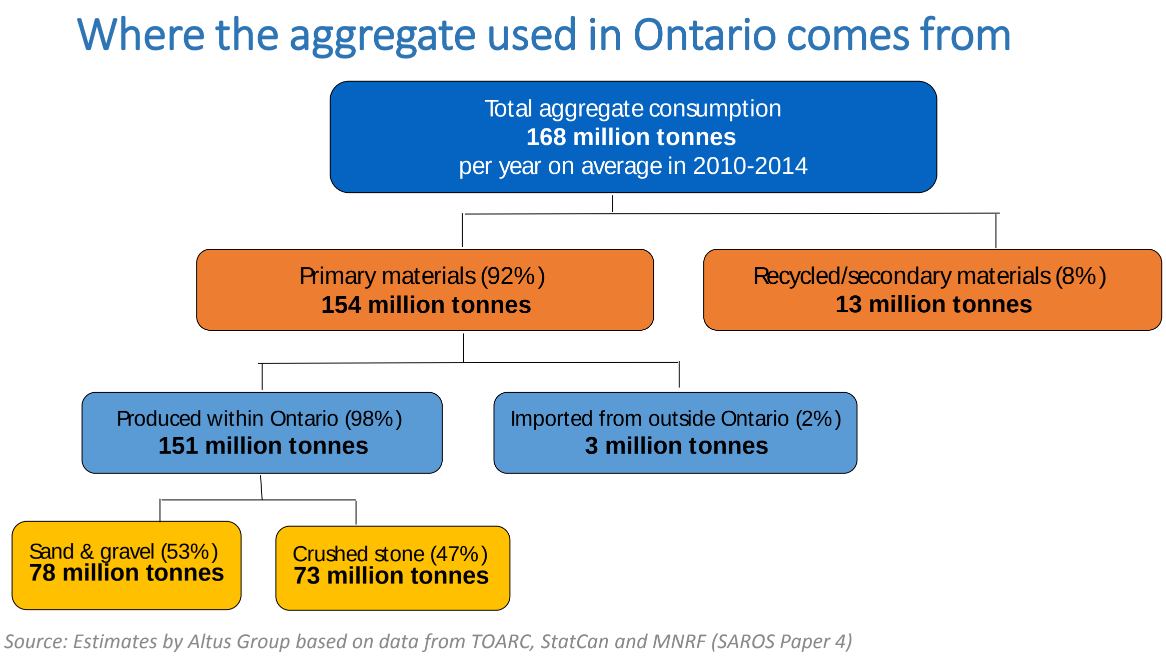
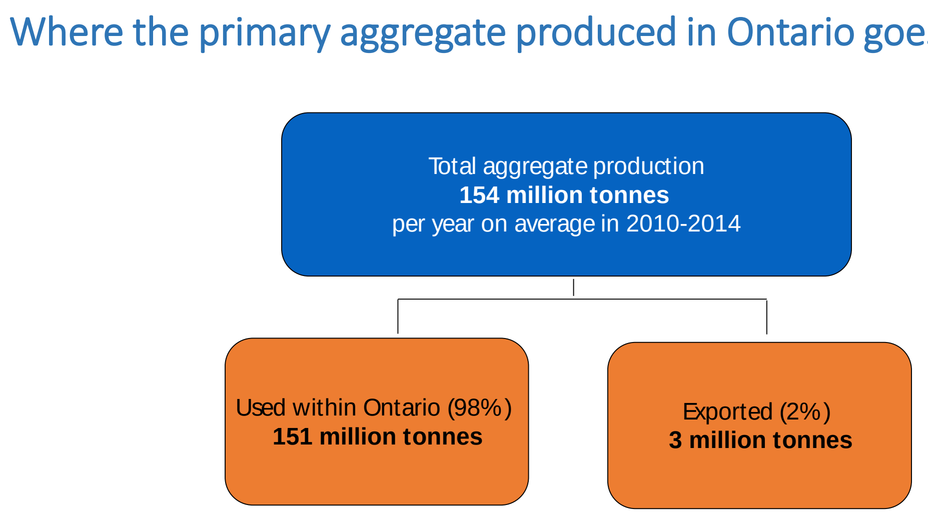


Figure 4-5 Sources of Aggregate Used in Ontario

[5] This is based on international trade statistics. Information on movements of aggregate between Ontario and other provinces is not known, however the quantities are considered to be minimal. Exports of aggregate from Ontario during the 2010-2014 period averaged about 3 MT per year, roughly the same amount as imports.



Source: Estimates by Altus Group based on data from TOARC and StatCan

Figure 4-6 Disposition of Primary Aggregate Produced in Ontario

- Production from within Ontario accounted for the vast majority of primary aggregate consumed in Ontario (98% in 2010-2014) and of total aggregate supply (over 90%). In the five year period, that amounted to a contribution of about 151 MT per year on average from Ontario's own pits and quarries.[6]
- Annual primary production in Ontario of aggregate compared to total consumption is shown on Figure 4-7. These primary production numbers are as reported by TOARC (and previously MNR and MNDM), with 2015 an estimate based on Statistics Canada data (TOARC information for 2015 was not available at the time this study was conducted).

[6] This estimate excludes an estimated 3 MT per year of aggregate produced in Ontario during the 2010-2014 period that was exported to other countries, the vast majority to the U.S. Great Lakes region. Total average annual production of primary aggregate in Ontario during the 2010-2014 period was therefore about 154 MT.

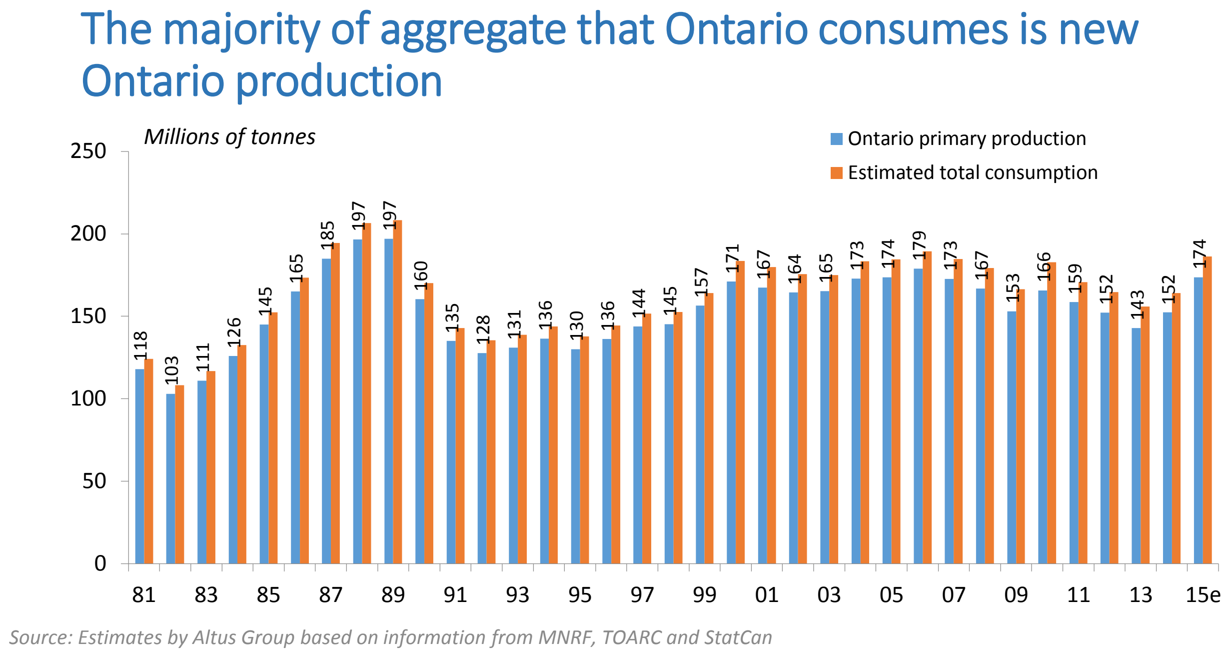


Figure 4-7 Annual Primary Production of Aggregate Compared to Total Consumption, Ontario

- Most of the primary aggregate produced in Ontario is used in Ontario. During the 2010-2014 period, exports averaged an estimated 3 MT per year, or about 2% of total production (refer back to Figure 4-5).
- During the 2010-2014 period, slightly more than half of the primary aggregate produced in Ontario was sand and gravel, and slightly less than half was crushed stone.[7]
- Crushed stone's relative role in aggregate consumption has grown over the past 25 years, from about a one-third share on average in the latter 1980s to almost half on average per year during the 2010-2014 period (Figure 4-8).

[7] The crushed stone estimates throughout this report include "other" types of aggregate (clay/shale, building stone, industrial stone and dimension stone); these account for only about 2% of all primary aggregate production in Ontario.

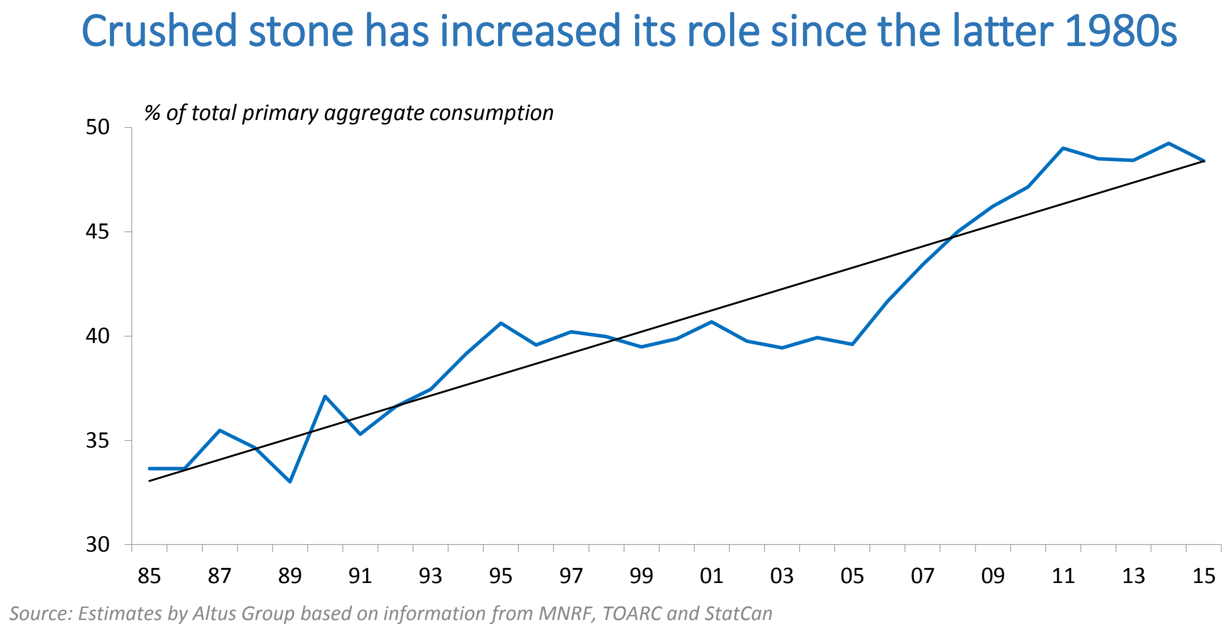
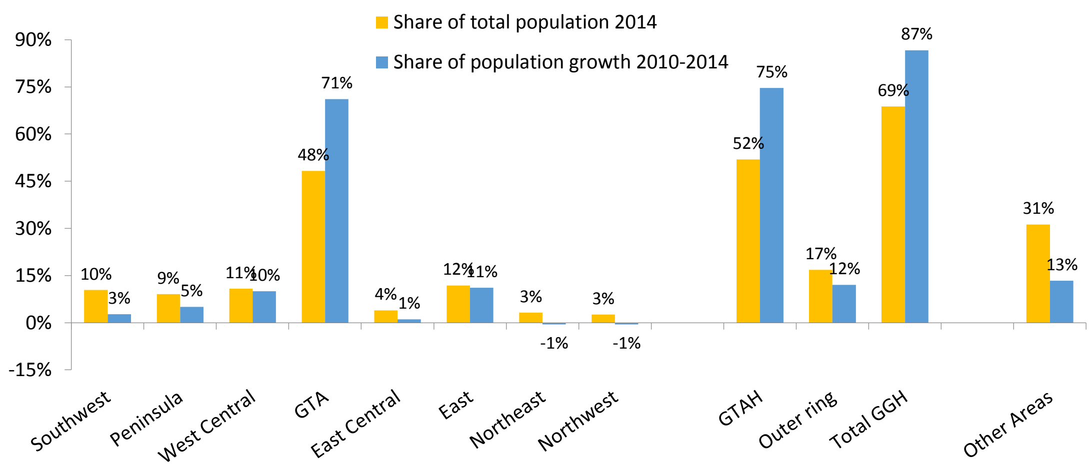


Figure 4-8 Crushed Stone as a % of Total Consumption of Primary Aggregate, Ontario

4.2.3 Aggregate Consumption Patterns by Area within Ontario

- As discussed in Section 4.2, the sub provincial analysis is this report is presented based on both the eight geographic zones considered in previous studies, as well as for the area that is the focus of the current study – the GGH. Given the focus on the GGH, the comments that follow are centred around this area.
- To provide context, it is helpful to look at population patterns within Ontario.
- The GGH is home to two out of every three Ontario citizens (Figure 4-9), and accounted for the vast majority of the province’s population growth in the 2010-2014 period.

2 out of 3 Ontarians live in the GGH – and it captures the majority of population growth



Source: Altus Group based on StatCan data

Figure 4-9: Total Population and Population Growth by Geographic Area within Ontario

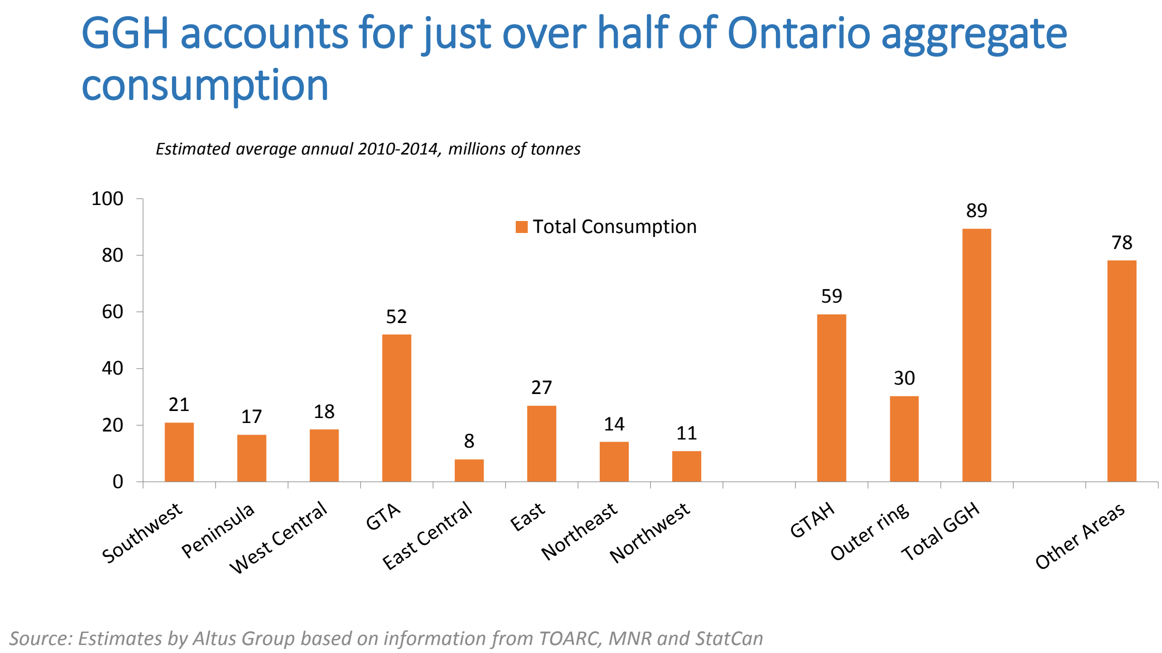


Figure 4-10: Total Population and Population Growth by Geographic Area within Ontario

- Given its sizeable and growing population base, it is not surprising therefore that the GGH has accounted for the lion's share of total Ontario aggregate consumption (Figure 4-10) – just over half of the total of 168 MT consumed in Ontario per year in the 2010-2014 period.
- While considerable, the GGH's share of aggregate consumption is below its share of population growth and total population, reflecting lower per capita consumption than the Ontario average (Figure 4-11).
- The highest per capita consumption of aggregate is in Northern Ontario (the Northeast and Northwest geographic areas). This in part reflects more intensive use of aggregate in road building due to more severe climate, as well as generally higher use of aggregate per capita in lower density areas due to need for, but less intensive use of, infrastructure. The opposite is true for the more densely populated areas of the GGH, in particular the GTA.

