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Ontario

Aggregate Resources Inventory of

Grey County

Southern Ontario

Ontario Geological Survey
Aggregate Resources Inventory
Paper 180

2009

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Grey County

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Ontario Geological Survey
Aggregate Resources Inventory
Paper 180

By Jagger Hims Limited and D.J. Rowell

2009

Users of OGS products are encouraged to contact those Aboriginal communities whose traditional territories may be located in the mineral exploration area to discuss their project.

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Every possible effort has been made to ensure the accuracy of the information contained in this report; however, the Ontario Ministry of Northern Development, Mines and Forestry does not assume any liability for errors that may occur. Source references are included in the report and users are urged to verify critical information.

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*** Map 1 and Map 2 accompanying this report are simplified to depict information critical to the majority of users. Enhanced information on the aggregate resources for this area is provided in a compressed (*.zip*) file available for download from GeologyOntario (www.ontario.ca/geology). Additional documents in the *.zip* file provide further details on the vector ESRI® ArcGIS® files for maps 1 and 2, Microsoft® Excel® versions of Tables 1 to 9, and other files that enhance this report.**

Abstract

This report includes an inventory and evaluation of the sand and gravel, and bedrock resources for Grey County. Twelve selected sand and gravel resource areas have been identified at the primary significance level, occupying a total of 35 618 ha. Once licenced operations are removed, and an allowance has been made to cover cultural, environmental and other land use planning constraints, an estimated 11 984 ha remain for possible resource extraction. This area is estimated to contain approximately 1670 million tonnes of aggregate resource.

The major sand and gravel deposits in Grey County are situated in the southern portion of the county, mainly in the Municipality of West Grey and the Township of Southgate. The central feature in this area of Grey County is the glaciofluvial portion of the Singhampton moraine, which was deposited during a major melting event during the retreat of glacial ice toward Georgian Bay. There are also significant outwash deposits associated with the Singhampton moraine, as well as the Gibraltar and Banks moraines that abut the Singhampton deposits. These deposits collectively comprise one of the largest sand and gravel deposits in Ontario. Smaller outwash and ice-contact deposits, still of primary significance, occur elsewhere within Grey County. Secondary sand and gravel resources are also scattered throughout the county. These secondary deposits are particularly important in the northern portion of the county where there are relatively few sources of sand and gravel available.

Sand and gravel extraction in Grey County has been limited to supplying local markets and a substantial proportion of production has been located in secondary sand and gravel deposits close to Owen Sound, Meaford, Thornbury and Hanover. A modest amount of pit development has occurred in the Durham–Markdale–Flesherton area to supply those local markets. A recent study has indicated the potential to ship aggregates to the Greater Toronto Area 10 to 20 years in the future.

Bedrock resources associated with the Amabel Formation are present in a broad band of the county immediately south of the Niagara Escarpment. Six areas have been selected for possible protection, although significant parts of these areas fall within the Niagara Escarpment Plan. An additional Selected Bedrock Resource Area is located in the Township of Georgian Bluffs where Guelph Formation overlies the Amabel Formation. This area has the potential to produce building stone and construction aggregate from the same source.

Selected Resource Areas are not intended to be permanent, single land use units that must be incorporated into an official planning document. They represent areas in which a major resource is known to exist. Such resource areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

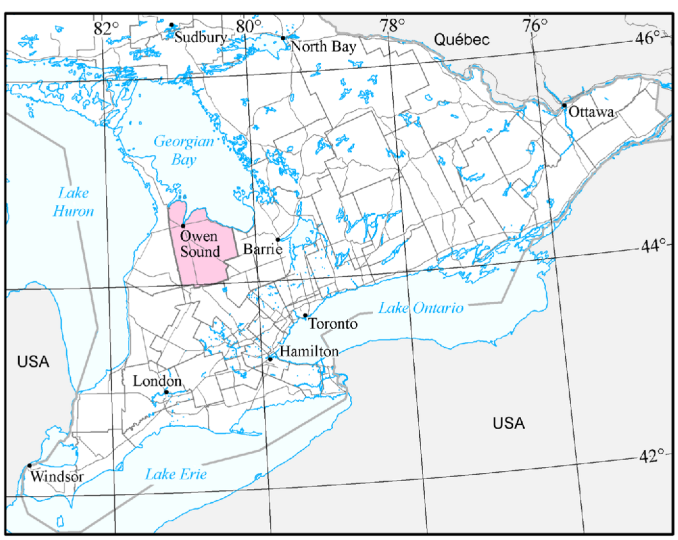

Figure 1. Key map showing the location of the study area.

Aggregate Resources Inventory of Grey County

By Jagger Hims Limited[1] and D.J. Rowell[2,3]

Field work, map production and report by A.J. Cooper and J. McIntosh of Jagger Hims Limited.

Editing completed by C. Gao and D.J. Rowell.

Manuscript accepted for publication in 2009 by C.L. Baker, Senior Manager, Sedimentary Geoscience Section, Ontario Geological Survey. This report is published with the permission of the Director, Ontario Geological Survey.

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Introduction

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road building and construction industries. Large quantities of these materials are used each year throughout the Province. For example, in 2007, the total tonnage of mineral aggregates extracted in Ontario was 173 million tonnes, greater than that of any other metallic or non-metallic commodity mined in the Province (The Ontario Aggregate Resources Corporation 2008).

Although mineral aggregate deposits are plentiful in Ontario, they are fixed-location, non-renewable resources that can be exploited only in those areas where they occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area as well as its quality and size. The potential for extractive development is usually greatest in areas where land use competition is extreme. For these reasons, the availability of adequate resources for future development is now being threatened in many areas, especially urban areas where demand is the greatest.

Comprehensive planning and resource management strategies are required to make the best use of available resources, especially in those areas experiencing rapid development. Unfortunately, in some cases, the best aggregate resources are found in or near areas of environmental sensitivity, resulting in the requirement to balance the need for the different natural resources. Therefore, planning strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory Program is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision-makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of an area's resources.

The report includes an assessment of sand and gravel resources as well as a discussion on the potential for bedrock-derived aggregate. The most recent information available has been used to prepare the report. As new information becomes available, revisions may be necessary.

Inventory Methods, Data Presentation and Interpretation

FIELD AND OFFICE METHODS

The methods used to prepare the report involved the interpretation of published geological data such as bedrock and surficial geology maps and reports, as well as field examination of possible resource areas. Field methods included the examination of natural and man-made exposures of granular material. Most observations were made at quarries and sand and gravel pits located by field surveys and from records held by the Ministry of Transportation of Ontario (MTO), the Ontario Geological Survey (OGS), and by Regional, District and Area Offices of the Ontario Ministry of Natural Resources (MNR). Observations made at pit sites included estimates of the total face height and the proportion of gravel- and sand-sized materials in the deposit. Observations regarding the shape and lithology of the particles were also made. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, subsurface materials may be assessed by hand augering, test pitting and drilling.

Deposits with potential for extractive development, or those where existing data are scarce, were studied in greater detail. In instances, representative sites in these deposits are evaluated by taking 11 to 45 kg samples from existing pit or quarry faces, roadcuts or other exposures. The samples may be subjected to some or all of the following tests: absorption; magnesium sulphate soundness test; micro-Deval abrasion test; unconfined freeze–thaw test; and some samples are selected for accelerated mortar bar testing.