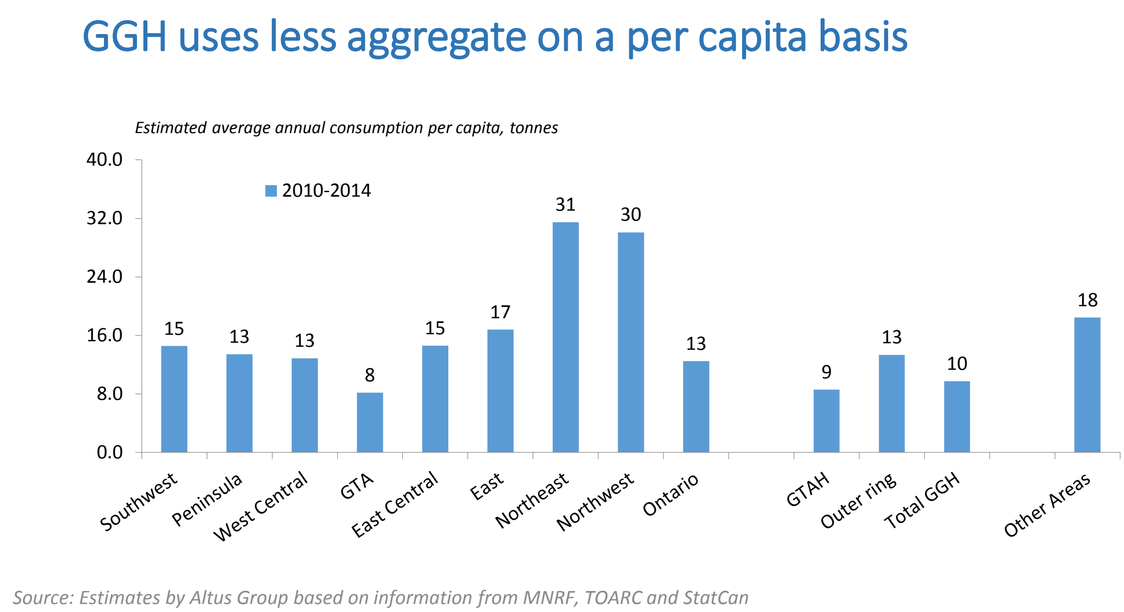


Figure 4-11: Per Capita Consumption of Aggregate by Geographic Area within Ontario

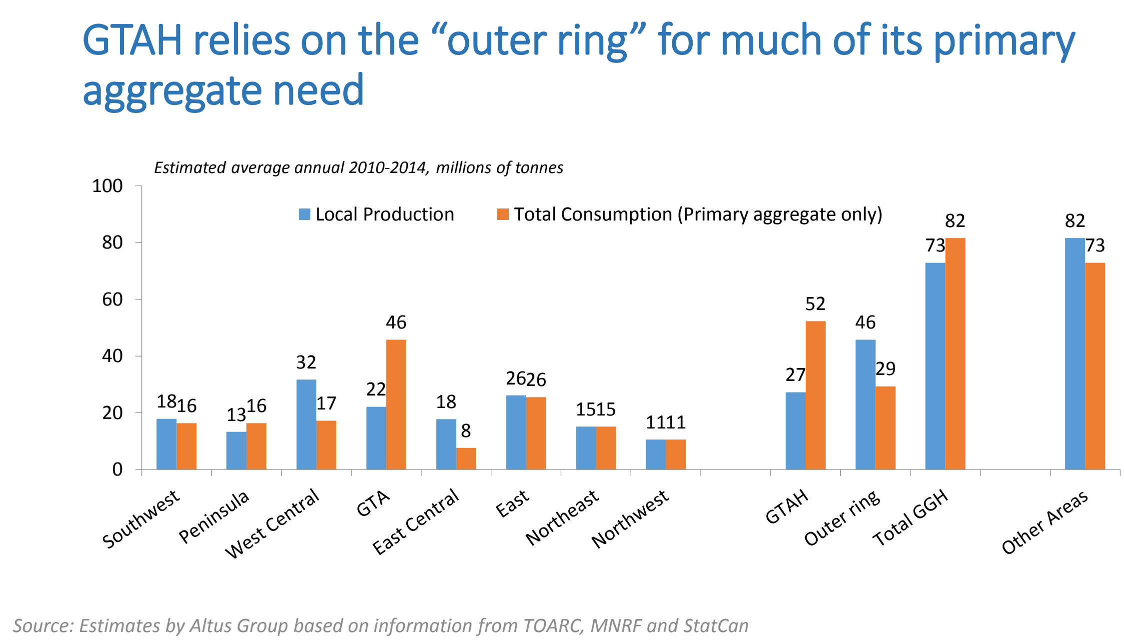


Figure 4-12: Comparison of Primary Aggregate Consumption and Local Primary Production by Area within Ontario

- For most of the eight geographic areas, the aggregate consumed comes from primary or secondary aggregate produced locally within those areas (Figure 4-12).

- However that is not the case for the GTA, which relies on "excess production" from neighbouring areas, in particular the West Central and East Central areas (including areas within the outer ring of the GGH), to provide a large portion of what it uses.

4.3 The Use of Aggregate

The preceding section examined the extent to which Ontario and the GGH uses aggregate each year. This section briefly examines the extent to which aggregate is used in construction versus other uses, the shares accounted for by different types of construction and how intensively it is used per dollar spending of construction of different types.

4.3.1 The Main Uses of Aggregate

- Aggregate can be used in a variety of applications, including various types of construction work and manufactured products. Some applications are shown on Figure 4-13.

Aggregate is used in many different applications

- abrasive cleanser
- agricultural purposes and fertilizer plants
- agricultural soil supplements
- asphalt aggregate
- automotive frames
- automobiles and aircraft parts
- automotive & vehicular glass & glazing
- backfill for mines
- bake & culinary ware
- bridges
- buildings (office, hospital, schools)
- carpet
- catalytic converters
- concrete aggregate
- container packaging
- cosmetics
- crushed glass (for water filtration)
- emergency flood retention
- fibre glass
- flat glass
- flux in iron and steel plants
- housing
- ice control (road sand)
- industrial flue scrubbers
- landfill cover
- landscaping
- light bulbs
- lime kilns
- medical research instruments
- metal cast moulding
- metal casting
- mild abrasive
- military field fortification
- mirrors
- monumental and ornamental
- mortar sand
- parking lots
- pharmaceuticals
- photovoltaics
- piers & wharfs
- pipes (main and sewers)
- power plants
- pulp and paper mills
- railway ballast
- railway bedding
- recreational sand
- glass tile
- retention walls
- riverbed lining
- road metal
- roads & highways
- roads: Ice control
- roads: road bed, surface
- roofing granules
- rubble and riprap
- runways
- Sandblasting
- septic system/beds
- shoreline protection
- sidewalks
- soil remediation
- streetcar & tram brake systems
- stucco dash
- subway tunnels
- sugar refineries
- surgery instruments
- tableware
- toothpaste
- tunnels
- TV & computer screens
- washing detergent
- water filtration
- wind turbines

Source: Compiled by Altus Group

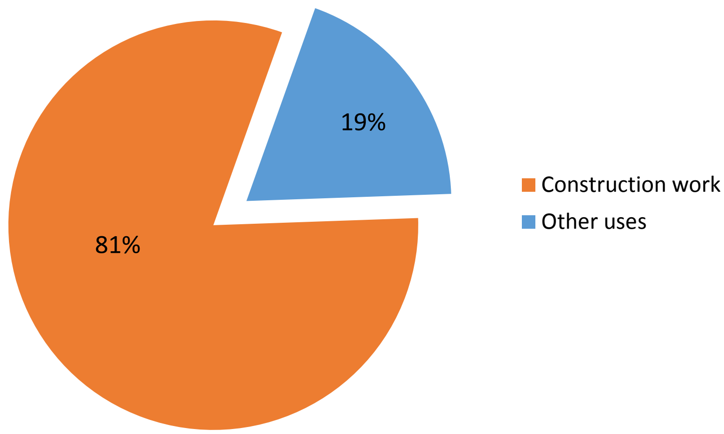
Figure 4-13: Examples of Uses of Aggregate

- Unfortunately, data is not available to quantify the amounts of aggregate that go into each type of specific use. However, the relative role of construction work versus other uses can be derived from information from Statistics Canada's Input-Output model of the Canadian economy.

- This analysis indicates that construction work accounts for the majority of aggregate consumed in Ontario. During the 2010-2014 period, an estimated 81% of the total aggregate consumed in Ontario was used in various construction applications (Figure 4-14); this is similar to the shares that were identified in the SAROS study for the 2000-2009 period.

Construction work is the major user of aggregate

% of total primary aggregate use, Ontario, 2010-2014



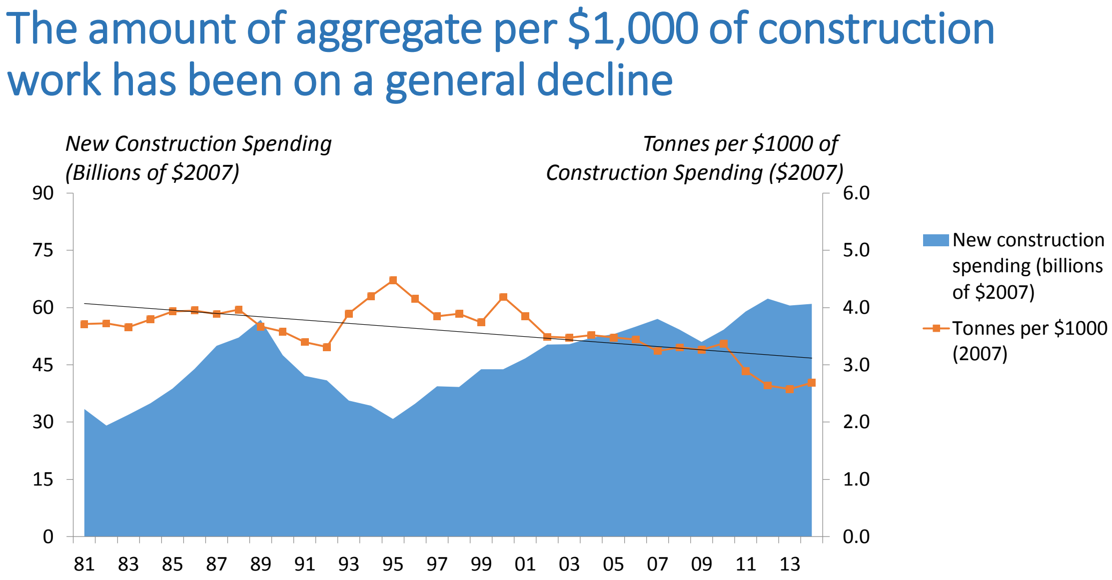
Source: Estimates by Altus Group based on StatCan 2011 National Input-Output model

Figure 4-14: Use of Aggregate in Construction vs. Other Uses, Ontario

- Some of this was aggregate that went directly into construction work (about two-thirds of total construction related aggregate); the remainder was indirectly used in construction, through building products such as ready-mix concrete, manufactured concrete products, and other building materials such as roofing tiles.
- The tonnes of aggregate used per $1,000 of total construction spending has been on a generally downward trend since the early 1980s.[8]
- For every $1,000 (in real 2007 dollars) spent on new construction work during the 2010-2014 period, there was a corresponding use of about 2.8 tonnes of aggregate (primary and secondary combined) on average per year (Figure 4-15). [9] The comparable figure for the early 1980s was about 3.8 tonnes.

[8] The pronounced lower intensity levels in the early 1990s reflected that construction spending during that period was primarily work that lingered from the non-residential overbuilding in the latter 1980s; much of the initial stages of work on these buildings (aggregate is typically used in the earlier stages of this type of work) would have been completed by the early 1990s.

[9] Note that no adjustment has been made here to exclude aggregate used in non-construction activity, due to lack of comprehensive information on annual trends in that component. Also, given lack of a good time series on repair construction, the chart only uses new construction work to illustrate the general trend.



Source: Estimates by Altus Group based on information from MNRF, TOARC, MOF and StatCan

Figure 4-15: Construction Spending by Type and Total Intensity of Use of Aggregate, Ontario

4.3.2 Aggregate Use in Different Types of Construction

- During the 2010-2014 period, new road construction in Ontario accounted for a relatively small share of total construction dollars, but almost 40% of construction-related aggregate use (Figure 4-16). Roads are estimated to account for most of the aggregate use related to repair work. Combined, therefore, new and repair road work are estimated to have accounted for close to half of the aggregate used in the 2010-2014 period.
- It is important to note that the public sector plays a key role in aggregate consumption through its roadbuilding and other infrastructure related programs (the latter most of which is included in “new other engineering”).

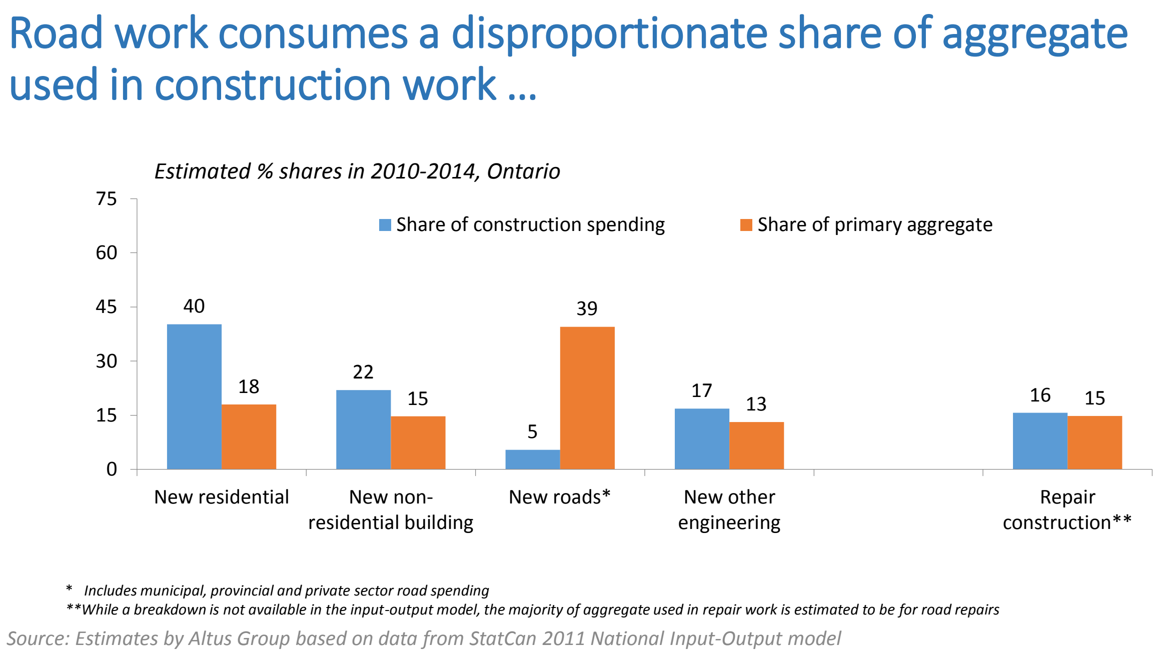


Figure 4-16: Use of Aggregate in Construction Work by Type of Construction, Ontario

- The amount of aggregate used per $1,000 of spending varies by type of construction work, with significantly more aggregate being used per dollar spent on road construction than other types of construction work (Figure 4-17).

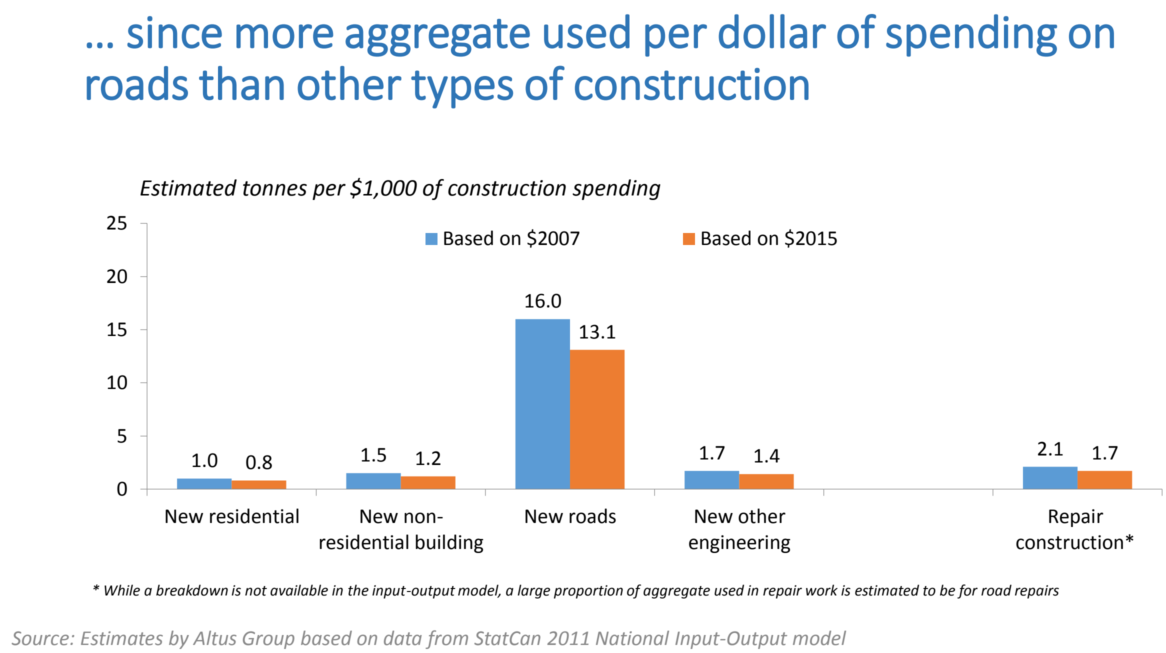


Figure 4-17: Amount of Aggregate Used Per $1,000 of Construction Spending by Type of Construction, Ontario

4.4 The Future Consumption of Aggregate in Ontario and the GGH

This section examines the prospects for future consumption of aggregate in Ontario as a whole, for each of the eight geographic areas and for the GGH.