The field data were supplemented by pit information on file with the Soils and Aggregates Section of the Ministry of Transportation of Ontario. Data contained in these files includes field estimates of the depth, composition and "workability" of deposits, as well as laboratory analyses of the physical properties and suitability of the aggregate. Information concerning the development history of the pit and acceptable uses of the aggregate is also recorded. The locations of additional aggregate sources were obtained from records held by Regional, District and Area Offices of the Ontario Ministry of Natural Resources. In addition, testing data for type, quantity and quality of aggregates were also obtained from aggregate licence applications where these reports are on file with the MNR, and from individuals and companies. The co-operation of the above-named groups in the compilation of inventory data is gratefully acknowledged.

Aerial photographs and remotely sensed imagery at various scales were used to determine the continuity of deposits, especially in areas where information is limited. Water well records, held by the Ontario Ministry of the Environment (MOE), were used in some areas to corroborate deposit thickness estimates or to indicate the presence of buried granular material. These records were used in conjunction with other evidence.

Topographic maps of the National Topographic System, at a scale of 1:50 000, were used as a compilation base for the field and office data. The information was then transferred to a base map, also at a scale of 1:50 000. These base maps were prepared using digital information taken from the Ontario Land Information Warehouse, Land Information Ontario, Ontario Ministry of Natural Resources, with modifications by staff of the Ministry of Northern Development, Mines and Forestry.

Units and Definitions

The measurements and other primary data available for resource tonnage calculations are presented in metric units in the text and on the tables that accompany the report. Data are generally rounded off in accordance with the Ontario Metric Practices Guide (Ontario Interministerial Committee on National Standards and Specifications 1975).

The tonnage estimates for aggregate deposits are termed possible resources (*see* Appendix B – Glossary,) in accordance with terminology used by the Ontario Resource Classification Scheme (Robertson 1975, p.7) and the Association of Professional Engineers of Ontario (1976).

DATA PRESENTATION AND INTERPRETATION

Two maps, each portraying a different aspect of the aggregate resources in the report area, accompany the report. Map 1, "Sand and Gravel Resources", provides an inventory and evaluation of the sand and gravel resources in the report area. Map 2, "Bedrock Resources", shows the distribution of bedrock formations and the thickness of overlying unconsolidated sediments, and identifies the Selected Bedrock Resource Areas.

The hard-copy versions of Map 1 and Map 2 (back pocket of the report) are simplified to depict information critical to the majority of users.

Enhanced information on the aggregate resources for this area (e.g., complete deposit information for Map 1) is provided in vector ESRI® ArcGIS® files available for download as a compressed (*.zip*) file from GeologyOntario (www.ontario.ca/geology). A "readme" file included in the *.zip* file provides further details regarding the contents of these vector files. In addition, cross-references to data provided in the *.zip* file are provided for clients who wish to access digital data that does not require opening the vector ArcGIS® files. The tables for sand and gravel resources data are found in the folder "Sand_Gravel"; the data for bedrock resources data are in the folder "Bedrock". The tables are in database format (*.dbf* file) that can be opened using other software, for example Microsoft® Excel®. The cross-references include the folder, the table and the field name separated by a short vertical line; the field name is indicated by bold, small capital letters (e.g., Bedrock | Drift_Thick.dbf | **AABBCC**).

Map 1: Sand and Gravel Resources

Map 1 shows the extent and quality of sand and gravel deposits within the study area and an evaluation of the aggregate resources. The map is derived from existing surficial geology maps of the area or from aerial photograph interpretation in areas where surficial mapping is incomplete.

The present level of extractive activity is also indicated on Map 1. Those areas licenced for extraction under the *Aggregate Resources Act* are shown by a solid outline and identified by a number that refers to the pit descriptions in Table 2. Each description notes the owner/operator and licenced hectarage of the pit, as well as the estimated face height and percentage gravel. A number of unlicenced pits (abandoned pits or pits operating on demand under authority of a wayside permit) are identified by a numbered dot on Map 1 and described in Table 2. Similarly, any test locations appear on Map 1 as a point symbol and the results of the test material are provided in Table 9.

SELECTED SAND AND GRAVEL RESOURCE AREAS

All the sand and gravel deposits are first delineated by geological boundaries and then classified into 3 levels of significance: primary, secondary and tertiary. The deposit's significance is also recorded in Sand_Gravel | Sand_Gravel.dbf | **SIGN**.

Each area of primary significance is coloured red on Map 1 and identified by a deposit number that corresponds to numbers in Table 3. The deposit number is also recorded in Sand_Gravel | Sand_Gravel.dbf | **SELECT_AREA**.

Selected Sand and Gravel Resource Areas of primary significance are not permanent, single land use units. They represent areas in which a major resource is known to exist, and may be reserved wholly or partially for extractive development and/or resource protection. In many of the recently approved municipal Official Plans, all or portions of resources of primary significance, and in some cases resources of secondary significance, are identified and protected.

Deposits of secondary significance are coloured orange on Map 1. Such deposits are believed to contain significant amounts of sand and gravel. Although deposits of secondary significance are not considered to be the "best" resources in the report area, they may contain large quantities of sand and gravel and should be considered as part of the overall aggregate supply of the area.

Deposits of tertiary significance are coloured yellow on Map 1. They are not considered to be important resource areas because of their low available resources or because of possible difficulties in extraction. Such areas may be useful for local needs or extraction under a wayside permit, but are unlikely to support large-scale development.

SELECTION CRITERIA

The process by which deposits are evaluated and selected involves the consideration of 2 sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity and distribution of resources in the region in which the report area is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

Site Specific Criteria

DEPOSIT SIZE AND THICKNESS

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall resources in the rest of the project area.

The "thickness class" indicates a depth range, which is related to the potential resource tonnage for each deposit (*see* Table 1, Column 1: "Class Number"). Four thickness class divisions have been established: Class 1 deposits are greater than 6 m thick. Class 2 sand and gravel deposits are from 3 to 6 m thick; Class 3 represents a deposit that is from 1.5 to 3 m thick; and Class 4 represents a sand and gravel deposit that is less than 1.5 m thick. The thickness class for each deposit is also recorded in Sand_Gravel | Sand_Gravel.dbf | **DEP_THICK**.

Generally, deposits in Class 1 and containing more than 35% gravel are considered to be most favourable for commercial development. Thinner deposits may be valuable in areas with low total resources.

AGGREGATE QUALITY

The limitations of natural aggregates for various uses result from variations in the lithology of the particles comprising the deposit and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the deposit information: gravel content (G or S), fines (C), oversize (O) and lithology (L). Three of the quality indicators deal with grain size distribution.

The gravel content ("G" or "S") indicates the suitability of aggregate for various uses. Deposits containing at least 35% gravel ("G") in addition to a minimum of 20% material greater than the 26.5 mm sieve are considered to be the most favourable extractive sites, since this content is the minimum from which crushed products can be economically produced. In "sandy" deposits ("S"), the gravel-sized aggregate (greater than 4.75 mm) makes up less than 35% of the whole deposit making it difficult to produce coarse aggregate products. The gravel content is also recorded in Sand_Gravel | Sand_Gravel.dbf | MATERIAL.

Excess fines (high silt and clay content) ("C") may severely limit the potential use of a deposit. Fines content in excess of 10% may impede drainage in road subbase aggregate and render it more susceptible to the effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles.

Deposits containing more than 20% oversize material (greater than 10 cm in diameter) ("O") may also have use limitations. The oversize component is unacceptable for uncrushed road base, so it must be either crushed or removed during processing.

Another indicator of the quality of an aggregate is lithology ("L"). Just as the unique physical and chemical properties of bedrock types determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high-quality uses such as concrete and asphalt. Similarly, highly weathered, very porous and friable rock can restrict the quality of an aggregate.

If the deposit information shows either "C", "O" or "L", or any combination of these indicators, the quality of the deposit is considered to be reduced for some aggregate uses. The deposit quality, if applicable, is recorded in Sand_Gravel | Sand_Gravel.dbf | LIMITATION. No attempt is made to quantify the degree of limitation imposed. Assessment of the 4 indicators is made from published data, from data contained in files of both the Ontario Ministry of Transportation (MTO) and the Sedimentary Geoscience Section of the Ontario Geological Survey, and from field observations.

Quality data may also appear in Table 9, where the results of MTO quality tests are listed by test type and sample location. The types of tests conducted and the test specifications are explained in Appendixes B and E, respectively.

Deposit Information

The deposit information coding is similar to that used in soil mapping and land classification systems commonly in use in North America and indicates the gravel content, thickness of material, origin (type) and quality limitations, if applicable. The "gravel content" and "thickness class", as described above, are basic criteria for distinguishing different deposits. The geologic deposit type is also reported (the types are summarized with respect to their main geologic and extractive characteristics in Appendix C of the report). The geologic deposit type is recorded in Sand_Gravel | Sand_Gravel.dbf | DEP_ORIGIN.

In the following example of a deposit information code,

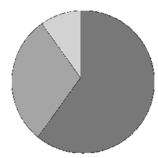
"G / 1 / OW / C",

where G represents gravel content, 1 represents thickness class, OW represents geological type and C represents aggregate quality, the deposit information code is interpreted as an outwash deposit greater than 6 m thick containing more than 35% gravel with excess silt and clay.

The deposit information is recorded in Sand_Gravel | Sand_Gravel.dbf | LABEL.

Texture Symbol

The texture symbol provides a more detailed assessment of the grain size distribution of material sampled during field study. These symbols are derived from the information plotted on the aggregate grading curves that, if available, are included with the report. The relative amounts of gravel, sand, and silt and clay in the sampled material are shown graphically in the texture symbol by the subdivision of a circle into proportional segments. The following example shows a hypothetical sample consisting of 60% gravel, 30% sand and 10% silt and clay ("fines").



LOCATION AND SETTING

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of natural, environmental and man-made features that may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, power lines and housing developments, which are built on a deposit, may prohibit its extraction. The constraining effect of legally required setbacks surrounding such features is included in the evaluation. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3 (Column 3).

In addition to man-made and cultural features, certain natural features, such as provincially significant wetlands, may prove to be constraints. In this report, such constraints have not been outlined and the reader is advised to consult with municipal planning staff and the local office of the MNR for information on these matters. Depending on the number and type of constraint applicable, anywhere from

15 to 85% of the total resources in a municipality may be unavailable for development (Planning Initiatives Limited 1993).

The assessment of sand and gravel deposits with respect to local land use and private land ownership is an important component of the general evaluation process. Since the approval of the Provincial Policy Statement (PPS) under the authority of the *Planning Act* in 2005, recently approved Official Plans now contain detailed policies regarding the location and operation of aggregate extraction activities. These official plans should be consulted at an early stage with regard to the establishment of an aggregate extraction operation. These aspects of the evaluation process are not considered further in this report, but readers are encouraged to discuss them with personnel of the pertinent office of the MNR, Ministry of Municipal Affairs and Housing staff, and/or regional and local planning officials.

Regional Considerations

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand, and that the present production "market share" of an area will remain roughly at the same level.

The aggregate resources in the region surrounding a project area should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, an area that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Areas with high resources in proximity to large demand centres, such as metropolitan areas, are special cases. The market demand for aggregate products in urban areas is often greater than the amount of production occurring in the area close to the urban boundaries.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data or on considerations outlined in preceding sections.

SAND AND GRAVEL RESOURCE TONNAGE CALCULATIONS

Once the interpretative boundaries of the aggregate units have been established, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows. First, the area of the deposit, as outlined on the final base map, is calculated in hectares (ha). The deposit area is also recorded in Sand_Gravel|Sand_Gravel.dbf|**AREA**. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data such as test holes and water well records. Tonnage values can then be calculated by multiplying the volume of the deposit by 0.01770 (the density factor). This factor is approximately the number of tonnes in a 1 m thick layer of sand and gravel, 1 ha in extent, assuming an average density of 1770 kg/m^3.

$$\text{Tonnage} = \text{Area} \times \text{Thickness} \times \text{Density Factor}$$

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e., original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 are calculated in the following way. Two successive subtractions are made from the total area. Column 3 accounts for the number of hectares unavailable because of the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas that have previously been extracted (e.g., wayside, unlicenced and abandoned pits are included in this category). The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factor (Column 5 × Column 6 × 0.01770), to give an estimate of the sand and gravel tonnage (Column 7) possibly available for extractive development and/or resource protection. It should be noted, however, that recent studies (Planning Initiatives Limited 1993) have shown that substantial proportions of the resources in an area may be constrained due to environmental considerations (e.g., floodplains, environmentally sensitive areas). Lack of landowner interest in development, a range of planning considerations or other matters may also reduce the available resources.

Resource estimates are calculated for deposits of primary significance. Resource estimates for deposits of secondary and tertiary significance are not calculated in Table 3, however, the aggregate potential of these deposits is discussed in the report.

Map 2: Bedrock Resources

Map 2 is an interpretative map derived from bedrock geology, drift thickness and bedrock topography maps, water well data from the Ontario Ministry of the Environment (MOE), oil and gas well data from the Non-Renewable Resources Section of the MNR, and from geotechnical test hole data from various sources. Map 2 is based on concepts similar to those outlined for Map 1.

Inventory information presented on Map 2 is designed to give an indication of the present level of extractive activity in the report area. Those areas licenced for extraction under the *Aggregate Resources Act* are shown by a solid outline and identified by a number that refers to the quarry descriptions in Table 5. Each description notes the owner/operator, licenced hectarage and an estimate of face height. Unlicenced quarries (abandoned quarries or wayside quarries operating on demand under authority of a permit) are also identified and numbered on Map 2 and described in Table 5. Drill hole locations or other descriptive stratigraphic sections appear as a point symbol on Map 2. Table 7 provides these descriptions. These descriptions are also recorded in Bedrock | Add_Info.dbf.

The geological boundaries of the Paleozoic bedrock units are shown by black dashed lines. Isolated Precambrian and Paleozoic outcrops are indicated by an "×". Three sets of contour lines delineate areas of less than 1 m of drift, areas of 1 to 8 m of drift, and areas of 8 to 15 m of drift. The extent of these areas of thin drift are indicated on Map 2 and are indicated in Table 4 (Column 1). The deposit's significance is also recorded in Bedrock | Drift_Thick.dbf | CONTOUR. The darkest shade of blue indicates where bedrock crops out or is within 1 m of the ground surface. These areas constitute potential resource areas because of their easy access. The medium shade of blue indicates areas where drift cover is up to 8 m thick. Quarrying is possible in this depth of overburden and these zones also represent potential resource areas. The lightest shade of blue indicates bedrock areas overlain by 8 to 15 m of overburden.