4.4.1 Review of Past Projections

- Figure 4-18 provides a comparison of projections of the demand for aggregate in Ontario from previous studies.

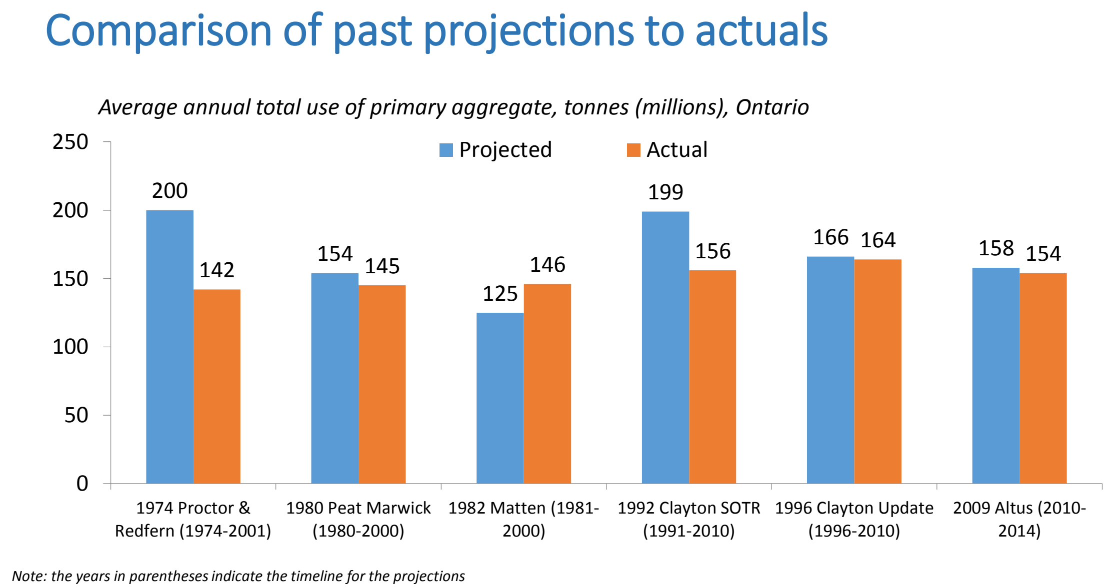


Figure 4-18: Comparison of Past Ontario Projections of Aggregate Use

- The various projections have had mixed performance results.
- The most recent projection from the 2009 SAROS study (Paper 1) performed reasonably well, with the projection for the 2010-2014 period for Ontario as a whole coming close to the actuals recorded.
- As such, the same methodology as the SAROS study has been adopted for the current study, as described in the next section.

4.4.2 The Projection Methodology

The projections of aggregate demand prepared for this study use a "per capita usage" approach. This is the same methodology used in the 2009 SAROS study (and is documented in more detail in that report). The key components of the methodology are outlined below:

- The methodology applies an assumption about per capita aggregate consumption to projections of total population – which is a relatively simple process.
- The key population data required for the exercise are readily available, as long-term projections of total population are prepared on a regular basis by the Ontario Ministry of Finance, for Ontario as a whole as well as for each census division, which can then be compiled into projections for each of the 8 geographic areas and the GGH.
- It is recognized however that a constant per capita assumption would not be reasonable. As shown previously, over the longer-term, per capita usage has been gradually declining. However, it also tends to be above trend in periods of stronger economic activity, and below trend in periods of weaker economic activity.

- Regression analysis is used therefore to help to determine the future trends in per capita aggregate consumption. Regression analysis statistically identifies the relationship between a dependent variable (in this case, per capita consumption of aggregates in Ontario) and a set of independent variables.
- The independent variables included in the regression model in this study are the same as those used in the 2009 SAROS study model (these variables are all variables contained in typical long-term Ministry of Finance economic projections):
  - total population
  - population growth
  - housing starts
  - real GDP growth (%)
  - unemployment rate (%)
- The regression model from the 2009 SAROS study was updated to include historical data for the 2010-2014 period. The updated regression model was then used to do initial runs of per capita usage. Some adjustments were then made to account for factors outside the model variables that might impact future trends in per capital aggregate usage, including
  - Major infrastructure spending outside of the "steady state" (specific infrastructure projects in the GGH and associated aggregate usage are discussed in the next section); and
  - An allowance later in the period for potential gains in road life as higher quality aggregates are used more often. The use of high quality crushed stone in road construction is increasing, particularly in urban settings where high volumes and heavy loads are encountered. This trend is expected to continue for both ongoing maintenance and new construction. This trend to the use of more high quality stone may result in reduced repair/maintenance in future, although any impact on per capita aggregate consumption would not likely be felt until later in the projection period.

4.4.3 The Economic and Population Growth Outlook

- The future economic and population outlook are key inputs into the model of future aggregate consumption.
- In terms of the economic outlook for Ontario, projections prepared by the Ministry of Finance[10] suggest that over the next 20 years as a whole, the province can be expected to record moderate average annual real GDP growth of just over 2% - somewhat below the average of the last 20 years (Figure 4-19).

[10] For the 2016-2020 period, the projections are from the 2016 budget documents. Post 2020, projections are from Ministry of Finance's 2014 report Ontario's Long-Term Report on the Economy.

Moderate economic growth to continue

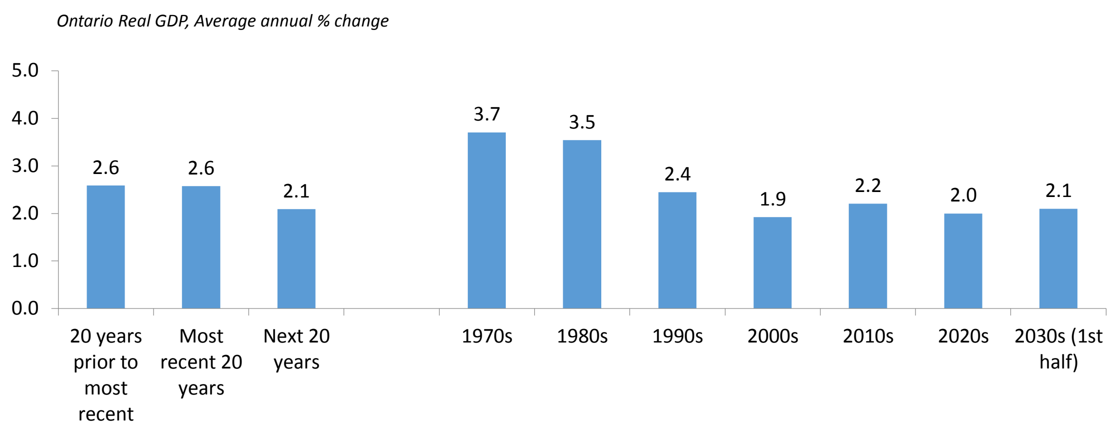
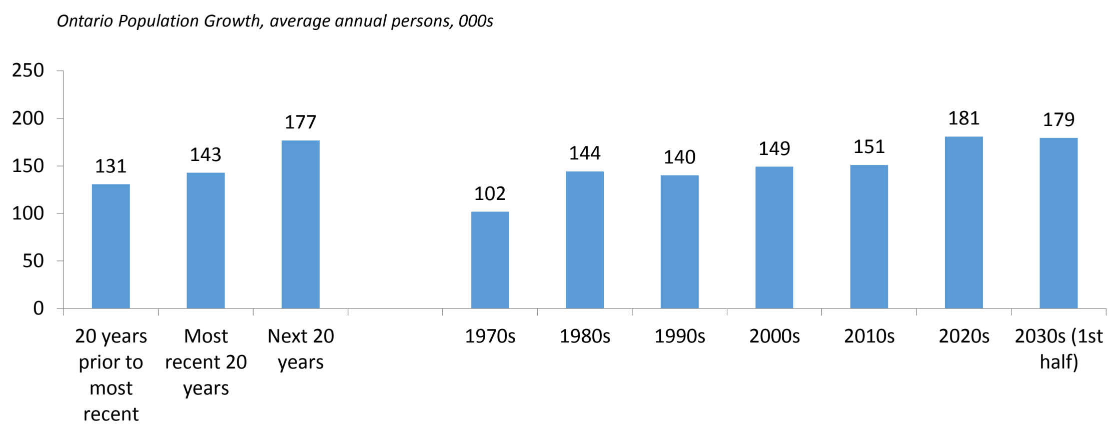


Figure 4-19: Projected Average Annual Real GDP Growth, Ontario

- The population of Ontario is projected to grow strongly over the next 20 years.
- Projections prepared by the Province[11] suggest that Ontario's population will grow by about 175,000 persons per year on average over the next 20 years – above the growth in the past 20 years (Figure 4-20).

[11] For the disaggregation by geographic area, the updated projections for the Greater Golden Horseshoe prepared by Hemson Consulting have been adopted (which are based on the compact growth scenario); for other areas of the province, the 2015 Ministry of Finance projections of growth are used. The province totals are the sum of the projections for the GGH and other areas.

Stronger population growth expected in terms of number of people

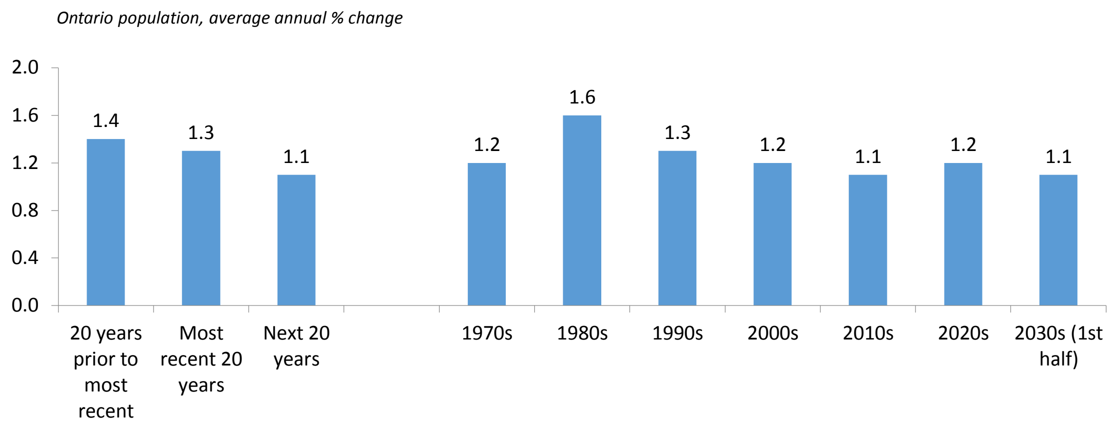


Source: Altus Group based on information from Statistics Canada and Ministry of Finance

Figure 4-20: Projected Average Annual Total Population Growth, Ontario

- The rate of population growth however – which measures absolute growth against the size of the existing population base – will be lower in the next 20 years than the most recent 20 years (Figure 4-21).
- In terms of the number of people, growth will continue to be focused in the GGH (Figure 4-22).
- However some of the relative growth within the GGH is expected to shift to the Outer Ring from the GTAH

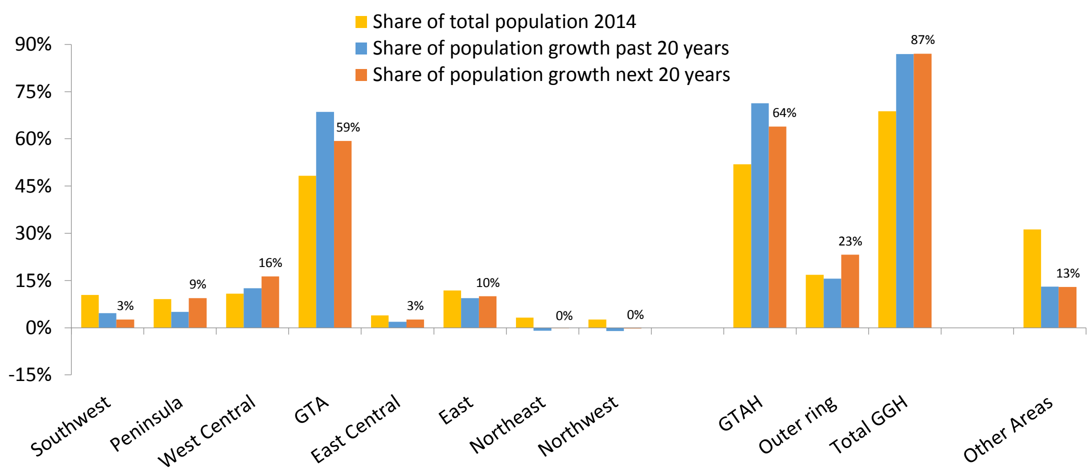
But slower population growth rate



Source: Altus Group based on information from Statistics Canada and Ministry of Finance

Figure 4-21: Projected Average Annual Population Growth Rate, Ontario

GGH expected to capture the majority of population growth in the province over next 20 years



Source: Altus Group based on data from Statistics Canada and Ministry of Finance

Figure 4-22: Share of Future Population Growth by Geographic Area

4.4.4 Per Capita Aggregate Consumption Trends

- Based on the economic and population growth scenario outlined it the previous section, as well as assumptions on future housing starts and the unemployment rate, an initial projection of per capita aggregate consumption was derived using the regression model outlined earlier.
- This initial projection showed lower average per capita consumption of aggregate in the next 20 years (12.6 tonnes per capita) compared to the most recent 20 years (which was 14.0 tonnes per capita).
- However, it was felt that there would likely be some moderate additional downward trend in per capita aggregate consumption due to the need for less repair and maintenance work as the role of higher quality stone increases. This impact would likely however not be felt until later in the projection period.
- The projections of per capita aggregate consumption are shown on Figure 4-23, next page.

4.4.5 Projected Consumption of Aggregate in Ontario and the GGH over the Next 20 Years

- The projections of per capita aggregate consumption were applied to the projections of total population outlined earlier to derive the projections of total aggregate consumption over the next 20 years.
- Ontario can be expected to consume in the order of 192 MT of aggregate per year on average over the next 20 years, both primary and secondary combined (Figure 4-24). This is above the average level of the last 20 years as a whole.

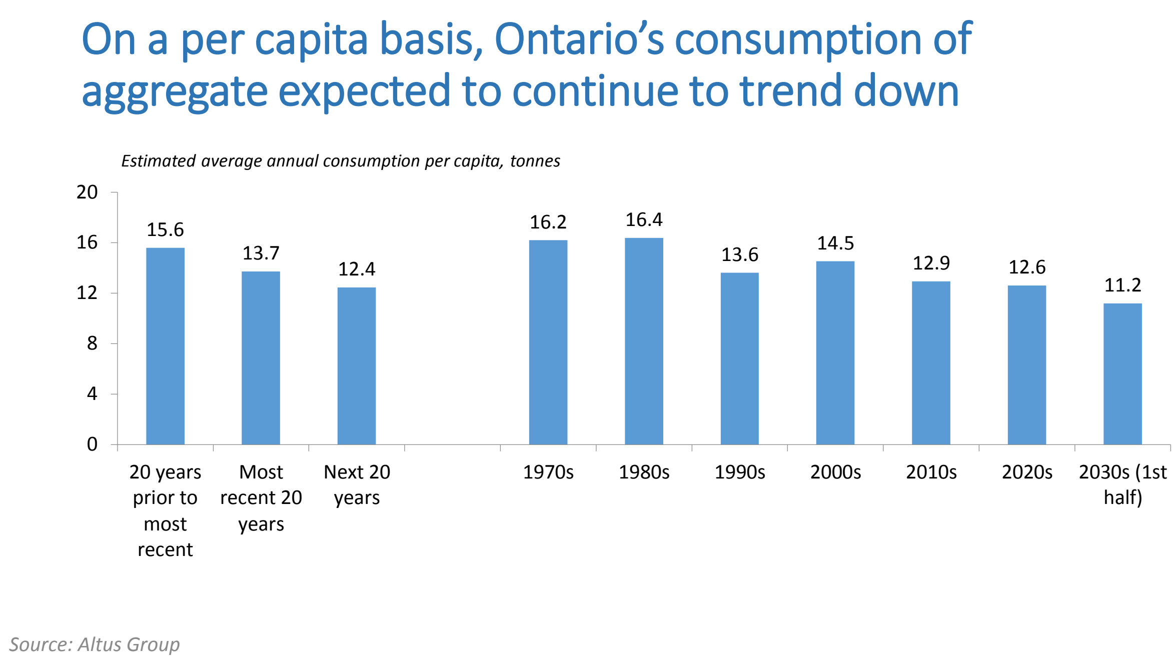
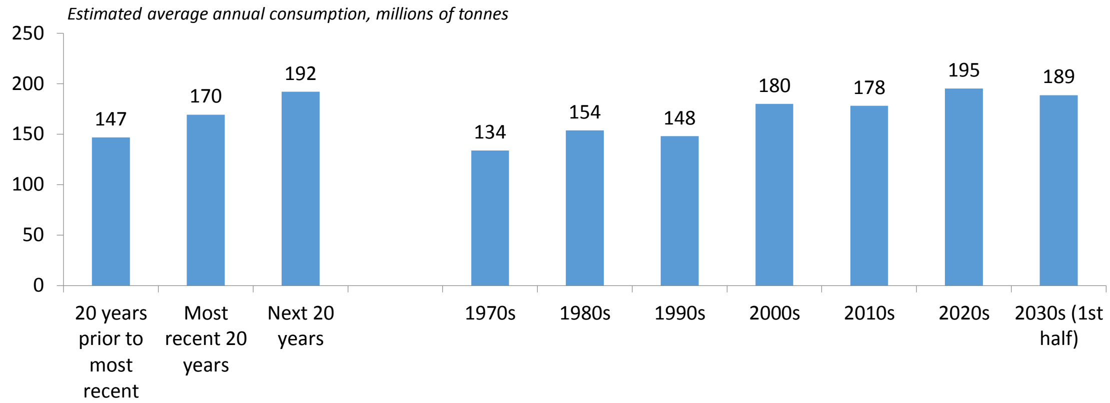


Figure 4-23: Projections of Future per Capita Aggregate Consumption, Ontario

Ontario's total consumption of aggregate expected to be higher next 20 years



Source: Altus Group

Figure 4-24: Average Annual Projected Total Aggregate Consumption, Ontario

- Note that the projections of future aggregate use should be viewed as being an "unconstrained" scenario. In particular, the projections assume that:
  - Increases in the future price of aggregate are more or less in line with general price increases in the economy (i.e., that aggregate prices do not experience any more substantial upward "shocks" that could impact underlying consumption patterns).
  - Sufficient aggregate is available to meet the expected underlying consumption patterns.
- Consumption of aggregate in the GGH is expected to be somewhat higher in the next 20 years compared to the most recent 20 years, and will continue to account for roughly one-half of the province's total aggregate use (Figure 4-25).