Outside of these delineated areas, the bedrock can be assumed to be covered by more than 15 m of overburden, a depth generally considered to be too great to allow economic extraction. **However, areas in which the bedrock is covered with greater than 8 m of overburden may constitute resources that have extractive value in specific circumstances. These circumstances include the resource being located adjacent to existing industrial infrastructure** (e.g., a quarry operation or processing plant)**; speciality industrial mineral products** (e.g., chemical lime and metallurgical rock) **that can be produced from the resources; or part or all of the overburden being composed of an economically attractive deposit.**

SELECTED BEDROCK RESOURCE AREAS

Selection of Bedrock Resource Areas has been restricted to a single level of significance. Three factors support this approach. First, quality and quantity variations within a specific geological formation are gradual. Second, the areal extent of a given quarry operation is much smaller than that of a sand and gravel pit producing an equivalent tonnage of material, and third, since crushed bedrock has a higher unit value than sand and gravel, longer haul distances can be considered. These factors allow the identification of alternative sites having similar development potential. The Selected Areas, if present, are shown on Map 2 by a line pattern and the calculated available tonnages are given in Table 6. The selected bedrock resource areas are also recorded in Bedrock | Drift_Thick.dbf | SELECT_AREA.

Selected Bedrock Resource Areas shown on Map 2 are not permanent, single land use units. They represent areas in which a major bedrock resource is known to exist and may be reserved wholly or partially for extractive development and/or resource protection, within an Official Plan.

SELECTION CRITERIA

Criteria equivalent to those used for sand and gravel deposits are used to select bedrock areas most favourable for extractive development.

The evaluation of bedrock resources is made primarily on the basis of performance and suitability data established by laboratory testing at the Ministry of Transportation of Ontario. The main characteristics and uses of the bedrock units found in southern Ontario are summarized in Appendix D.

Deposit "size" is related directly to the areal extent of thin drift cover overlying favourable bedrock formations. The deposit size is recorded in Bedrock | Drift_Thick.dbf | AREA; the favourable bedrock formations are reported in Bedrock | Drift_Thick.dbf | FORMATION. Since vertical and lateral variations in bedrock units are much more gradual than in sand and gravel deposits, the quality and quantity of the resource are usually consistent over large areas.

Quality of the aggregate derived from specific bedrock units is established by the performance standards previously mentioned. Location and setting criteria and regional considerations are identical to those for sand and gravel deposits.

BEDROCK RESOURCE TONNAGE CALCULATIONS

The method used to calculate resources of bedrock-derived aggregate is much the same as that described above for sand and gravel resources. The areal extent of bedrock formations overlain by less than 15 m of unconsolidated overburden is determined from bedrock geology maps, drift thickness and bedrock topography maps, and from the interpretation of water well records (Table 4). The measured extent of such areas is then multiplied by the estimated quarriable thickness of the formation, based on stratigraphic analyses and on estimates of existing quarry faces in the unit. In some cases, a standardized estimate of 18 m is used for thickness. Volume estimates are then multiplied by the density factor (the estimated weight in tonnes of a 1 m thick section of rock, 1 ha in extent). The areal extent of bedrock formations is also recorded in Bedrock | Drift_Thick.dbf | AREA.

Resources of limestone and dolostone are calculated using a density factor of 2649 kg/m^3; sandstone resources are calculated using a density estimate of 2344 kg/m^3; and shale resources are calculated with a factor of 2408 kg/m^3 (Telford et al. 1980).

Assessment of Aggregate Resources in Grey County

LOCATION AND POPULATION

Grey County occupies an area of approximately 4509 km^2 and is located south of Georgian Bay and northwest of the City of Toronto (Figure 1). The county is covered by all or parts of 10, 1:50 000 scale map sheets of the National Topographic System (NTS). The 10 maps sheets are Dundalk (41 A/1), Durham (41 A/2), Walkerton (41 A/3), Chesley (41 A/6), Markdale (41 A/7), Collingwood (41 A/8), Nottawassaga (41 A/9), Owen Sound (41 A/10), Wiarton (41 A/11) and North Keppel (41 A/15).

In 2006, the population of Grey County was 92 411 (Statistics Canada 2006), which represents a 3.7% increase from 2001 (Table A). Grey County is largely rural in character and the majority of the county is either forested or farmed. There are 3 major urban centres, Owen Sound, Meaford and Hanover, and these centres comprise 24%, 12% and 8% of the overall population of the county, respectively. Road access to Grey County is provided by Provincial highways 6, 10, 21 and 26. A well-developed network of county and township roads provide access throughout the county.

Table A – Area and Population, Grey County

Municipality	Area in 2006 (km^2)	2001 Population	2006 Population
Township of Chatsworth	595	6280	6392
Township of Georgian Bluffs	604	10 127	10 506
Municipality of Grey Highlands	881	9196	9480
Town of Hanover	10	6869	7147
Municipality of Meaford	589	10 381	10 948
City of Owen Sound	24	21 456	21 753
Township of Southgate	644	6907	7167
Town of The Blue Mountains	287	6116	6825
Municipality of West Grey	875	11 741	12 193
Total	**4509**	**89 073**	**92 411**

SURFICIAL GEOLOGY AND PHYSIOGRAPHY

The physiography of the northern part of Grey County is dominated by the Niagara Escarpment, which is a major bedrock feature trending subparallel to the shoreline of Georgian Bay. Bedrock occurs at, or near, surface in the vicinity of the Niagara Escarpment and in much of the area between the escarpment and the shore of Georgian Bay. Bedrock also crops out for several kilometres south of the escarpment and occasionally isolated outcrops occur in incised river valleys in the central and southern portion of the county.

The topographic relief along the face of the Niagara Escarpment exceeds 50 m in the Singhampton–Thornbury area and the face of the escarpment commonly exposes the resistant caprock of the Amabel Formation. Underlying the Amabel Formation, the Fossil Hill, Cabot Head, Manitoulin, Queenston, Georgian Bay and Lindsay formations are exposed elsewhere in Grey County.

The bedrock is covered by a gradually thickening wedge of glacial sediments as one moves south and west from the brow of the Niagara Escarpment. The southern half of the county is dominated by large glacial landforms. These glacial and proglacial deposits were laid down during the late Wisconsinan substage of the Pleistocene Epoch approximately 23 000 to 10 000 years ago.

Chapman and Putnam (1984) have documented the occurrence of a series of subparallel moraines in the study area deposited by the Lake Huron–Georgian Bay ice lobes. The largest moraine in Grey County is the Singhampton moraine that occurs mainly in the Township of Southgate and the Municipality of West Grey. This is a large, irregularly shaped feature composed of ice-contact glaciofluvial sediments that have been mapped as a "kame moraine" and called the "Saugeen Kames" by Chapman and Putnam (1984). The moraine has been dissected into a series of individual hummocky mounds by a series of outwash spillway deposits. The interrelationship of the moraine and the outwash deposits suggest that the ice was melting and ablating rapidly during the formation of the Singhampton moraine. Several southeast-trending eskers and a narrow, but well-defined, morainic ridge called the Maple Lake moraine, occur in the till plain to the southeast of the Singhampton moraine.

The deterioration of the ice sheet during the deposition of the Singhampton moraine signalled a shift in the ice movement and a general thinning of the ice. Most of the other moraines located in the study area, and other directional features in the northern half of the county, record the ice movement coming out of Georgian Bay with progressively less influence from the Lake Huron basin. The change in the ice flow direction also corresponds with a change in the till sheet exposed in the southern part of the county: the "Elma–Catfish Creek Continuum" (Sharpe and Edwards 1979) to the younger, fine-grained Dunkeld and St. Joseph tills, which occur in the Gibraltar, Banks, Williscroft and Tara moraines (Sharpe and Edwards 1979; Burwasser 1974a). The general occurrence of the Elma till in, and around, Grey County (Sharpe and Edwards 1979; Feenstra 1994; Sharpe and Broster 1977; Burwasser 1974a) suggests that the Elma Till may be a correlative of the Newmarket Till, which is recognized to the east of the Grey County area.