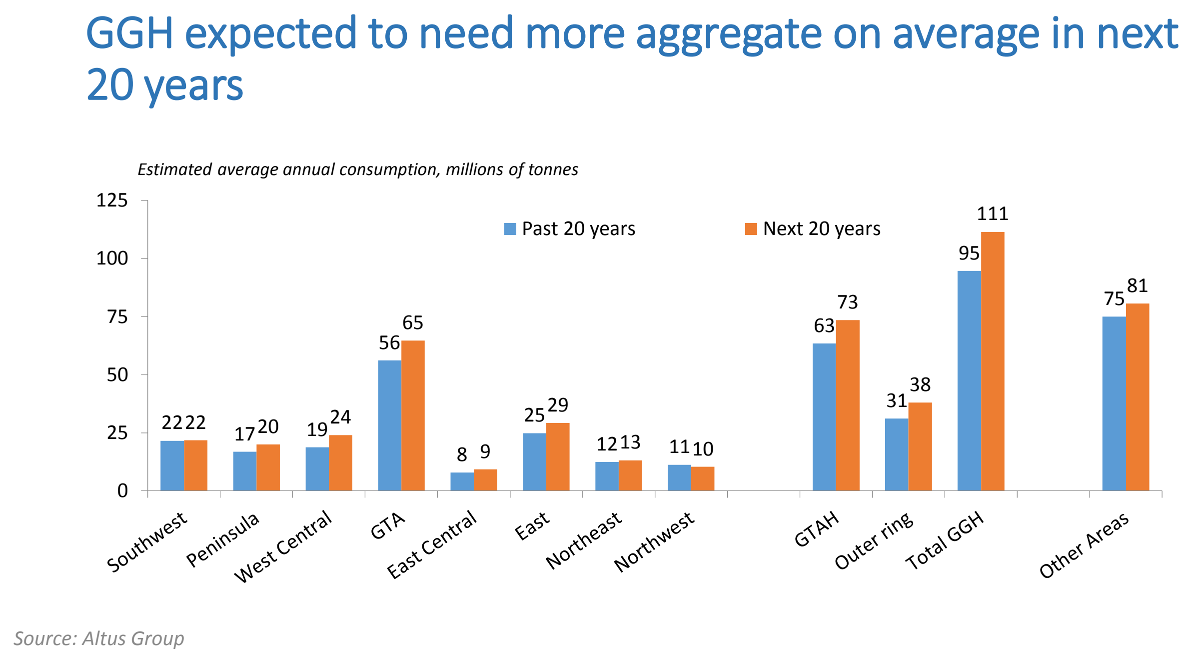


Figure 4-25: Projected Total Aggregate Consumption by Geographic Area within Ontario

- Most other areas of the province also will have higher average aggregate consumption levels than in the past 20 years, except for the Southwest and the Northwest.
- Note that the consumption figures shown on the charts above include both primary aggregate (locally produced and imported), as well as secondary sources.

4.4.6 Sources of Aggregate to Fill Future Need

- The likely sources of aggregate used in Ontario over the next 20 years given past trends are outlined on Figure 4-26.
- Primary sources of aggregate are expected to continue to fill the vast majority of need, although a slightly higher share is expected for recycled product.

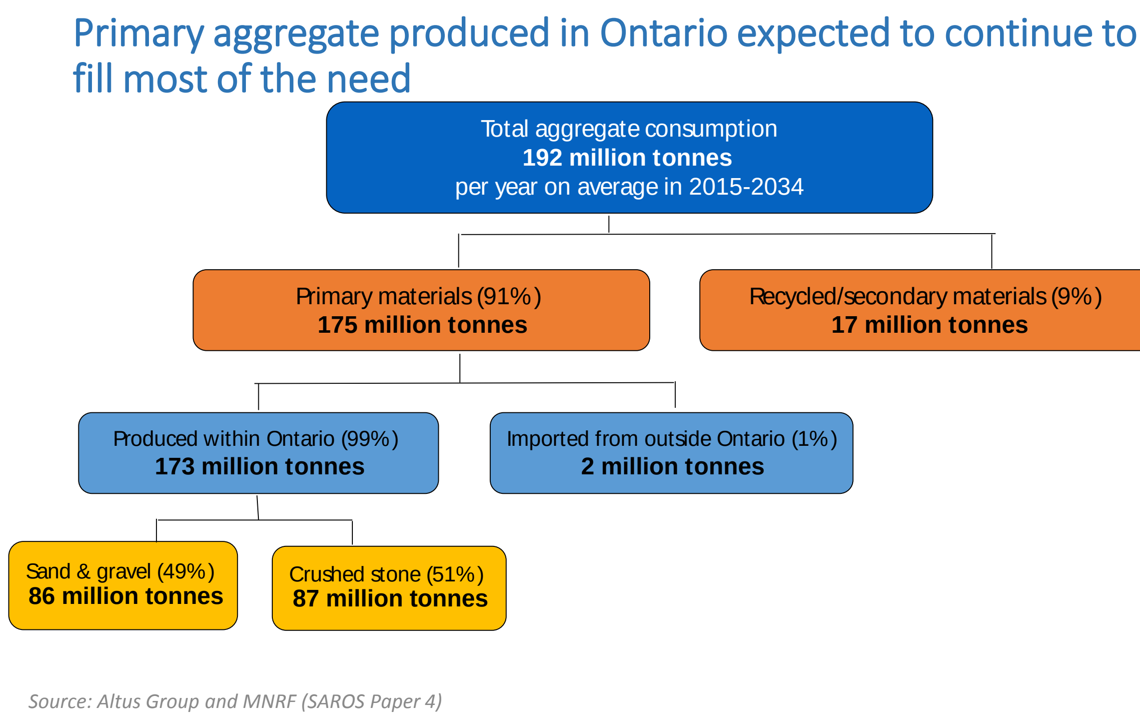


Figure 4-26: Sources of Aggregate over the Next 20 Years, Ontario

- The vast majority of primary aggregate is expected to continue to be supplied from Ontario operations.
- There is expected to be a continued, modest shift to the use of higher quality crushed stone, to just over half on average for the next 20 years.
- The GGH's needs would require just over 100 MT a year from Ontario production (Figure 4-27), with most of that coming from within the GGH itself (Figure 4-28).

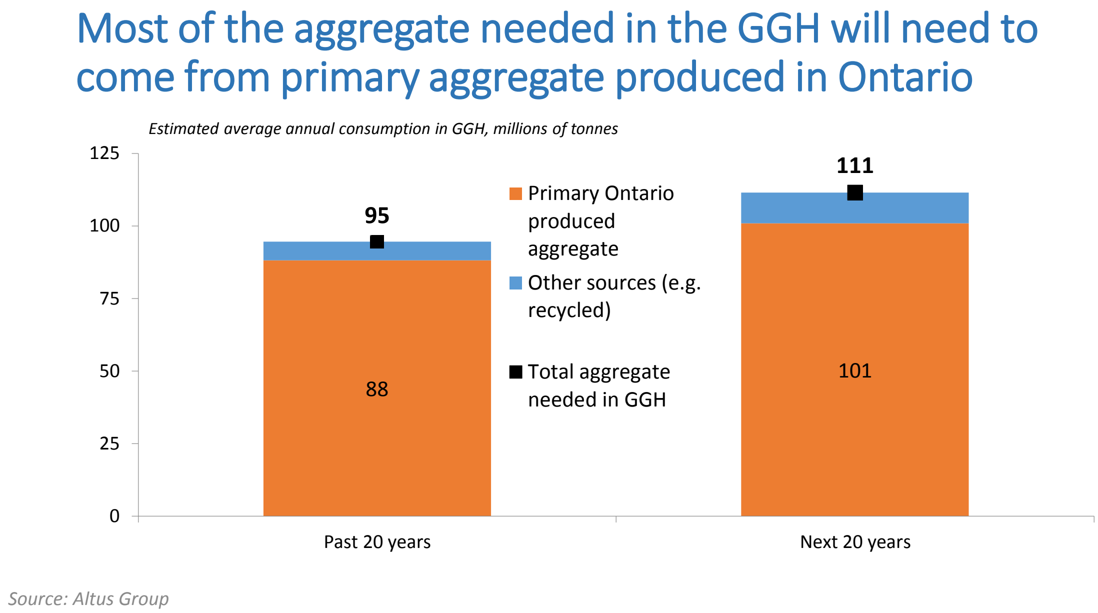


Figure 4-27: Aggregate Needed in the GGH over the Next 20 Years

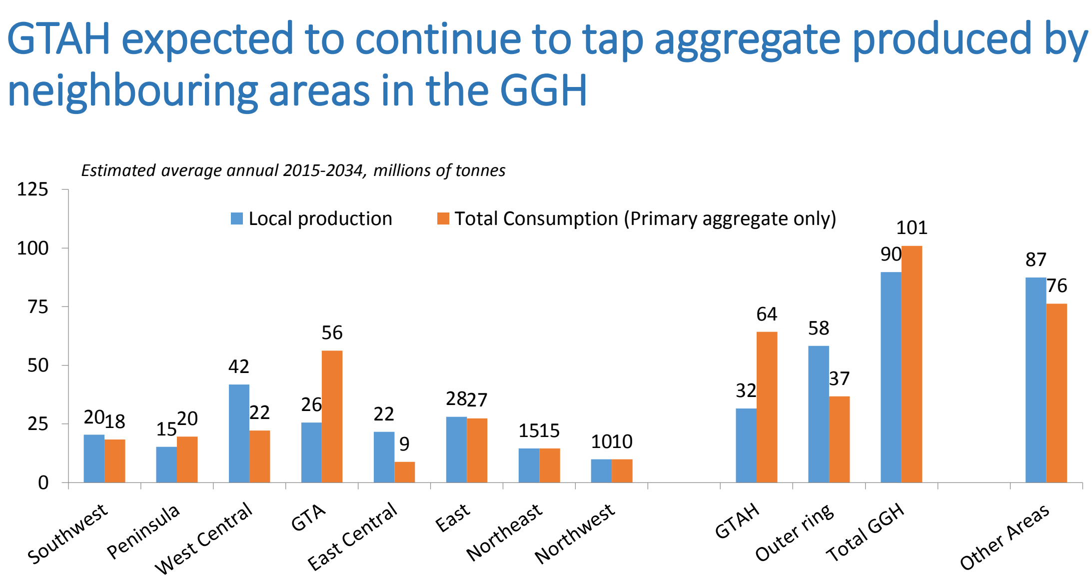
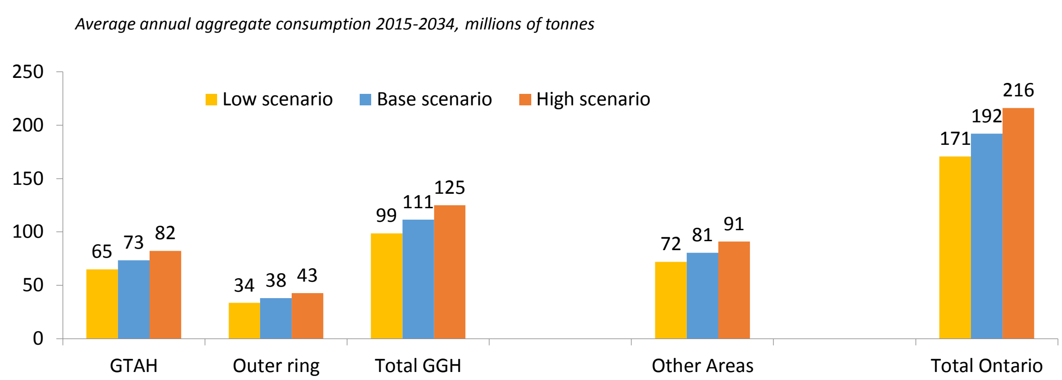


Figure 4-28: Comparison of Local Production and Consumption of Primary Aggregate by Area within Ontario, Next 20 Years

4.4.7 Alternate Demand Scenarios

- The projections discussed to date in this chapter reflect the “base case” scenario, which is one of moderate growth over the projection period.
- Two alternate projections were also generated, a low and a high growth scenario.
- For Ontario as a whole, the projections of aggregate need range from a low of 171 MT on average per year in 2015-2034 under the low scenario to 216 MT per year under the high scenario (Figure 4-29).
- For the GGH, the projections range from 99 to 125 MT per year on average.
- Even under the low scenario, the GGH would need as much aggregate over the next 20 years as over the past 20 years (Figure 4-30).

Two alternate scenarios of aggregate demand were generated



Source: Altus Group

Figure 4-29: Alternate Scenarios of Future Aggregate Consumption, Ontario and GGH

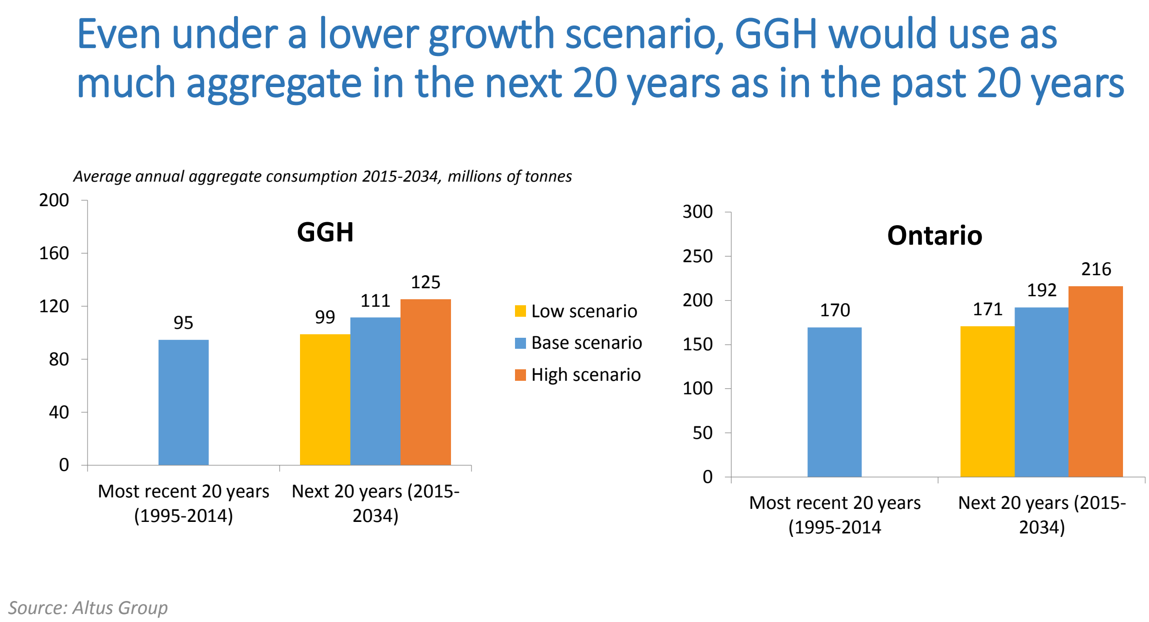


Figure 4-30: Comparison of Alternate Projections for Next 20 Years to Most Recent 20 Years

4.5 Aggregate Quantities Needed for Planned Major Infrastructure Projects in the GGH

This section assesses the aggregate quantities associated with specific larger public sector infrastructure projects in the GGH.

4.5.1 Methodology

The approach for assessing the need for aggregate associated with demand for major infrastructure projects in the GGH for the five to ten year horizons was as follows:

- Create lists of planned infrastructure projects in the GGH in the next five years in the three major sectors:
  - the Ministry of Transportation of Ontario (MTO);
  - Transit projects; and
  - Major Municipal Infrastructure projects
- Calculate approximate quantities of three types of aggregates (concrete aggregates, asphalt aggregates and unbound aggregates) required for the MTO projects planned in the next five years, based on typical drawings of past MTO projects;
- Calculate approximate quantities of three types of aggregates (concrete aggregates, asphalt aggregates and unbound aggregates) required for Transit projects planned in the next 5-10 years based on past project experience;

- Calculate approximate quantities of total aggregates required for Major Municipal Infrastructure projects planned in the next 5-10 years based on factors of aggregate usage per $1,000 of spending.