The Gibraltar, Banks, Williscroft and Tara moraines have been associated with the Dunkeld and St. Joseph tills. The 2 tills and the associated moraines represent the final ice advances in the Grey County area. The ice advances were relatively brief events and, after the deposition of the Tara moraine, the ice withdrew to the north of the Niagara Escarpment and northward into the Georgian Bay basin. All 4 of these moraines show exposures of sand and silt at surface, and some are associated with occurrences of sand and gravel. Fragments of eskers have been identified within, and adjacent to these moraines, and the general landscape and occurrence of features is suggestive of a chaotic sedimentary regime (Sharpe and Edwards 1979; Feenstra 1994).

A number of small glacial features occur within the study area associated with the major moraines. Several small, southeast-trending eskers and a number of drumlins with a similar orientation occur in the extreme south and southeast portion of Grey County. These features occur on the northern edge of a large till plain associated with the Elma till. The eskers are relatively prominent, as they display a characteristic linear ridge within an area of gently rolling till plain, but they are small in size and commonly less than 20 m in height. The materials in these deposits are often sandy, but they are valuable for local construction. Portions of the eskers have been almost entirely removed by extraction operations. Substantial portions of the Elma till plain in this area are poorly drained and there are several broad flat areas containing organic materials in the Township of Southgate.

Numerous drumlins have been mapped between Owen Sound and Meaford, and to the west of Owen Sound. The drumlins have a general south to southwest orientation that indicates the ice flow direction in the local area. It is possible to observe several areas where bedrock relief has modified the local ice flow direction. Ice-contact glaciofluvial deposits, esker segments and associated kame features also occur in the study area west of Owen Sound. These features occur in association with the Tara moraine and they have provided a convenient supply of aggregate for many projects in the Owen Sound area.

As the ice retreated northward past the height of land in the vicinity of the Niagara Escarpment, the meltwater became trapped between the land and the ice front, and a series of proglacial ponds and lakes developed. The lakes that formed in the Thornbury–Meaford–Owen Sound area are among the youngest of a series of proglacial lakes that occurred in southern Ontario during and after the retreat of the ice from the Great Lakes basins. As a result, there are a variety of features and deposits associated with ponded water and proglacial lakes. There are several areas, particularly north of the Banks moraine, where the till is covered by a veneer of silt and fine sand several metres thick. As the lake levels dropped, a series of shoreline bars and shorebluffs relating to proglacial lakes Algonquin and Nipissing have been preserved in the Meaford, Thornbury and Collingwood areas. There are also similar small features near the Owen Sound and Wiarton areas, parallel to, and above, the present shoreline. Although these shoreline features are relatively thin, they have been a source of aggregate materials for local construction activity.

The Quaternary geology of the study area is provided in greater detail in the following maps and publications: Burwasser (1974a), Cowan (1976, 1979), Cowan and Pinch (1986), Gwyn (1972), Sharpe and Broster (1977), Sharpe and Edwards (1979) and Sharpe and Jamieson (1982).

EXTRACTIVE ACTIVITY

The moraines and outwash channels in the central part of Grey County have impressed many observers because of their sheer size and the potential sand and gravel resources that may be available. The Singhampton moraine, and the outwash deposits associated with the Singhampton, Gibraltar and Banks moraines, clearly contain substantial quantities of sand and gravel. Unfortunately, there are relatively few pits and exposures within these deposits that can be used to fully evaluate the material present and its aggregate potential. Subsurface information derived from Ministry of the Environment water-well data indicate that some of these deposits may contain over 50 m of sand and gravel material, but there are no data available at this time to provide confirmation of the internal composition or what amount of variability may be. The ability to assess these resources will improve greatly once exposures and/or detailed drilling data become available.

Aggregate resources in the Tara moraine area, west of Owen Sound, have been extracted for many years and continue to be an important source of construction materials for the Owen Sound area. These materials have a restricted product range and many of the higher quality materials are obtained from 2 local quarries. Many of the small shoreline sand and gravel deposits in the Wiarton, Owen Sound, Meaford and Thornbury areas have also been used as sources of aggregate over many years. Most of these sites are now inactive and there is only one area at Thornbury that is currently undergoing extraction. Extraction in the southern portion of the county has taken place in the eskers and in the Maple Lake moraine. While there are a number of depleted sites in these deposits, there are several licenced operations serving local construction needs.

There are a number of licenced pits in the Mount Forest–Chatsworth–Flesherton area within moraines and associated outwash deposits. The majority of the extraction has taken place in the outwash materials and many of these properties are substantial operations capable of producing a variety of medium- to high-quality aggregate products.

At the time of writing, there were 116 pits and 9 quarries licenced to operate in Grey County. This licence information was provided by the Ministry of Natural Resources in the summer of 2002. MNDMF would like to gratefully acknowledge the co-operation of MNR staff in providing this information. Overall production in 2000, including wayside permits, was approximately 2.5 million tonnes. Production in Grey County is consistently between 2.0 million and 3.0 million tonnes (Table B).

Historically, the aggregate production in Grey County has supplied the local market. There are numerous abandoned and current small operations disbursed throughout the county. Many of these operations have provided basic construction materials for local construction activity, plus the occasional road construction project. The major urban centre for the county is Owen Sound and there is a concentration of operations and production in the Township of Georgian Bluffs and the Township of Chatsworth which supply that market (Table C). The Municipality of Grey Highlands produces approximately 15% of the county's aggregate. This is generally consumed in the Markdale area and in the Town of The Blue Mountains–Collingwood area where there has been significant development in recent years. Recent building in Meaford and Thornbury area has also fuelled local demand for aggregates and an increasing amount of aggregate will have to be shipped to those areas as local supplies dwindle.

Table B – Aggregate Production, Grey County (1992–2000)*

Year	Production (000s tonnes)
1992	2600
1993	2400
1994	2700
1995	2400
1996	2000
1997	2100
1998	2100
1999	2800
2000	2500

*The Ontario Aggregate Resource Corporation (TOARC) (2006)

Table C – Aggregate Production by Municipality, Grey County (2006)*

Municipality	Wayside Permits (tonnes)	Licenced Pits and Quarries (tonnes)	Total (tonnes)	%
Township of Chatsworth	0	419 848	419 848	12.4
Township of Georgian Bluffs	0	717 487	717 487	21.1
Municipality of Grey Highlands	0	513 305	513 305	15.1
Town of Hanover	0			
Municipality of Meaford	0	580 955	580 955	17.1
City of Owen Sound	0			
Township of Southgate	0	307 069	307 069	9.0
Town of The Blue Mountains	0	450 833	450 833	13.4
Municipality of West Grey	17 000	387 558	404 558	11.9
County Total	**17 000**	**3 377 055**	**3 394 055**	**100**

*The Ontario Aggregate Resource Corporation (TOARC) (2006)

Grey County has been recognized as a potential source of sand and gravel for the Greater Toronto Area (GTA). This potential was assessed by Peat, Marwick and Partners and M.M. Dillon Limited (1980). This potential was recently reassessed by Jagger Hims Limited (2004). This recent study concluded that localized import and export of aggregate is occurring between adjacent municipalities, but that there is currently no significant export of aggregate from Grey County to the GTA. Further, an economic analysis concludes that current production levels in the 3 million tonnes per annum range will be maintained for the foreseeable future. Export of aggregate to the GTA is highly dependent on a number of factors, but is not likely to occur for 10 to 20 years (Jagger Hims Limited 2004).