4.5.2 Key Information Sources

- MTO – discussions with representative, MTO Southern Highways Program 2015-2019, past MTO contracts
- Municipal Websites – Capital budget forecasts, DC Background Studies
- Transit Websites – Metrolinx, VivaNext, etc.
- Infrastructure Ontario Website – Planned projects
- SAROS Paper 1, 2009 – factors for typical projects
- Aggregate use per dollar of construction spending factors (updated for this study)

4.5.3 MTO Projects

- Ministry of Transportation Southern Highways Program 2015-2019 provides a listing of all forecasted MTO work in the West, Central and East Regions.
- From this list, the forecasted projects within the GGH were considered in the aggregate calculations. Furthermore, based on past MTO contracts, quantity take offs were carried out from selected contract drawings in order to estimate typical amounts of the various aggregates for the following types of projects:
  - New highway
  - Highway widening
  - Highway resurfacing
  - New interchange
  - Overpass bridge structure
  - New culvert
- Aggregates were split into three categories, as follows:
  - Aggregates in concrete mixes
  - Aggregates in asphalt mixes (note Precambrian sources for FC1 and FC2 aggregates were not specifically considered as a separate source in this study)
  - Unbound aggregates (Granular base, Granular sub-base, etc.)
- Estimated aggregate quantities for 2015-2019 forecasted MTO projects by broad type of work and broad type of aggregate are summarized on Figure 4-31 and Figure 4-32.
- In total, the five year need for MTO projects is estimated at about 20 MT.

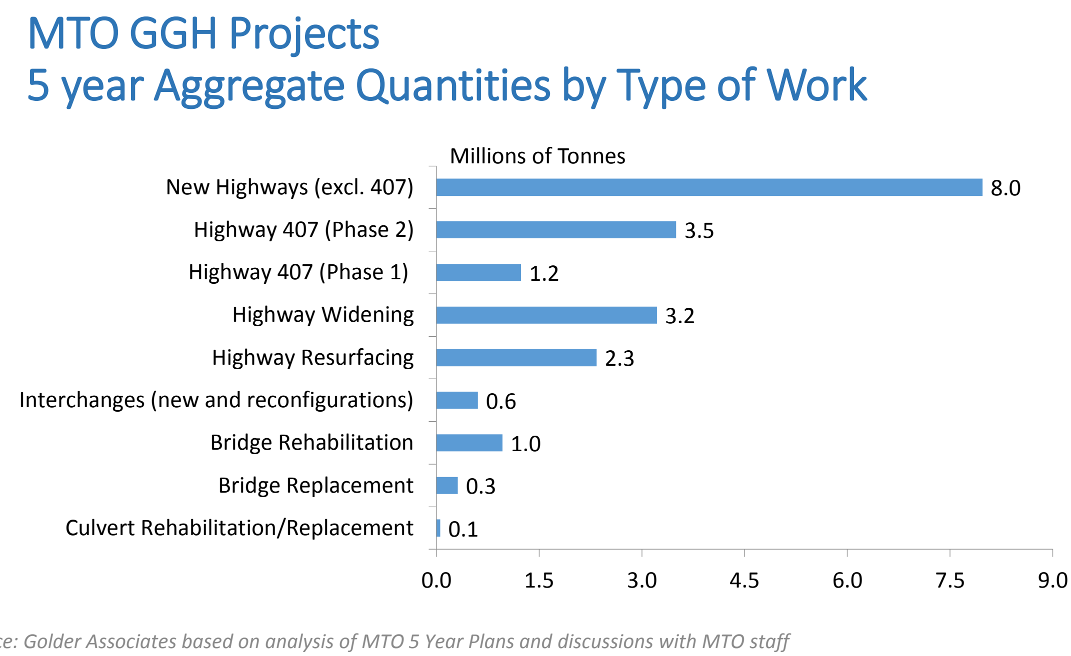


Figure 4-31: MTO Planned Projects in the GGH by Type of Work

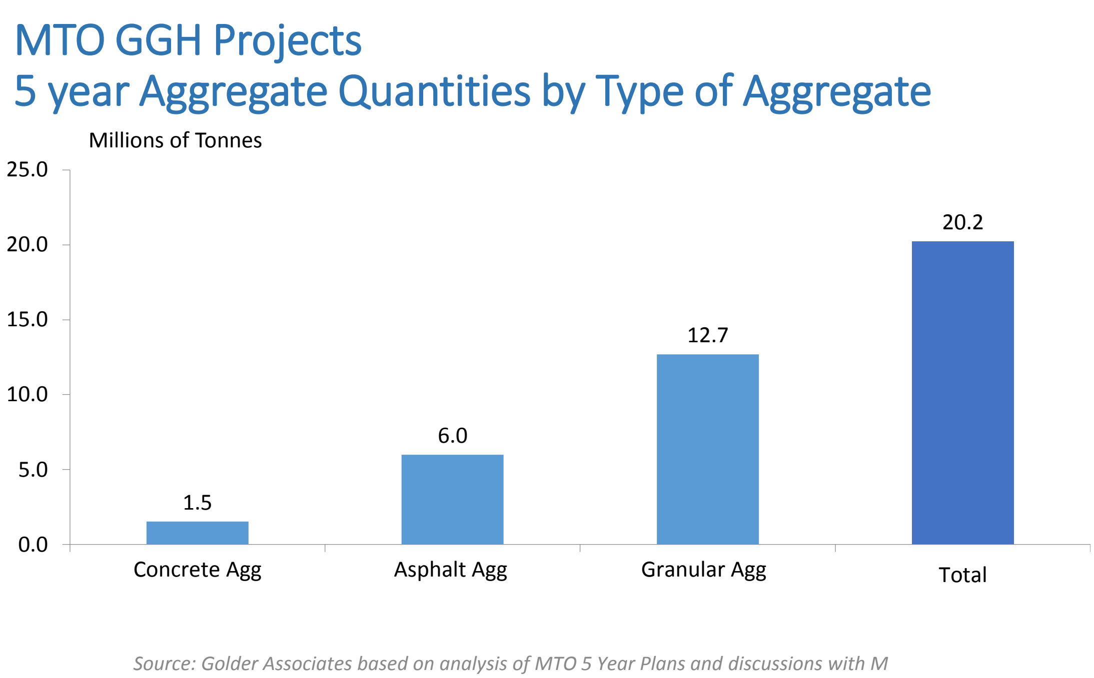


Figure 4-32: MTO Planned Projects in the GGH by Type of Aggregate Needed

- These amounts were verified with an MTO representative who confirmed they were realistic when compared to aggregate consumption of the three aggregate types in recent years.
- Figure 4-33 provides a snapshot of details on some of the larger MTO projects.

5 Largest Planned MTO Projects in the GGH Showing Aggregate Quantities

Project Type	Location	Expected Completion	Concrete Aggregates (Tonnes)	Asphalt Aggregates (Tonnes)	Unbound Aggregates (Tonnes)	*Total (Million Tonnes)*
New Highway	Highway 7N – Kitchener to Guelph	>2019	62,000	615,000	2,582,000	*3.3*
New Highway	HWY 407- Harmony Rd to Taunton Rd	2017	135,000	350,000	1,686,000	*2.2*
New Highway	HWY 407-Taunton Rd to Highway 115/35 including north-south link	>2019	96,000	249,000	1,197,000	*1.5*
New Highway	Highway 427 – Highway 7 to Major Mackenzie Dr	2019	16,000	165,000	692,000	*0.9*
HOV Expansion	Highway 401 - RR25 to Trafalgar Rd & Trafalgar Rd to Credit River Bridge	>2019	5,000	137,000	315,000	*0.5*

Source: Golder Associates based on analysis of MTO 5 Year Plans and discussions with MTO staff

Figure 4-33: Sample of Large MTO Projects in the GGH Showing Aggregate Quantities

4.5.4 Transit Projects

- A list of projected transit projects in the GGH was compiled from publically accessible websites, such as Metrolinx, VivaNext, etc.
- The information collected for each project included estimated completion date, estimated project value, length, and number of stops.
- Based on the lengths and types of various projects (for example, 20 km of Light Rail Transit (LRT)), quantities of concrete aggregates, asphalt aggregates and unbound aggregates were estimated based on project reports available online, past project experience as well as aggregate quantities for typical projects from the SAROS 2009 report.
- The types of Transit projects identified are as follows:
  - Light Rail Transit (LRT)
  - Bus Rapid Transit (BRT)
  - Subway

- Combination of LRT and Subway
- Retrofit of existing GO Rail Tracks
- Highway 407 Transitway

- Figure 4-34 provides highlights for the information for some of the largest projects.

Largest Planned Transit Projects in GGH Showing Aggregate Quantities

Municipality	Description	Expected Completion	Concrete Aggregates (Tonnes)	Asphalt Aggregates (Tonnes)	Unbound Aggregates (Tonnes)	*Total (Million Tonnes)*
Region of Waterloo	Waterloo Transit ION (2 phases)	Unknown	284,000	481,000	841,000	*1.6*
City of Toronto	Eglinton Crosstown	2021	971,000	60,000	313,000	*1.3*
City of Toronto	SmartTrack	2022	346,000	-	224,000	*0.6*
Region of Peel	Hurontario LRT	2022	131,000	134,000	273,000	*0.5*
City of Toronto	Scarborough LRT	2024	105,000	108,000	219,000	*0.4*
City of Hamilton	Hamilton LRT	2024	88,000	91,000	185,000	*0.4*

Source: Golder Associates based on analysis of 5 Year Transit Plans

Figure 4-34: Sample of Planned Transit Projects in the GGH Showing Aggregate Quantities

- The six projects shown on the chart require almost 5 MT of aggregate. In total, the transit projects identified (including others not shown here) would need about 6.3 MT of aggregate.

4.5.5 Major Municipal Infrastructure Projects

- Municipal websites and Development Charge Studies of the upper tier municipalities in the GGH were consulted to develop a list of major municipal infrastructure projects. The projects considered major were ones with anticipated expenditures of at least $10 million per year.
- Types of projects included facilities, public spaces, water/wastewater and transportation infrastructure.

- To estimate aggregate quantities associated with each project, factors were used that relate tonnes of aggregates to a given amount of expenditure, based on the 2015 dollar factors by type of construction work shown previously on Figure 4-17, adjusted for inflation. Appropriate factors were applied to the different types of projects to estimate the amount of aggregates required for each project.
- Highlights of potential aggregate need by year by upper tier municipality are summarized on Figure 4-35, which show a five year total need of about 21 MT.
- Note that this exercise does not identify the overall total amounts of aggregate needed for upper tier municipal use, as it only included projects where spending of $10 million or more per year was expected.

Aggregate Quantities Needed for Major Municipal Infrastructure Projects Planned in Next 5 Years*

	2016	2017	2018	2019	2020	5 Year Total
			Millions of Tonnes			
City of Toronto	1.94	1.66	2.13	2.81	2.49	11.02
Durham Region	0.12	0.14	0.25	0.07	0.06	0.64
York Region	0.64	0.59	0.32	0.24	0.29	2.07
Halton Region	0.10	0.21	0.06	0.12	0.26	0.76
Peel Region	1.28	0.70	0.60	0.98	1.72	5.28
City of Hamilton	0.08	0.12	0.08	0.06	0.05	0.39
Niagara Region	0.05	0.12	0.07	0.12	0.05	0.41
Waterloo Region	0.01	0.01	0.01	0.00	0.01	0.04
City of Barrie	0.02	0.04	0.05	0.20	0.00	0.32
City of Brantford	0.00	0.01	0.00	0.00	0.00	0.01
City of Guelph	0.00	0.00	0.07	0.00	0.00	0.07
Total	**4.25**	**3.61**	**3.61**	**4.59**	**4.94**	**21.00**
Type of Work						
Transportation	*2.16*	*1.61*	*1.64*	*2.56*	*2.71*	*10.67*
Water/Wastewater	*1.45*	*1.26*	*1.18*	*1.25*	*1.42*	*6.56*
Other	*0.64*	*0.74*	*0.79*	*0.79*	*0.80*	*3.76*

** Based on projects with spending of $10 million or more per year in at least one of the next 5 years*

Source: Golder Associates based on analysis of municipal budgets

Figure 4-35: Major Municipal Infrastructure Projects Showing Aggregate Quantities

4.5.6 Summary

- There are many major public infrastructure projects planned in the GGH, all of which will need aggregate - based on the projects examined for this study, almost 50 MT over the next five years:
  - **MTO Highway Programs projects** are expected to need about 20 MT in total over the next five years.
  - **Transit projects** are expected to need just over 6 MT through completion (some of which is beyond the next five years).
  - **Larger municipal infrastructure projects** are expected to need about 21 MT over the next five years.

4.6 Key Findings

This section summarizes the key findings of the preceding analysis.

- Over the past 20 years, Ontario has consumed about 3.4 billion tonnes of aggregate - or about 170 MT per year on average.
- Given expected levels of economic and population growth, Ontario's consumption of aggregates is projected to average about 192 MT per year on average over the next 20 years, 13% higher than in the past 20 years.
- Despite lower per capita usage of aggregate, the GGH is expected to consume more than half of the provincial total, or about 111 MT per year over the next 20 years.
- On a per capita basis, aggregate consumption has been on a longer-term decline and this downward trend is expected to continue going forward.
- The aggregate that Ontario uses comes mainly from primary sources of material extracted from Ontario pits and quarries. Imports from other countries play only a very small role. Secondary sources of material (primarily recycled materials) have played an increasing role, and recycled material is expected to continue to gradual increase its contribution to total aggregate consumption over the next 20 years. However, the main source of aggregate supply is expected to continue to be primary aggregate from Ontario pits and quarries.
- The GTAH obtains approximately half of the aggregate it uses from neighbouring areas, largely from within the outer ring of the GGH.
- Aggregate is used in a wide range of applications, however the primary use is in construction work - either directly on construction sites, or in the manufacturing of concrete and other building products. Roads (provincial highways, as well as municipal and private roads), both new and repair work, account for the largest share of aggregate used in construction work.
- There are many major public infrastructure projects planned in the GGH, all of which will need aggregate:
  - **MTO Highway Programs projects** are expected to need about 20 MT in total over the next five years.
  - **Transit projects** are expected to need about 6 MT through completion (some of which is beyond the next five years).
  - **Larger municipal infrastructure projects** are expected to need about 21 MT over the next five years.

5.0 TRAFFIC ASSESSMENT

5.1 Introduction

Aggregate resources including sand, gravel, crushed stone, or any other material prescribed under the ARA, are a cornerstone of Ontario's economy. Aggregates are used in the construction of roads, buildings and other important infrastructure throughout the province. As well, aggregates are an important component in the manufacture of iron, steel and plastic, and are integral in the production of materials such as glass, paint and pharmaceuticals and are found in fertilizer, floor coverings and toothpaste. As a result, the aggregate industry provides employment for approximately 300,000 people within Ontario alone. The Growth Plan predicts that the GTA will see an increase in population by approximately three million by 2041, and the GGH an increase of approximately four and a half million. This level of growth will require significant investment in infrastructure to support the future needs of the population.

In 1992 the province prepared the first study on aggregates in the province of Ontario entitled "Aggregate Resources of Southern Ontario – A State of the Resource Study" that reviewed, among other things, transportation issues associated with aggregate material haulage. This study was subsequently updated in 2010 by the MNRF with the SAROS Report. The SAROS report was produced to bring the understanding of aggregate resources up to date and examined economic, social and environmental factors of the industry in consideration of aspects such as value of the resource, consumption and demand, availability and location of existing and future reserves, supply and transportation alternatives.

In 2015, MHBC Planning, on behalf of the OSSGA, prepared a study entitled "The Future of Ontario's Close to Market Aggregate Supply: The 2015 Provincial Plan Review – Aggregate Industry Discussion Paper". The MHBC report investigated the need for high quality aggregate material to support the infrastructure requirements of the GGH Growth Plan with respect to location and availability of supply, environmental and economic impacts.

The MNRF is implementing the next stage of the SAROS project to bring the data presented in the 2010 study up to date, and to further investigate the supply and demand for aggregate in the GGH to 2031. The enclosed study covers the following primary topics:

- reviews the findings and conclusions of the SAROS and MHBC studies;
- maps out the major aggregate resources (supply) and the destinations for aggregate (expressed in terms of specific major infrastructure projects and major population growth centres);
- presents high-level transportation routes based on the close to market transportation model of aggregate haulage; and
- summarizes opportunities and constraints to improve identified transportation routes.

5.2 Study Overviews and Summary

5.2.1 2010 SAROS Report

The transportation component of the SAROS report completed in 2010 examines the feasibility of alternative transportation systems to supply aggregates to the GTA. The GTA is the major aggregate consumer of the broader Ontario market representing almost a third of Ontario's aggregate demand. The 2010 report compared long haul trucking, rail and marine transport to a close to market (CTM) supply model.

For comparison purposes, the location selected for the source of material for the long haul trucking and rail transportation scenarios was North Bay, while for the marine transportation scenario it was Manitoulin Island. The final destination of material was assumed to be the GTA. Material arriving from long distance sources would require redistribution terminals to accommodate the high volumes of incoming delivery vehicles (i.e., long haul trucks, rail car and container ships).

The SAROS analysis assumed the Vaughan Corporate Centre (now the Vaughan Metropolitan Centre, VMC), as a representative location for the terminals in order to allow for a common point of reference (see Section 5.2.1.3 for specifics about the marine transportation logistics). The quantity of material required was assumed to be 35 MT, which represents 1.0 to 1.4 million truck loads depending on truck size.

The 2010 report analyzed cost and greenhouse gas (GHG) emissions associated with each scenario and provided a comparative discussion on the environmental and social impacts resulting from each method of transport.

5.2.1.1 Long Haul Trucking Transport

The transport of material via the long haul trucking scenario was divided into three sections:

- Loading of material in North Bay
- Transportation between North Bay and the GTA
- Arrival at the redistribution terminal in the GTA

Development of the long haul trucking scenario considered the following in regard to overall costs:

- 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.

Once loaded in North Bay, it was assumed that all truck trips originated at the Highway 11/17 intersection with the end point assumed to be the Highway 400/Highway 7 interchange. This allowed analysis of a representative 'common' distance. North Bay and the distribution terminal are approximately 320 km apart and it was assumed that a one-way trip would take approximately 4.6 hours.

Transportation from the source to the distribution terminal was assumed to be made in a tractor-triaxle semi-trailer with a total of six axles. It was assumed that tractors would need to be replaced every five years and trailers every eight years. The total cost of the vehicle was estimated at $265,000.

Based on the foregoing, 5,000 truck trips per day per direction would be required to deliver 35 MT of material per year. This represents approximately 500 trips per hour travelling south on Highway 11/40 from the source location in North Bay to the redistribution terminal in Vaughan.

The SAROS paper notes that some sections of Highway 11/400 would require widening prior to 2020 in order to accommodate organic background growth in combination with the high volume of concentrated aggregate truck trips. The cost of widening the highway was included in the cost calculations, as was the incremental costs for road maintenance resulting from having additional heavy trucks on the road.

The destination of the material was considered to be the distribution terminal in Vaughan. At the distribution terminal, aggregate would be unloaded from the long-haul trucks to be stockpiled and then loaded into smaller trucks for delivery to processing plants and/or job sites. The terminals were assumed to carry a capital cost of $3,500,000.00 per MT of redistributed aggregate. The average distance to a job site from the distribution terminal was assumed to be 35 km.

The following summarizes the statistics for the long haul trucking option as per the SAROS report:

- Haul route consists of Highway 11/400
- Highway 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 MT of greenhouse gases

5.2.1.2 Rail Transport

Similar to the long haul trucking option, the transport of material via rail was also divided into three sections in the SAROS report:

- Loading of material in North Bay
- Rail transportation between North Bay and the GTA
- Arrival at the rail yard/redistribution terminal in the GTA

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.

Aggregate delivered to the terminal would be stockpiled. Conveyors would be used to load the rail cars. It was assumed that all trains delivering aggregate would consist of 80 railcars each with a capacity of 90 tonnes. These cars would be bottom-unloading hopper cars with open tops. The rail cars are estimated to have a capital cost of $90,000.00 and a lifespan of 30 years.

The line provides a direct route from North Bay to the GTA and there were no assumed infrastructure improvements on the rail lines. Once at the distribution terminal in the GTA, the aggregate would be unloaded into collection areas under the tracks and then stockpiled via conveyors and front end loaders. The terminals were assumed to carry a capital cost of $3,500,000.00 / MT of redistributed aggregate.

A series of rail yards/redistribution terminals (the number dependent on the traffic capacities of available sites) would be required in the GTA for storage and distribution of the aggregate to local job sites. The redistribution terminal expansions would consist of additional track, laydown/stockpiling area, and associated aggregate handling equipment (conveyors, front-end loaders, etc.). These improvements were expected to require a footprint of approximately 40 hectares (100 acres).

The SAROS report noted that railyard improvements in North Bay at the source location 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. The report also indicated that 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.

The following summarizes the statistics for the long haul trucking option as per the SAROS report:

- Expand CNR rail yard in North Bay with 40 ha (100 ac) footprint required for additional track, 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 track work.
- Cost: $17.66/tonne (2009 dollars).
- 5.5 billion litres of fuel.
- 26.5 MT of greenhouse gases.

5.2.1.3 Marine Transport

The movement of material via marine transport was divided into five sections in the SAROS report:

- Loading of material at Manitoulin Island.
- Marine transportation between Manitoulin Island and the receiving ports.
- Transfer of the material from the marine vessel to rail or truck.
- Transport from the ports to the GTA.
- Arrival at the rail yard/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).

Four ports were considered as destination locations for aggregate material transported via ship; Goderich, Sarnia, Windsor and Toronto. These four locations were selected based on factors such as distance from source, vessel size, routing, availability of existing port facilities, water depth, and rail and road access. The SAROS report determined that although all four ports have aggregate handling facilities, all would require significant improvements to handle the increased amount of aggregate and that despite the modifications, it was not expected that a combined receiving capacity greater than 10 MT per year would be achievable. Shipping more than 10 MT of aggregate to the GTA market would require the construction of new ports and quarries on Manitoulin Island and at other locations along the shorelines of the Great Lakes.

Furthermore, marine transport is not available during the winter months due to freezing conditions on the Great Lakes. This would require the stockpiling of significant amounts of aggregate at the destination ports. The SAROS report estimates that the ports would need to stockpile 3.7 MT of aggregate, which would require 82 hectares or 203 acres of additional area for storage.

While some direct trucking of aggregate from the ports to job sites could occur, due to location of the ports, an additional transport stage would be required to move the aggregate to more centrally located redistribution terminals. Ships arriving at the destination port would be unloaded via a conveyor system and trucks or trains would be loaded by four-wheeled loaders.

The vessels anticipated to transport the aggregate cost approximately $65,000,000.00 each and have a per day operating cost of $25,000.00 including fuel, wages, etc.

The following summarizes the statistics for the marine transportation option as per the SAROS report:

- 27 new vessels for 35 MT/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 10 MT/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.
- 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 MT of greenhouse gases for marine-rail, 47.3 MT of greenhouse gases for marine-truck.

5.2.1.4 Close to Market

As stated in the SAROS report, CTM trucking refers to the short-haul transportation of aggregates by trucking directly from local pits and quarries to the job sites. CTM trucking is generally carried out using 4-axle dump trucks with a capacity of 23.5 tonnes. The capital costs per truck are approximately $140,000 (2009 dollars). Operational costs for short-haul trucking reflect those of long haul trucking with some modified parameters (such as lower wages).

At the time the SAROS report was prepared in 2010, the average haul distance for GTA CTM pits and quarries was estimated at 35 km. Even with strong implementation to achieve CTM supply, it was anticipated that this distance would increase over the long-term as the closest sites were depleted. To account for this, the CTM haul distance was 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 required in this transportation model as the material can usually be delivered directly from the pit or quarry to the GTA job site (and/or intermediary processing facility).

The following summarizes the statistics for the CTM scenario as outlined in the SAROS report:

- 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 MT of greenhouse gases

5.2.1.5 Transport Scenario Comparison

The following presents a summary of the of the results of the comparison of the four options of aggregate transport in respect of cost, GHG emissions, environmental and social considerations as per the SAROS report. The analysis assumes the CTM (status quo) scenario as the baseline for comparison with the alternative transport options.

Table 5.1: Transportation Cost Comparison – Delivery to GTA

Scenario	Cost per Tonne (2009 Dollars)	Ratio to CTM
Long Haul Trucking from North Bay	$44.71	4.7
Rail Transport from North Bay	$17.66	1.9
Marine Transport from Manitoulin Island with Rail Transport from the Port to the GTA	$29.29	3.1
Close to Market (CTM) Status Quo / Baseline	$9.46	1

As illustrated in Table 5.1 above, the long haul trucking option is approximately five times the cost of CTM. The least expensive alternative to CTM was found to be rail transport but this was still twice the cost of CTM. The option of transporting aggregate via marine transport results in costs approximately three times CTM due to the additional steps involved in getting the material from the port to the job site.

5.2.1.6 Greenhouse Gas (GHG) Emissions

The SAROS report presented an analysis of GHG emission intensity for each of the transport scenarios. The investigation was based on a simplified Life Cycle Analysis (LCA) assuming that the production and final use of the aggregate would have a similar GHG intensity for all transport scenarios. The GHG emissions associated with aggregate transport from the sources to the job sites and material handling operations were also included in the SAROS calculations.

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.
- 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.

Other potential indirect GHG emission sources associated with the life cycle of the transport scenarios were not considered in the SAROS study. 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 SAROS study quantified the life cycle GHG emissions associated with each transport scenario by 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 MT.

Table 5.2 below summarizes the GHG emissions associated with each of the transport options:

Table 5.2: GHG Emissions Comparison – Delivery to GTA

Scenario	GHG Intensity Transport Total (t CO2e/1000 t agg.)	Ratio to CTM
Long Haul Trucking from North Bay	44.4	3.67
Rail Transport from North Bay	26.5	2.19
Marine Transport from Manitoulin Island with Rail Transport from the Port to the GTA	28.4	2.35
Marine Transport from Manitoulin Island with Road Transport from the Port to the GTA	47.3	3.91
Close to Market (CTM) Status Quo / Baseline	12.1	1.00

As illustrated in Table 5.2 above, the SAROS study found that all alternative scenarios assessed would lead to significant higher life cycle GHG emissions when compared to the CTM status quo scenario. This was found to be the result of the significant increase in transport distances in the alternative scenarios. 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.

The SAROS report noted that emission intensities may be lower in the future as a result of improvements in technology such as hybrid/electric vehicles. However, this was not considered in the analysis.

5.2.1.7 Other Environmental Considerations

The SAROS report also reviewed 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 2010 study pointed out that there would be environmental implications associated with the construction of additional infrastructure such as new or expanded origin and destination docks, additional lanes of highway, new rail lines, new redistribution terminals, etc. This infrastructure would have incremental environmental impacts that are over and above what is required to deliver from CTM job sites to the GTA market.

In addition, according the findings of the SAROS study, moving to long distance sources would phase out pits and quarries which are an interim land use to be replaced by distribution terminals which are a permanent use. Rehabilitated CTM pits and quarries provide agricultural and recreational space once the extraction site is no longer in use.

5.2.2 Social Considerations

The SAROS report considered how the evaluated transportation alternatives would affect people in the vicinity of the associated extraction sites, transportation routes and redistribution centres. The study based its comparison of social impacts 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 in consideration of size, volume and number of operations and associated transportation facilities.

The SAROS study states that 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.

In order to compare social impacts, the study noted four areas of potential impact high-lighted for discussion for each mode:

- 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).

As indicted in the SAROS study, 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.

Along the primary transportation routes, the study notes the social impacts would be especially low for the marine shipping options where very few people or communities would be affected on route. While social impacts along primary transportation routes would be higher for long distance truck and rail options when compared to the CTM option. 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 supply are dispersed / diluted across wider areas whereas the impacts along rail lines or key highway links for long distance sources would be more concentrated.

The SAROS study correctly points out that accident rates and traffic delays are significant social considerations that are directly related to the number and mix of vehicles on the road and total kilometres travelled. The study estimates that over the 30-year study period at a rate of 165 collision per million vehicle kilometres travelled, the incremental effect of delivering just 10 MT per year by long haul truck as compared to delivery from CTM sources would be approximately 9,950 additional collisions including nearly 32 fatalities. 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 considering the need for redistribution terminals and delivery to the job site.

Furthermore, the SAROS study indicates noise from trucking would have an impact but the main route from North Bay to the GTA would have limited effect on residents. However, there would be new social impacts at the redistribution terminals including truck traffic, noise, dust and visual impacts. As pointed out in the SAROS study, the distribution terminals are not required under the CTM scenario.

The SAROS study indicates that the social impacts of alternative delivery systems from long distance sources would be greater than continued delivery from status quo CTM and concludes that based on social impacts, the preferred option is CTM followed by marine, rail and long distance trucking.

5.2.3 SAROS Report Conclusions

The SAROS report stated that based on the analysis completed, “there would be significant economic, environmental and social implications of shifting away from the CTM policy in favour of importation from long distance sources in the GTA market”.

The SAROS report identified real barriers to replacing CTM supply with long distance sources. In the case of marine shipping 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. Under the rail scenario, there is the need for multiple redistribution terminals in the GTA along rail lines.

The SAROS report concluded that there are strong economic, environmental and social reasons why the alternative scenarios will not (and should not) take the place of CTM sources and short haul delivery and that the results of the review confirm that **extracting aggregates close to where they are utilized is the most environmentally sensitive alternative and has significant social and economic benefits**.

5.2.3.1 2015 MHBC Planning Report

As indicated in Section 5, MHBC, endorsed by the OSSGA, prepared a study on behalf of aggregate producers with operations throughout Ontario entitled, “The Future of Ontario’s Close to Market Aggregate Supply: The 2015 Provincial Plan Review – Aggregate Industry Discussion Paper”. The MHBC report looked at the need for high quality aggregate material to support the infrastructure requirements of the GGH Growth Plan in respect of location and availability of supply, environmental and economic impacts. Based on the findings contained in the study, MHBC made recommendations on policies for managing aggregate availability in consideration of the Provincial Plans.

The MHBC report emphasized the importance of the aggregate industry to the economy of Ontario and was in agreement with the SAROS report on the need for a CTM supply of aggregate to meet the needs of the expected future growth of the GGH.

5.2.3.2 Aggregate Production and Consumption in Ontario

The MHBC report reviewed the production and consumption of aggregates in Ontario and found that while aggregate production has averaged 164 MT per year for the last 15 years, in 2013, production was the lowest since 1996 at only 143 MT. This is a result of aggregate production being directly tied to Ontario's economy which had a downturn in 2013.

As per the SAROS study the GTA consumes approximately one third of the aggregate production in Ontario per year, which equates to approximately 60 MT (the GGH consumes approximately 90 to 100 MT). Based on the projected growth in population predicted by 2041, the MHBC report states that a readily available supply of close to market aggregate is required to address the provinces infrastructure deficit and aggregate consumption levels in the GGH.

The report also notes that for every three tonnes of aggregate consumed in the GTA only one tonne is produced within the GTA and that since 2001 there has been an average annual decrease in aggregate production of 1.1 MT. The MHBC report acknowledges that a portion of this is due to a slowing economy, but also points out that a decreasing amount of licensed supply is directly impacting production. For example, the study indicates that for every three tonnes of aggregate produced in the GTA only one tonne comes from new licences.

5.2.3.3 Provincial Interest in Aggregate Availability

The MHBC report indicates that aggregate resources are required in economically active and growing regions such as the GTA and GGH, which are among the fastest growing in North America, and provincial policies support the continued growth and development in these areas. As such there is a provincial interest in the conservation and management of aggregate resources and a need for a readily available supply of CTM aggregate to minimize environmental and social impacts and transportation costs. Based on the foregoing, the MHBC report indicates that importing aggregate from long distance sources will negatively impact the ability of the province to implement its infrastructure plans due to budget limits that would be affected by the higher costs of transporting aggregate over a greater distance versus CTM.

5.2.3.4 Location of Aggregate Resources

The MHBC report points out that aggregates are fixed in location and cannot be extracted just anywhere. Many locations of aggregate are undeveloped and contain wetlands, woodlands and water features. Many of these areas are protected and planning for aggregate extraction must be done in conjunction with these 'protection' measures. As indicated in the study, planning for aggregate cannot assume there will be resources available once everything else is planned for or protected. Indeed, the SAROS report found that 93% of selected bedrock resources had overlapping environmental, agricultural or social constraints.

In regard to environmental impacts, and as indicated in the MHBC study, provincial policy has acknowledged both agricultural and aggregate resources are important to the province and these two uses are frequently in conflict. The issues around these uses are often resolved by rehabilitating the source of aggregate back to agricultural land once the extraction of the aggregate resource is completed. This is a recognized provincial policy that prevents the loss of agricultural land as a result of the extraction process. In addition, the MHBC report notes that rehabilitated pits and quarries can provide opportunities for water storage and the creation of wetland habitats.

5.2.3.5 Implications of Extracting Resources Further from Market

As did the SAROS report, the MHBC study concluded that there would be significant economic, environmental and social implications to shifting away from CTM policy in favour of importation of aggregate from long distance sources to the GTA/GGH market. Indeed, the study noted there are no identifiable environmental benefits of extracting aggregate from a pit or quarry located far from market.

The MHBC report notes that moving extraction further from market creates new incremental impacts and issues as a result of the delivery distance. Figure 5-1, taken from the MHBC report, illustrates the impacts resulting from transporting aggregate from long distance locations and that when assessing alternatives to CTM transport, it is essential to review the entire transportation route; material source to job site in order to understand the impacts from alternative delivery methods. For example, as described in the MHBC study, long distance aggregate delivery will require additional stages of transportation such as distribution terminals and stockpile areas among others.