Aggregate Quality

Significant changes have occurred in the testing and specifications applied to aggregates since the original Aggregate Resource Inventory Papers were completed for the townships in Grey County (Ontario Geological Survey 1981a, 1981b, 1984a-f, 1985a-d, 1991, 1992a, 1992b). The Los Angeles abrasion test (LS-603) is no longer used in the Ontario Provincial Standard Specifications (OPSS) and the magnesium sulphate soundness test (LS-606) has been reduced to an alternate test. Two new tests, the micro-Deval abrasion test (LS-618 and LS-619) and the unconfined freeze–thaw test (LS-614) have been added. The accelerated mortar bar test (LS-620) has also become a standard test for the determination of potential alkali–silica reactivity in concrete aggregate. The current aggregate resource inventory study tested 59 samples from a variety of sources throughout the county in order to provide some information on the performance of Grey County aggregates under these new test procedures. Five bedrock sources were tested for concrete suitability using the accelerated mortar bar test. Test data are presented in Table 9.

A review of the overall test data in Table 9 reveals several general trends. Values for absorption are generally above 1% and 9 of 59 values are above 2%, which is the standard for many concrete and asphalt products. Test data for the micro-Deval abrasion test tend to average around 11% and 12 of 59 samples exceeded the 14% standard for concrete pavement. There is a strong correlation between elevated absorption values and elevated micro-Deval losses. Seven of 59 freeze–thaw test data exceeded 6% loss and these values appear to correlate with many of the higher values for the micro-Deval and absorption tests. It should be noted that, in spite of some elevated values for the micro-Deval and freeze–thaw tests, the majority of the samples will meet OPSS for most granular, asphalt and concrete products. Detailed resource and product testing will be required to determine the acceptability of individual deposits and properties.

Hewitt (1960) identified the potentially soft and absorptive nature of zones within the Amabel Formation. Both the current field program and the results of the testing program suggest that there is variability in test results from location to location and that care will be required to maintain high-quality products. Elevated absorption values have been recognized in the area and producers and regular consumers have learned to address concerns by adjusting asphalt or cement/water contents appropriately. Additional aggregate quality information is provided by Dieke (1978a-f, 1979, 1982a-f) and Sado (1976a-e).

SELECTED SAND AND GRAVEL RESOURCE AREAS

Selected Sand and Gravel Resource Area 1

Selected Sand and Gravel Resource Area 1 is located between the Banks and Gibraltar moraines, in the vicinity of McCullough Lake, in the Township of Chatsworth. The selected area consists of one main area and several smaller areas of outwash gravel deposits. Collectively, Selected Sand and Gravel Resource Area 1 occupies approximately 1318 ha.

One licenced pit (Pit No. 143) and 11 unlicenced pits (Pit Nos. 219, 234-243) have been developed in Selected Sand and Gravel Resource Area 1. Face heights in the unlicenced pits range from 1 to 4 m. The available water-well data indicate the potential for more than 10 m of sand and gravel in the selected area.

The percentage of gravel in the abandoned pits and other exposures commonly range from 30 to 65%. Several exposures suggest that these deposits contain less gravel toward the edges of the deposits. The materials have been assessed as suitable, in terms of gradation, for use in the production of Granular B and SSM (Ontario Geological Survey 1984a, 1985a; Dieke 1982a, 1982b).

A variety of sample data have been reviewed from individual properties, from the previous township reports as noted above and from the current assessment. These data indicate that there is variability in the material within the deposits, but that significant portions of the deposits are capable of meeting the grain size specifications for Granular A and most other granular products. It is likely that a variety of other products such as clear stone, fine and coarse aggregate, and other specialty products can be manufactured with routine levels of crushing and screening. Data from 2 samples (Sample Nos. 1 and 2) taken from roadcuts within the selected area show acceptable magnesium sulphate soundness and absorption test values, elevated but acceptable values for coarse micro-Deval abrasion tests and varied test results for the freeze–thaw test. These data indicate the potential to meet common granular, asphaltic and concrete uses for aggregate, but careful site-specific testing will be required depending on the desired aggregate product.

Selected Sand and Gravel Resource Area 1 has 495 ha potentially available for resource extraction after cultural features have been considered. Based on an average thickness of 5 m of usable material, the deposits contain an estimated 44 million tonnes of sand and gravel (Table 3). The deposits are easily accessible by county and township roads, and are located in close proximity to Highway 6.

Selected Sand and Gravel Resource Area 2

Selected Sand and Gravel Resource Area 2 is composed of several outwash deposits located predominantly north of Highway 10 between Chatsworth and Markdale, near Holland Centre. The outwash deposits abut the southern edge of the Banks moraine and portions of the outwash deposits have been dissected into multiple areas by the streams in the area, notably the various branches of Hamilton Creek.

The largest portion of the deposit abuts the Robeson Lakes. Two licenced pits (Pit Nos. 139 and 140) are located within the selected resource area, and there are 11 unlicenced and abandoned pits (Pit Nos. 227, 228, 229, 230, 231, 232, 255, 256, 257, 258 and 259). Two samples were taken during the current study (Sample Nos. 38 and 39) with the results of the tests presented in Table 9. Test and production records for the 2 licenced pits are available and date back several decades.

Pit faces commonly range from 3 to 5 m, however, one exposure shows up to 15 m of aggregate material. The materials are outwash sand and gravel, averaging 40 to 80% gravel and 30 to 60% crushable. The outwash is proximal to the Banks moraine, which may account for the moderate variability observed in the faces. Previous assessments (Ontario Geological Survey 1984b; Dieke 1982b) have indicated quality concerns related to soft porous dolostone and slightly elevated test data for absorption and micro-Deval abrasion. Test results from the current sampling program confirm that the quality of the material may be a concern for the manufacture of high-quality asphalt or concrete products. The materials are capable of meeting granular specifications and some lower specification asphalt.

Available information indicates that the deposit is locally in excess of 15 m thick, although none of the abandoned pits exceed 5 m. It is likely that the deposit thickness decreases somewhat toward the outer edges and an average thickness of 8 m of usable sand and gravel has been assigned. The overall deposit area is 918 ha with 450 ha of the area constrained by environmental and cultural features. This leaves a potentially available resource of 468 ha. The possible available resource contains approximately 66 million tonnes of sand and gravel (*see* Table 3). The Robson Lakes abut the selected resource area and environmental and cultural concerns relating to the lakes may further restrict the availability and development of this resource.

Selected Sand and Gravel Resource Area 3

Selected Sand and Gravel Resource Area 3 is an area of outwash located on the west side of the Township of Chatsworth, between the Banks and Gibraltar moraines. The deposit includes a small esker that is associated with the outwash deposit. Three licenced pits occur in this area (Pit Nos. 146, 147 and 148) with initial pit development and excavation in the esker portion of the deposit. There is one abandoned pit located in Selected Sand and Gravel Resource Area 3 (Pit No. 263).

Pit faces and other exposures reveal approximately 10 to 25% gravel and an average thickness of about 5 m. There seems to be a low percentage of fine material. Previous work in the area (Ontario Geological Survey 1985a; Dieke 1982a) indicates that the material will meet specifications for Granular B and SSM, but that compaction may be a concern due to the relatively low amount of fines. Previous testing indicated that the gradation of the material will meet concrete sand specifications without processing. Selected quality testing of one sample (Sample No. 3) from the outwash portion of the deposit reveals that the coarse aggregate will meet most common granular, asphalt and concrete specifications (*see* Table 9).

Selected Sand and Gravel Resource Area 3 was previously noted as having the potential to make high-quality fine aggregate (Ontario Geological Survey 1985a). The current assessment reaches the same conclusion and selected test data on one sample indicate that high physical quality specifications may be achieved. Detailed testing will be required for any site specific development. The resource lies in a relatively low area and it may be necessary to extract beneath the water table in order to remove the full thickness of the deposit.

Selected Sand and Gravel Resource Area 3 occupies approximately 392 ha of which approximately 210 ha are considered potentially available for extraction. Assuming an average thickness of 5 m, the possible sand and gravel resources are estimated to be 19 million tonnes (*see* Table 3). Access to the deposit is via County Roads 25 and 3, plus several township roads.

Selected Sand and Gravel Resource Area 4

Selected Sand and Gravel Resource Area 4 consists of areas of outwash to the south and west of the Town of Markdale, mainly in the Municipality of West Grey. The outwash is generally associated with the Saugeen River spillway system. This system was active near the end of the deposition of the Singhampton moraine through to the deposition of the Gibraltar moraine.

Selected Sand and Gravel Resource Area 4 contains 2 licenced pits (Pit Nos. 407 and 408) and 21 abandoned pits (Pit Nos. 277 to 281, 361, 440, 441, 455-458, 460-462, 481-483, 488, 506 and 507). Three samples were taken from this area and subjected to laboratory analysis during the current study (Sample Nos. 34, 35 and 37). The results of these tests are presented in Table 9. The MTO tested several properties within the selected area between 1955 and 1975 for the production of granular material for highway construction projects. The MTO test programs generally acknowledge the ability of the material within these deposits to produce granular products with appropriate grading control. Laboratory test data from the current study generally meet specifications for granular, asphalt and concrete use, although 1 sample exceeded the 2% limit for absorption and the other 2 samples yielded results close to the limit. The existence of elevated absorption rates suggests the presence of soft and/or porous dolostone in the gravel, but none of the other test data appear to correlate with these results and further testing will be required to address this concern (Ontario Geological Survey 1981a, 1984a, 1984b; Dieke 1978a, 1978f, 1982b; Sado 1976a, 1976e).

Exposures in the deposit indicate a gravel content ranging from 30 to 80% with an average overall gravel content of approximately 60%. Crushable gravel commonly accounts for 20 to 40% of the material, 5 to 10% oversized material is reported, and an upper 1 to 2 m thick layer of "dirty" sand and gravel is noted in many faces. Exposed faces include layers of sand with abrupt bedding changes.

Selected Sand and Gravel Resource Area 4 includes a number of separate, smaller deposits cut by post-depositional stream erosion. The combined area of these segments in the Township of Chatsworth, the Municipality of Grey Highlands and the Municipality of West Grey is 1298 ha when allowances are made for cultural constraints. Based on an average thickness of 7 m, Selected Sand and Gravel Resource Area 4 contains an estimated 160 million tonnes of sand and gravel (*see* Table 3). The deposit is located close to Markdale and within 10 km of Highway 10. The western portion of the selected area is within 10 km of Highway 6. Access to these provincial highways is provided by township roads.

Selected Sand and Gravel Resource Area 5

Selected Sand and Gravel Resource Area 5 is a major outwash complex situated in the spillways between the Gibraltar and Singhampton moraines, northwest of the Town of Durham. It contains 10 licenced pits (Pit Nos. 405, 409, 410, 412, 413, 414, 415, 416, 418 and 419), numerous abandoned pits and a number of good roadcut exposures. The deposit has provided aggregate for local consumption for a number of years.

The outwash deposits in Selected Sand and Gravel Resource Area 5 were laid down by meltwater flowing in a generally southerly direction from the ice margin while it stood at the Gibraltar moraine. The size of the outwash deposit and the magnitude of the channels cut into the previously deposited Singhampton moraine to the south are clear indications of a major melting event at this point in the geologic history of the area. Selected Sand and Gravel Resource Area 5 was separated from other aggregate deposits in the area because of its position between the Gibraltar and Singhampton moraines. It does connect with a number of other outwash deposits in the area, notably Selected Sand and Gravel Resource Area 7 located to the southeast, but Selected Sand and Gravel Resource Area 5 is located closest to the Gibraltar ice frontal position and the deposits are inferred to have the highest gravel content. The overall outwash system relating to the Gibraltar moraine meltwater position is expected to display a gradual fining in the material with increasing distance from the moraine (to the southeast). Many of the previously existing outwash deposits that were laid down while the ice stood at the Singhampton moraine were reworked by the meltwater flowing from the Gibraltar moraine at this time. The expectation of a gradual fining in the outwash in a southeasterly direction has been confirmed by general observations from pits in Selected Sand and Gravel Resource Areas 5 and 7.

Data from MTO files on several of the abandoned pits in the deposit indicate the potential to produce granular materials and selected asphaltic aggregate products provided normal processing is employed. The actual testing was with older methods and specifications, so a reassessment using current testing methods and specifications was necessary. Selected testing completed during the current study (Sample Nos. 5, 6, 8, 9, and 10) indicate that Selected Sand and Gravel Resource Area 5 will meet specifications for granular and general asphalt and concrete products. Field observations confirm a moderately variable grain size with most locations showing 40 to 60% gravel. Observed faces in pits tend to be consistent in gravel content with relatively few boulders. Sand may dominate near the edges of the deposits and some pits have encountered significant amounts (to 10%) of boulder sized material. Pit faces are commonly 8 to 10 m, but there are areas in Selected Sand and Gravel Resource Area 5 that exceed 20 m in thickness according to water-well data. Actual thickness will depend on the depth of the eroded bottom of the spillway and the presence of multiple terraces. The lower terraces, particularly those along the Saugeen River, contain a higher water table, and it may be necessary to extract below the water table in order to remove the full thickness of the resource (Ontario Geological Survey 1984b, 1984c, 1984d; Dieke 1978a-d; Sado 1976a, 1976b, 1976c).

After consideration of cultural setbacks and previously extracted areas, Selected Sand and Gravel Resource Area 5 has approximately 2431 ha potentially available for extraction. Based on a thickness of 8 m, the deposit contains an estimated 345 million tonnes of aggregate (*see* Table 3). The resource is accessible by a variety of township roads that connect to Highway 6. County Roads 4, 12 and 25 also cross portions of the resource area.

Selected Sand and Gravel Resource Area 6

Selected Sand and Gravel Resource Area 6 is located on the west side of the Municipality of West Grey, approximately 5 km northeast of Hanover. It is comprised of an ice-marginal deltaic deposit of sand and gravel formed by the joining of 2 glaciofluvial deltas plus the esker system that fed the delta. Coarse material is generally concentrated in the upper (topset) beds of the deposit and near the former inlet channels of the deltas. The prominent esker, which represents the former channel flowing into the delta, feeds into the north end of the deposit. Gravelly sand extending to a depth of 15 m below the surface is inferred to be part of the esker core. A second esker occurs at the eastern edge of the delta complex, approximately 1 km to the east. Exposures indicate that the lower part of the delta complex is fine sand and that the gravel is concentrated in the esker cores and in the upper portions of the delta. The upper surface of the delta is relatively flat.

Four abandoned pits (Pit Nos. 489, 510, 511 and 512) and one licenced pit (Pit No. 411) have been developed in the selected resource area. Sample No. 58 was collected and tested as part of the current study. The boundaries of the resource were drawn to include the 2 tributary eskers on the basis that the esker core materials will likely exhibit similar quality to that documented in the upper gravelly layer of the delta.

The overall geology of the delta–esker complex suggests several sedimentary episodes that have left a series of layers of sand with interbedded thinner layers of gravel. The thickest gravel layer is exposed at the surface in Pit No. 411; this licenced property has produced high-quality asphalt and concrete products for several decades. A long history of test data has been maintained by the MTO and these data confirm that the deposit produces materials that consistently meet high-quality asphalt and concrete specifications (Ontario Geological Survey 1984c, 1984d; Dieke 1978b, 1978c, 1978d; Sado 1976b, 1976c). Laboratory data from Sample No. 58 confirmed the ability of the material to meet high-quality asphalt and concrete specifications.