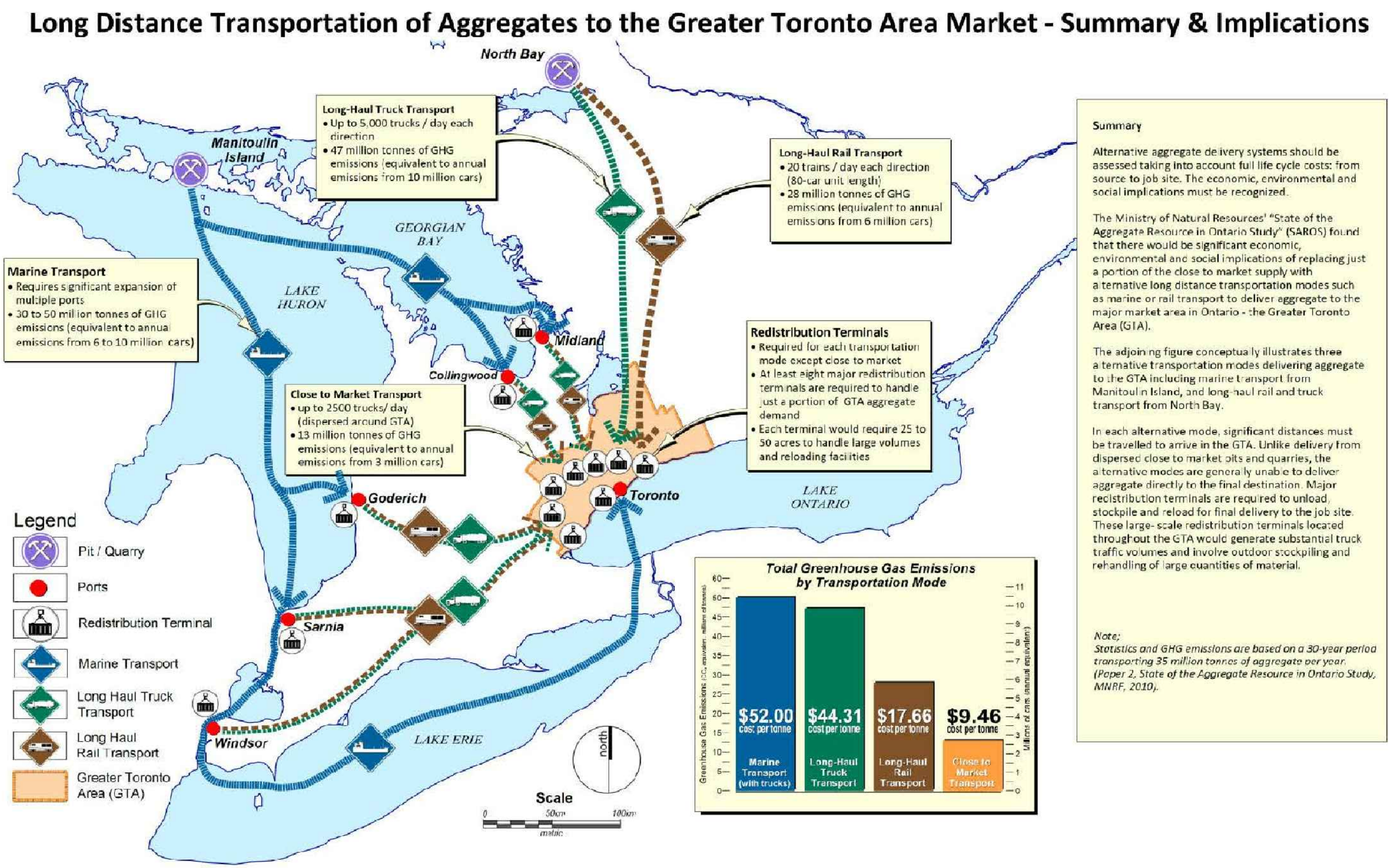


Figure 5 of MHBC's "The Future of Ontario's CLose to Market Aggregate Supply: The 2015 Provincial Plan Review - Aggregate Industry Discussion Paper"
Dated April 30, 2015

DIONNE BACCHUS & ASSOCIATES CONSULTING ENGINEERS LTD.

LONG DISTANCE AGGREGATE TRANSPORT - SUMMARY & IMPLICATIONS (MHBC)

N

PROJECT No: T15-134

DATE: 03/31/16

FIGURE 5-1

As with the SAROS report, the MHBC study cites the social, environmental and economic impacts that would accrue as a result of using alternative long distance transportation methods such as the availability of large areas of land to store material, the capacity of the road network to accommodate large volumes of truck traffic and the need for multiple facilities in and around urban areas.

5.2.3.6 Regulation of Aggregate Resources and Provincial Plans

The MHBC report notes there are over 25 provincial and federal acts that apply to the management of aggregate resources. The ARA is continually updated to stay current and is reviewed on an ongoing basis.

There are eight provincial policies currently in effect:

- Parkway Belt West Plan (1978)
- Niagara Escarpment Plan (1985, 1994, 2005)
- Oak Ridges Moraine Conservation Plan (2002)
- Greenbelt Plan (2005)
- Growth Plan for the Greater Golden Horseshoe (2006)
- Central Pickering Development Plan (2006)
- Lake Simcoe Protection Plan (2009)
- Growth Plan for Northern Ontario (2011)

As outlined in the MHBC study, all of the above policies with the exception of the Growth Plan for Northern Ontario are located within some portion of the GTA and GGH areas. The Niagara Escarpment Plan (NEP), Oak Ridges Moraine Conservation Plan (ORMCP) and Greenbelt Plan (GP) surround the largest urban area in Canada and encompass over 8,000 km^2 of land.

Aggregate production from the areas specifically controlled by the foregoing three provincial policies was approximately 28.4 MT or 20% of Ontario's total supply despite covering only 0.7% of Ontario's land area. As indicated in the MHBC study, while Provincial Plan Areas contribute a significant amount of the aggregate supply, only 1.5% of the Plan Areas are licensed for extraction.

The NEP, ORMCP and GP are applicable to areas that contain very high quality sources of close to market aggregate required by the GGH. All three of the Provincial Plan Areas are located within and/or adjacent to Ontario's economic and population centres. The Growth Plan for the GGH requires higher density development and infrastructure needs that can only be produced from high quality aggregate resources, such as those found within the Plan Areas.

The GGH has a major infrastructure deficit. The Province is investing more than $130 billion in public infrastructure over the next 10 years including $31.5 billion in dedicated funds available for public transit, transportation and other priority infrastructure projects under Moving Ontario Forward17. In the GGH, over 2 billion tonnes of aggregate will be needed over the next 25 years to build and maintain required infrastructure. However, since 1990 over 3,000 ha (100+ licences) have been surrendered and rehabilitated, the lands returned to other uses such as natural heritage areas, greenspace and agricultural uses. Since the Provincial Plans gained approval, only 0.1% of the Plan Areas have been licensed for aggregate extraction. As per the MHBC report, this equates to only 22 licences.

The public and provincial interest in close to market supply can only be achieved if Provincial Plans contain reasonable policies to make aggregate available and not include arbitrary restrictions or prohibitions. A readily available supply of close to market aggregate can ensure these resources are economically competitive while minimizing social and environmental impacts in accordance with the PPS.

5.2.4 MHBC Report Conclusions

The MHBC Discussion Paper concluded that there were significant barriers to the importation of aggregate from long distance sources rather than maximizing close to market supply. The study indicated higher costs, the need for additional infrastructure, increased GHG emissions and the negative impact on people resulting from the long distance transportation alternatives.

According to the report the growth plan for the GGH area will require over 2 billion tonnes of aggregate over the next 25 years in order to build and maintain the required infrastructure necessary to meet the needs of the province’s growth plans for the area. The NEP, ORMCP and GP contain very high quality sources of close to market aggregate required by the GGH. However, only a very small portion of the Plan Areas are licensed for extraction.

The MHBC report concluded that it is necessary that the provincial plans contain policies to make aggregate from CTM sources readily available in order to meet future needs and that in order to achieve the broader provincial growth goals, MHBC concluded that a CTM scenario for aggregate is required.

5.3 Future Sources of Aggregate Demand

The future demands for aggregate in the GGH study area have been identified through a review of major planned infrastructure projects (by the MTO from their Southern Highways Program and by GGH municipalities from a review of their Capital Works Programs), and identification of the population growth centres across the GGH provided by the study team (Altus Group).

These large sources of aggregate demand will account for the vast majority of all aggregate consumption across the GGH for the foreseeable future. It is imperative to investigate whether a sufficient road network exists that can accommodate the future aggregate traffic demands into and through the GGH area under the CTM haulage model.

5.3.1 Planned Major Infrastructure Projects

Major Infrastructure projects planned by the MTO and Regions within the GGH over the next five years were researched by the study team. It was determined after reviewing available project information that most of the planned major projects would geographically correspond to population growth centres within the GGH area.

While major projects may indeed be large consumers of aggregate, they are in essence transitory in nature, that is, even large highway expansion projects do not typically last more than a few years. For this reason, we have focused our haul route review not on specific (and short-lived) individual projects, but on the transportation networks surrounding the existing and future population centres, which will be long term consumers of aggregate.

5.3.2 Population Growth Centres

Table 5.3 compares the Altus Group's projected growth of each GGH municipality's population to the total overall population growth of the GGH.

The City of Toronto accounts for the highest percentage of population growth increase in the GGH from 2011 to 2021, whereas the Region of York has the highest population growth increase in the GGH from 2011 to 2031. The municipalities of the City of Toronto, Region of Durham, Region of York, and Region of Peel are predicted to each experience growth in excess of ten percent of the total GGH population growth. When combined, these four municipalities represent 62.93% and 59.60% of the total GGH population growth in 2021 and 2031, respectively.

They also represent the geographic core of the GGH municipalities. In terms of aggregate transportation routes, the City of Toronto, Region of Durham, Region of York, and Region of Peel are accessible via multiple freeways as a part of the larger available provincial highway system, which will be utilized by future CTM aggregate traffic servicing these growing municipalities.

Please note that we have not quantified the demand for aggregate by population size or growth for our purposes of identifying whether there are transportation routes available in the area. We have assumed all population centres will consume some measure of aggregate, therefore they will require haulage corridors.

Table 5.3: Population Growth of GGH by Municipality

Municipality	Predicted Population Increase Compared to 2011 Population		Percentage of Total GGH Population Growth from 2011	
	2021	2031	2021	2031
City of Toronto	270,400	488,400	18.98%	16.38%
Region of Durham	143,200	343,200	10.05%	11.52%
Region of York	264,500	519,500	18.57%	17.43%
Region of Peel	218,500	425,500	15.33%	14.27%
Region of Halton	127,800	297,800	8.97%	9.99%
City of Hamilton	65,400	147,400	4.59%	4.95%
Region of Niagara	40,200	100,200	2.82%	3.36%
County of Brant	16,100	48,100	1.13%	1.61%
County of Haldimand	4,000	11,000	0.28%	0.37%
County of Simcoe	96,100	208,100	6.74%	6.98%
County of Dufferin	8,500	18,500	0.59%	0.62%
County of Wellington	39,300	84,300	2.76%	2.83%
Region of Waterloo	100,200	218,200	7.04%	7.32%
City of Kawartha Lakes	8,100	20,100	0.57%	0.67%
County of Peterborough	15,500	34,500	1.09%	1.16%
County of Northumberland	6,900	15,900	0.49%	0.53%
Total	1,424,700	2,980,700	100%	100%

5.4 Aggregate Transportation Facilities

The base GGH road network used for this transportation considerations study was developed using roads classified as arterials, highways/expressways, and freeways by the GIS metadata retrieved from Land Information Ontario's website. Alterations to the base network were made if documentation from a given municipality was found that identified roads in the base network to not be suitable for heavy trucking operations, or if roads outside of the base network, such as collector and local roads, were deemed to allow heavy traffic. For example, the Region of Peel and the City of Hamilton have made available to the public maps of their heavy truck route networks. Some lower-tier municipalities, such as the Town of Caledon, have also published aggregate specific haul routes and have identified regional/municipal roads where aggregate traffic is prohibited. Through changes to the base GGH road network, a potential GGH-wide aggregate haul route network was compiled.

A reasonable effort was made by the DBA study team to research and identify documented heavy traffic and aggregate haulage restrictions in place for any given GGH municipality. If aggregate or heavy haulage policies were not found, seasonal and yearly load restriction by-laws were investigated. DBA acknowledges that some of the information gathered may be incomplete, or may be in the process of being updated or changed by the municipalities. As such, DBA does not claim to have acquired a full, extensive list of completely accurate information for the entirety of the GGH region. All future specific haul route analyses should therefore follow appropriate due diligence processes to identify whether heavy goods movement can be accommodated.

The MHBC SAROS Paper 2 report estimated that the 2009 average haul distance for GTA CTM pits and quarries was 35 km. The estimated CTM haul distance for 2020 and 2050 are 45 and 60 km respectively. The 35 km geometric radius is considered to be representative of the future increases haul route distances, as aggregate trucking routes often need to navigate multiple roads and/or indirect routes from the aggregate source to a given growth centre that may be in excess of 35 km due to indirect haul route options. Generally speaking, there are very few routes available from an aggregate source to a given infrastructure project or growth centre that can be travelled using a single, straight road, so the 35 km geometric radius is representative of existing and future travel distances.

The following presents a summary review of the available haulage routes for the 16 regions within the study area (GGH). The roadways illustrated are, by classification and definition, only those able to be used for the movement of heavy goods movement (i.e., aggregate). It should also be noted that in certain instances even these roads may not be suitable for the transportation of large volumes of aggregate and appropriate due diligence should be exercised in determining the impacts (and mitigation) necessary to accommodate the hauling of aggregate along these roads.

The sections that follow present and interpret the aggregate transportation opportunities and constraints within a 35 km geometric radius of the growth centres within each of the 16 regions and upper tier municipalities.

No distinction has been made between constrained and unconstrained reserves, nor is there any relative scaling of the population growth centres or quantification of impacts on same from aggregate haulage. The discussions that follow are in alphabetical order by region.

5.4.1 County of Brant

Located south of Cambridge, the County of Brant is a predominantly rural municipality bordered by the Region of Waterloo to the north, Haldimand to the south and Hamilton to the east.

The County is bisected in the east-west direction by Highway 403 which provides direct access to the Cities of Brantford and Paris. Highway 2, north of Highway 403, essentially runs parallel to Highway 403 serving as an alternative and more local route between Brantford and London. Highway 24 is the main north-south roadway through the County. Two arterial roadways, Middle Townline Road (R.R. 25) and Bishopsgate Road (R.R. 16), located in the western portion of the County, also provide a north-south haul route through Brant.

While the County has numerous arterial roadways that can accommodate heavy vehicles. We also understand that the County, through a Transportation Master Plan Update, is undergoing a review of their network and are in the process of reviewing haul route needs and pre-screen and designate heavy truck / aggregate haul routes.

5.4.2 County of Dufferin

The County of Dufferin is a primarily rural community bounded by the Region of Peel to the south, the County of Simcoe to the east and the County of Wellington to the west. The County encompasses Orangeville and Shelbourne.

The County is well served by the existing road network in regard to aggregate transport. Highways 10, 89, 109 and Dufferin Road 124 in addition to a number of other arterial roads provide direct good penetration into and through the County. It should be noted that Highway 10 passes directly through Orangeville and Shelbourne. Highway 89 also would require heavy vehicles to pass through Shelbourne. However, the arterial road network provides route options to vehicles transporting aggregate to avoid the major population centres.

5.4.3 Region of Durham

The Regional Municipality of Durham is located in Southern Ontario east of Toronto. It has an area of approximately 2,500 square kilometres extending from Beaverton in the north to Lake Ontario in the south. Durham Region is bounded by the City of Kawartha Lakes and Northumberland County to the north and northeast and the Region of York and City of Toronto to the west.

The southern portion of the region along Lake Ontario is primarily suburban in nature, forming the eastern end of the 905 belt around Toronto. The northern portion is mostly rural in nature, with several scattered population centres.

The southern half of the region is well represented in both the north-south and east-west directions in regard to potential haul routes. There are a number of north-south arterial roadways that can accommodate the movement of aggregate resources. In the east-west direction, in addition to the substantial arterial road network, this part of the Region is also served by Highway 401. Highway 407 currently terminates at Brock Road in Pickering, but by spring 2016 will be extended eastward to Harmony Road in Oshawa, providing a second major highway (albeit with tolls) north of the major population centres.

In the northern portion of the Region, there are two main north-south roadways suitable for aggregate haulage; Lake Ridge Road (R.R. 23) and Highway 7/12. Lake Ridge Road is located just east of Uxbridge bypassing the urban area. Highway 7/12 passes through Whitby, Brooklin and some smaller hamlets on its route northward. No contiguous roadways extend from the east to west limits of the Region in the northern sections. The Region may wish to monitor the existing road network to determine if there is a constraint to aggregate haulage in this area and if so, consider mitigation such as the reconstruction/upgrading of existing roadways, or the construction of new roadways, to accommodate the anticipated need for aggregate in the future.

5.4.4 County of Haldimand

The County of Haldimand is a generally rural area located on the north shore of Lake Erie and bordered by Hamilton to the north, the Region of Niagara to the east and the County of Brant to the west.

The County is served by Highway 6 in a north-south direction along its western limit and is bisected east to west by Highway 3. There are numerous north-south and east-west arterial roadways providing access to both Highway 3 and 6. A direct route through the County using either Highway 3 or 6 would entail traveling through the more populated areas of Dunnville, Cayuga or Caledonia. However, trucks hauling aggregate could avoid these areas by utilizing other routes along the arterial road system.

5.4.5 Region of Halton

The Regional Municipality of Halton is located in the southwest part of the Greater Toronto Area and contains the City of Burlington and the Towns of Oakville, Milton, and Halton Hills. The Town of Oakville and the City of Burlington are largely urban, while the Towns of Milton and Halton Hills to the north are more rural. The Region of Halton is bounded by Wellington County to the north, the Region of Peel to the east and the City of Hamilton to the west.

The southern half of the region is well served by potential haul routes in both the north-south and east-west directions. There are a number of north-south roadways and contiguous east-west routes available, which can accommodate the movement of aggregate resources. In the east-west direction, this section of Halton is served by Highways 403 and 407. Halton is crossed (east-west) by Highway 401 through the midpoint of the Region just north of Milton.

In the northern portion of the Region, there are three north-south arterial roadways suitable for aggregate haulage that have direct access to Highway 401; Guelph Line, Highway 25 and Trafalgar Road. Highway 7, located in the northeast quadrant of the Region runs from the eastern boundary of the Region to the northern boundary in a generally north-south direction. In the northern portion of Halton, other than Highway 401, there are no contiguous roadways providing an east-west route across the Region. As such, the Region may wish to monitor the existing road network to determine if this apparent lack of east-west connectivity is a constraint to aggregate haulage and if so, consider mitigation such as the reconstruction of existing roadways, or the construction of new roadways, to accommodate the anticipated need for aggregate in the future.

5.4.6 City of Hamilton

The City of Hamilton lies on the western tip of Lake Ontario and is bounded by the Region of Waterloo and the City of Guelph to the north, the Region of Niagara to the south, the Region of Halton to the east and the County of Brant and Region of Haldimand to the west.

Hamilton has a number of provincial highways and arterial roads in both the north-south and east-west directions that allow the transport of aggregate across the region. Provincial highways within the Hamilton boundary include Highways 5, 6, 8, 403, the Queen Elizabeth Way and the Red Hill Valley Parkway. The combination of provincial highways and arterial roadways appear to provide multiple options for aggregate haulage throughout the area. It should be noted that there is only one major source of aggregate in Hamilton generally located between Highway 5 to the south and 5th Concession Road West to the north.

5.4.7 City of Kawartha Lakes

The City of Kawartha Lakes is primarily rural in nature. Kawartha Lakes is bounded by the Counties of Peterborough and Northumberland to the east and south and the Region of Durham and County of Simcoe to the west and south.

The major population centres in the Kawartha Lakes region are Lindsay and Bobcaygeon. The area is served by Highway 35 in a north-south direction and Highways 7 and 7A in an east-west direction. All three highways by-pass the Town of Lindsay allowing vehicles hauling aggregate to avoid this populated area. Vehicles transporting aggregate can also utilize the arterial road system to avoid the City's other populated areas.

5.4.8 Region of Niagara

The Region of Niagara occupies most of the Niagara Peninsula. Its eastern boundary is the Niagara River and is bounded to the north by Lake Ontario, to the south by Lake Erie and to the east by the Region of Haldimand and City of Hamilton.

Niagara Region is served by Highways 405, 406 and the Queen Elizabeth Way as well as numerous arterial roadways. The Region's roadways are not laid out in a typical grid pattern as in other Municipalities and a large portion of the area is protected from aggregate extraction. However, in the areas where extraction activity is allowed, the deposits are relatively close to provincial highways and easily accessible via the arterial road network.

5.4.9 County of Northumberland

Northumberland County is situated on the north shore of Lake Ontario and is bounded to the north by Peterborough and to the east by the Regional Municipality of Durham.

Highway 401 extends across the County at its southern limit. No other provincial highways serve the area. There is a network of arterial roads throughout the county that are suitable for aggregate haulage. However, the road pattern results in circuitous routes to travel through the county. The County may wish to monitor the existing road network to determine if the circuitous road pattern creates a constraint to aggregate haulage in this area and if so, consider mitigation by way of upgrading strategic roadways to accommodate heavy goods movement.

5.4.10 Region of Peel

The Regional Municipality of Peel is located to the west and northwest of Toronto. The Region contains the large cities of Brampton and Mississauga, and medium to small settlements within the Town of Caledon. The Region of Peel is bounded by the Counties of Simcoe and Dufferin to the north, Lake Ontario to the south, the Region of York and City of Toronto to the east and the County of Wellington and Region of Halton to the west.

The southern half of the Peel Region is well served in both the north-south and east-west directions in regard to existing and potential haul routes. There are a number of north-south roadways, including Highway 403/410 that can accommodate the movement of aggregate resources. In the east-west direction, this part of the Region is served by Highways 401, 403, 407 and the Queen Elizabeth Way and several arterial roads providing options for the transport of aggregate across the Region.

In the northern portion of the Region, there are only three north-south roadways suitable for aggregate haulage; Highway 10, Regional Road 50 and Airport Road. There are no contiguous roadways extending east-west across the northern portion of the Region. This potentially creates a constraint to the transport of aggregate within this area as drivers destined to from aggregate sources must choose a circuitous route to navigate the northern portion of the Region. The Region may wish to investigate the existing road network to determine if these limitations are actually a constraint to aggregate haulage in this area and if so, consider mitigation such as the reconstruction of existing roadways to accommodate heavy trucks or the construction of new roadways in order to address the anticipated need for aggregate in the future.

5.4.11 County of Peterborough

The County of Peterborough is a mix of agriculture and urban properties. The County is bounded by Northumberland to the south and the City of Kawartha Lakes and the Region of Durham to the west. The major population centre is the City of Peterborough located in the southwest quadrant of the County.

Highway 7/115 enters the County at its southwest boundary providing a connection to Highway 7 allowing for east-west movement through the County and to Highway 28 which provides a north-south passage through the area. Highways 7 and 7/115 pass through the south limit of the City of Peterborough but do not enter the main part of the City allowing vehicles transporting aggregate to generally by-pass the busiest areas. The arterial road system, while not extensive outside of the City proper, does provide access to the aggregate resources in the northern portion of the County.

5.4.12 County of Simcoe

Simcoe County is situated north of the GTA stretching from Lake Simcoe in the east to Georgian Bay in the west. The County is bounded by the Region of York to the southeast and the County of Dufferin to the west.

Highway 400 is the major north-south route through the County passing through Barrie, its largest population centre. Highway 89 provides an east-west route through the County with a connection to Highway 400 in the southern portion. There are a number of arterial roadways in Simcoe County providing both north-south and east-west routes for vehicles transporting aggregate that will allow them to avoid the more populous areas of the County.

The provincial highway / County arterial network to the northeast of Barrie towards Orillia and up to the northeast boundary of the County is sparse. There are several active licensed pits in this area (generally surrounding Orillia), that likely rely on lower class roadways to access the arterial/provincial grid (these routes would have been approved during their individual license / zoning applications). The general lack of arterial roads in this area is a constraint and it is likely that any new licences granted in this part of the County would be contingent on significant pit operator-funded investments in new and/or upgraded local roadways. The County may want to assess the need for arterial facilities to more comprehensively direct and control aggregate haulage in this part of the County.

5.4.13 City of Toronto

The City of Toronto is the most populous City in Canada and is the Centre of the GTA. Located on the northwestern shore of Lake Ontario, Toronto is bounded by the Region of York to the north, Durham Region to the east and Peel Region to the west.

The City of Toronto is served by Highways 400, 401, 404, 409, 427, the Don Valley Parkway and the Gardiner Expressway. In addition, there is an extensive grid system of arterial roads that have the capability to accommodate aggregate haulage.

5.4.14 Region of Waterloo

The Region of Waterloo contains the Cities of Kitchener, Cambridge and Waterloo. The Region is located at the western limit of the GGH and is bounded by The County of Wellington and Hamilton to the north and east and the County of Brant to the south.

The Region is served by Highways 6, 8 and 401 as well as an extensive arterial road network allowing heavy vehicles to by-pass the more populated areas.

5.4.15 County of Wellington

Wellington County is primarily a rural area containing the City of Guelph. The County is bounded by Hamilton and Halton to the south, Dufferin and Peel to the east and Waterloo to the west.

The area is well served by the provincial highway system with Highways 6, 9, 23, 89 and 401 all providing access to and passage through the County. Within the boundaries of the County there are arterial road network provides access to the existing aggregate sources primarily located south of the City of Guelph in the triangular area generally bounded by Highway 401 to the south, Highway 6 to the east and Hespeler Road (R.R. 24) to the west. Substantial aggregate activity is a mainstay of this area, and there are well established haul routes in place serving the many licensed pits in the area.

5.4.16 Region of York

The Regional Municipality of York is located south of Lake Simcoe and is bounded by the County of Simcoe to the northwest, the City of Toronto to the south, Durham Region to the east and Peel Region to the west.

The Region of York is well served by both regional and provincial roadways in terms of available aggregate haul routes. Provincial Highways 400, 404 and 48 run north-south through the Region providing connections to Highways 401 and 407. Highway 407 crosses the southern portion of Region (east-west) through Vaughan, Richmond Hill, and Markham. In addition, there is a multitude of arterial roadways suitable for aggregate haulage providing both north-south and east-west routes throughout the Region.

5.5 Conclusions and Recommendations

Our review of 2010 SAROS study and the 2015 MHBC report examining the feasibility of alternative modes of transportation (long haul trucking, rail and marine) revealed that significant economic, environmental and social implications would result from a shift away from current provincial policy directing a CTM transportation solution. These earlier studies identified significant limitations to the implementation of the alternative transport modes including limited road capacity along the key Highway 11 / 400 corridor (in the case of long haul trucking), the need for multiple distribution terminals to support rail transport and the limited port capacities to support marine transport. Any of the long distance alternatives to CTM would result in much higher transport costs and increased GHG intensities per kilometre when compared with the current CTM policy. Based on the foregoing, it can be concluded that the extraction of aggregates close to where they are needed results in the most environmentally sensitive solution along with having economic and social benefits.

Our review of road networks within the 16 regions of the GGH indicated that the majority of jurisdictions are well served by the provincial highway system and have numerous arterial roads that can accommodate the movement of aggregate. However, it was noted that some areas have transportation limitations and/or constraints and as a result, heavy vehicles destined to/from an aggregate resource might be forced into taking a circuitous route, travelling through densely populated areas, or requiring ad hoc local solutions to the transportation of aggregate product to market. It was also noted that many jurisdictions do not have a current policy pre-determining haul routes to regulate the movement of heavy vehicles through a region.

Based on the foregoing, it would be beneficial for individual jurisdictions without goods movement policies in place to proactively review their road networks and establish defined haul routes for the movement of aggregate through their regions. The establishment of appropriate truck routes will help ensure mobility for all road users and optimize freight capacity minimizing the impacts on sensitive areas by:

- Defining roadways that are suitable for heavy vehicle traffic
- Ensure roadways have appropriate capacity and design to accommodate the heavy vehicles
- Avoid residential and/or otherwise sensitive areas
- Reduce congestion throughout the region

In establishing a truck route, jurisdictions should consider involving key stakeholders such as local residents and businesses, aggregate suppliers, and economic and transportation specialists to ensure haul route solutions consider all perspectives and interests. In addition, it would be beneficial to coordinate such efforts with neighbouring jurisdictions to ensure continuity of goods movement from one jurisdiction to the next.

6.0 SUMMARY

The following provides a summary of the key results of this Supply and Demand Study of the Aggregate Resource Supplying the Greater Golden Horseshoe.

6.1 Material Supply

While Potential reserves exist in many parts of the Province there are current concerns about scarcity of higher quality materials in key close to market areas that will lead to increased costs and environmental impacts associated with increased haul distance.

For example:

- Critical situation in terms of availability of high quality crushed stone;
- Depletion of Niagara Region sand and gravel;
- Limited supply of optimum gradation and particle shape concrete sands; and
- Overall diminishing close to market supply within the GGH.

This material supply component of the SAROS update report provides information on available supply from licensed pits and quarries. The research completed included a review of previous work and studies relating to aggregate supply and a discussion of the geology and nature of the resource (from resource to reserves). The evaluation updates the estimated limestone licensed reserves from 2009 and provides additional estimates of potential reserves from selected sand and gravel pits.

Previous studies completed over five decades have identified a need for continued replacement of depleting licensed supply to keep up with consumption and anticipated demand for aggregate products in Southern Ontario. The information provided in this update does not contradict or change the picture. While there are substantial potential unlicensed and licensed reserves there continues to be reductions in availability and scarcity of some products in parts of the GGH.

The SAROS 2009 estimate for selected licensed limestone quarries was 3.44 billion tonnes of which 2.55 billion tonnes were in the GGH study area. Since 2009 545 MT have been added to this estimate as a result of new licences issued and additional sites being included in an adjusted study area boundary. Only 268 MT of this total are from new licences issued since 2009 (49%). This additional amount from new licences is generally offset by an estimated production of over 250 MT in the 2009 - 2015 period. As a result, the net change is not significant and the 2009 SAROS conclusions remain valid:

- While the total resource base of 3.44 billion tonnes (now about 3 billion), appears to be a large number, it is important to understand that the majority of these reserves are not high quality stone and are located at greater distances from the market areas that are demanding them.
- The total estimated amount of 'high' quality reserves is approximately 1.47 billion tonnes. It should be noted that of this total amount of 'high' quality reserves only a maximum of about two thirds, would be available for inclusion in concrete and asphalt grade products in the form of stone and manufactured sand.

- Abundant' reserves are found within relatively few quarries, most of which are located more than 75 km from the Vaughan Corporate City Center. A large proportion (85% in 2009) of the quarries have either a scarce or moderate reserve base. As such, it is clear that the majority of the reserves supplying the GTA market are coming either from moderate or scarce reserves. In addition, when annual tonnage limits and internal customer demand from these quarries are taken into consideration, annual available supply to the general market is further limited.

- Volume and tonnage calculations are based on dimensions, distances and elevations provided on the site plan, and these calculations assume that all material is extracted and in turn is viable for aggregate production, and that no reserves are used for construction of internal haul roads, ramps or left in place as benches for rehabilitation.

The provided estimate of potential sand and gravel resources that might be available in 123 selected licensed pits is 2,792 MT. This is based on an estimate of gross volume that has potential to be extracted from licensed sites based on site plan limits on area and depth of extraction. It is a poor measure of actual licensed supply of aggregate required to meet market demands. Consistent with previous studies and evaluations, this study identifies serious limitations in the methodology particularly as it relates to glacial sand and gravel deposits. The reader is cautioned that there are many variables that will determine if the estimated volume can be “made available” notwithstanding its “licensed” status.

Inventory of licensed supply should be considerably greater (many times more) than the anticipated demand. The market is complex and the public interest will be well served by ensuring licensed supply includes abundant reserves in competitive holdings for the full range of products in close to market locations.

6.2 Constraint Analysis

Based on the constraint analysis, the following percentage of the aggregate resource areas had overlapping constraints in the GGH and 100 km surrounding the GGH:

i) 96.0% of selected bedrock area,

ii) 97.7% of primary sand and gravel, and

iii) 92.0% of secondary sand and gravel.

This is not to say that these resources are not available. The applied constraints are factors that have to be considered in assessing the availability of the resource; they are not all constraints that would necessarily or reasonably preclude access to the resource.

Nor should the results be interpreted to mean that the remaining resource areas (i.e., unconstrained) are available as there are numerous other site specific and unmapped factors that need to be considered before a resource can be licensed and extracted.

What the results do tell us is that the availability of aggregate resources in Ontario needs to be carefully planned for. Aggregates will not be available if it is assumed or taken for granted that there will be plentiful supply after all other planning considerations are accounted for. Planning for aggregate availability will require an integrated and balanced approach that recognizes some compromises will be required. Without this recognition it is more likely that aggregate deposits are not protected or made available given the likelihood of on-site and adjacent constraints.

6.3 Demand Analysis

The results of the demand analysis indicate that:

- Given expected levels of economic and population growth, Ontario's consumption of aggregates is projected to average about 192 MT per year on average over the next 20 years, 13% higher than in the past 20 years.
- Despite lower per capita usage of aggregate, the GGH is expected to consume more than half of the provincial total, or about 111 MT per year over the next 20 years.
- On a per capita basis, aggregate consumption has been on a longer-term decline and this downward trend is expected to continue going forward.
- The aggregate that Ontario uses comes mainly from primary sources of material extracted from Ontario pits and quarries. Imports from other countries play only a very small role. Secondary sources of material (primarily recycled materials) have played an increasing role, and recycled material is expected to continue to gradual increase its contribution to total aggregate consumption over the next 20 years. However, the main source of aggregate supply is expected to continue to be primary aggregate from Ontario pits and quarries.
- There are many major public infrastructure projects planned in the GGH, all of which will need aggregate:
  - MTO projects are expected to need about 20 MT in total over the next five years.
  - Transit projects are expected to need about 6 MT through completion (some of which is beyond the next five years).
  - Larger municipal infrastructure projects are expected to need about 21 MT over the next five years.

6.4 Traffic Assessment

Based on the findings of the traffic assessment, it would be beneficial for individual jurisdictions without goods movement policies in place to proactively review their road networks and establish defined haul routes for the movement of aggregate through their regions. The establishment of appropriate truck routes will help ensure mobility for all road users and optimize freight capacity minimizing the impacts on sensitive areas by:

- Defining roadways that are suitable for heavy vehicle traffic
- Ensure roadways have appropriate capacity and design to accommodate the heavy vehicles
- Avoid residential and/or otherwise sensitive areas
- Reduce congestion throughout the region

7.0 LIMITATIONS

This report was prepared for the exclusive use of the Ontario Ministry of Natural Resources for the purpose of identifying remaining reserves in selected quarries in certain market areas in the Province of Ontario. The services performed as described in this report were conducted in a manner consistent with the level of care and skill normally exercised by other members of the engineering and geosciences professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

In preparing the report, Golder has assumed that the information provided by other parties was factual and accurate. To the extent that Golder relied on the information provided by others, Golder disclaims any responsibility for errors resulting from this use. Golder also accepts no responsibility for any deficiency, misstatement or inaccuracy contained in the report as a result of omissions or misinterpretations.

8.0 CLOSURE

We trust that this report meets your requirements and we are looking forward to your review and comments. If you have any questions please do not hesitate to contact the undersigned.

Report Signature Page

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