Selected Sand and Gravel Resource Area 6 is a relatively small feature and approximately a third of the delta portion of the deposit has been extracted at the time of the field visit. Approximately 37 ha of resource remain after allowances for cultural and environmental features. A series of roadcuts and pit exposures indicate an average of 8 m of granular material in the remaining resource area with an estimated 5 million tonnes of sand and gravel. The deposit is located on a paved county road approximately 5 km from Hanover. Township roads connect the deposit to County Roads 3, 4 and 10.

Selected Sand and Gravel Resource Area 7

Selected Sand and Gravel Resource Area 7 is a large portion of the Singhampton moraine located in the Markdale–Durham area, primarily in the Municipality of West Grey and the Township of Southgate. The resource area contains 6 licenced pits (Pit Nos. 289, 290, 417, 418, 419 and 622), and numerous small abandoned pits. Eight samples were tested during the current assessment (Sample Nos. 11, 12, 13, 33, 36, 48, 49 and 50).

The Singhampton moraine displays a variety of characteristics over its length and Selected Sand and Gravel Resource Area 7 is a large glaciofluvial part of the moraine potentially containing large quantities of sand and gravel. Numerous small exposures, plus the presence of extensive associated outwash–spillway deposits, indicate that the ice was melting rapidly at the time the moraine was formed in the Markdale–Durham area. The moraine ranges from 5 to 10 km in width and reaches 50 m or more in relief. Much of the central portion of the moraine displays a pronounced hummocky relief and this contrasts strongly with the flatter topography associated outwash deposits, which occur in the adjoining valley areas.

Numerous small roadcuts and unlicenced gravel pits expose the granular resources of the Singhampton moraine. Licenced pit operations and several back-hoe test pit programs, documented by the MTO, confirm the existence of resources of potential commercial grades. Field assessments generally indicate that the materials meet granular and common asphalt specifications provided that grain size variability is addressed (Ontario Geological Survey 1981a, 1981b, 1984b, 1984e; Dieke 1978a, 1978e, 1978f; Sado 1976a, 1976d, 1976e). Exposures and test pit programs confirm the existence of variability in the aggregate material, which should be anticipated in any ice-contact glaciofluvial landform such as the Singhampton moraine.

There are 6 licenced pits in Selected Sand and Gravel Resource Area 7, but there is little record of production as the majority of the licenced land remains unopened. The lack of good exposures and/or high-quality subsurface data preclude an accurate determination of the nature of the deposit; however, available information indicate that there are significant bodies of aggregate in the moraine which have the potential to support commercial extraction. Laboratory test data from the 8 samples obtained during the current study confirm the acceptability of the materials for granular and asphaltic aggregate production. Specific tests for concrete suitability were not conducted, but routine test data confirm that the materials may also meet most concrete specifications.

Selected Sand and Gravel Resource Area 7 includes a number of segments of the Singhampton moraine in the Township of Chatsworth, the Municipality of Grey Highlands, the Municipality of West Grey and the Township of Southgate. The overall area of these segments is 3827 ha, once allowances have been made for cultural constraints. A thickness of 8 m has been used to calculate a deposit volume of 542 million tonnes (*see* Table 3). Additional data, subsurface analysis and site specific testing will be required to define and delineate individual properties.

Selected Sand and Gravel Resource Area 8

Selected Sand and Gravel Resource Area 8 is a glaciofluvial deposit located beneath the towns of Flesherton and Eugenia, in the Municipality of Grey Highlands, at the head of the Beaver Valley. The glaciofluvial outwash–delta complex is associated with the Singhampton moraine. The land surface in the area is gently rolling.

Nine unlicenced pits (Pit Nos. 365, 366, 368, 369, 372, 378, 379, 380 and 382) have been opened in the resource area, whereas 3 pits are currently licenced for extraction (Pit No. 294, 295 and 296). A 9 m face in the central part of the deposit exposes uniform, poorly sorted cobble gravel with little evidence of stratification. This material may have been deposited in a deltaic channel. Other faces in the pit expose finer grained, better sorted aggregate. Historical data from the MTO indicate that material with a gravel content of 50 to 55% was extracted from these pits.

Historical records indicate that aggregate from Selected Sand and Gravel Resource Area 8 has been used for a wide range of road-building and construction products. The stone is of good quality and is suitable for granular base as well as concrete aggregate (Ontario Geological Survey 1981a, 1984b; Deike 1978a, 1978f; Sado 1976a, 1976e). Gradation control will be required for crushing in the peripheral areas, whereas, in the central portion of the deposit, in the delta core, oversize stones must be addressed. The sand fraction grades fine for asphaltic aggregate in parts of the deposit. Test data obtained during the current study (Sample No. 28) indicate generally acceptable results, but absorption exceeded the specification limits for asphalt and concrete aggregate.

Selected Sand and Gravel Resource Area 8 occupies approximately 219 ha once previously extracted and cultural features have been considered. Assuming an average thickness of 8 m throughout the resource area, possible resources of sand and gravel are estimated to be 31 million tonnes (*see* Table 3).

Competing land uses in Selected Sand and Gravel Resource Area 8 are agricultural and residential development on the fringes of Flesherton. These uses may constrain possible extraction in the southern portion of the selected resource area. Parts of the area lie within development control areas of the Niagara Escarpment Plan.

Selected Sand and Gravel Resource Area 9

Selected Sand and Gravel Resource Area 9 is part of a series of deposits, occurring in meltwater channels, which extend eastward from Flesherton as far as the hamlet of Feversham. The gravels were deposited by meltwaters that ran off the ice sheet while it stood at the Gibraltar moraine (Burwasser 1974a). The land surface in Selected Sand and Gravel Resource Area 9 is generally level, but has several terraces with intervening marshy depressions and lower terraces composed of sandy aggregate.

Three pits, all of which are presently licenced to operate (Pit Nos. 297, 301 and 302) are developed in the resource area. Pit faces range in height to 8 m and expose both coarse and fine outwash aggregate. Three unlicenced pits (Pit Nos. 375, 383 and 384) occur in Selected Sand and Gravel Resource Area 9 and 2 additional samples (Sample Nos. 29 and 30) were collected during the current survey. The central portion of the higher terraces expose massive, poorly to moderately sorted, poorly stratified coarse gravel. Gravel content ranges from 50 to 75%. Pit faces in the lower terraces expose less than 6 m of sandy gravel and interlayered sand consisting of approximately 30 to 50% gravel. The underlying silt till is occasionally exposed in the pit floors. In the lower terraces, the water table is often near the ground surface and the lower portion of the aggregate may be below the water level.

Aggregate from the pits has been used for a wide range of road-building and construction products, but, according to test data compiled by the MTO, the sand and stone quality are borderline to unacceptable for concrete and asphaltic aggregates. Shale and soft carbonates in the aggregate are prone to rapid weathering and cause “pop-out” failures in pavement (Deike 1978f). Current test results (Sample Nos. 29 and 30) indicate varied but high values for absorption and micro-Deval tests, which may affect the ability of the materials to meet some asphalt and concrete specifications. The material in Selected Sand and Gravel Resource Area 9 should be tested before use in high-specification products. The aggregate is suited for granular base and fill (Ontario Geological Survey 1981a, 1984f; Deike 1978f, 1979; Sado 1976e).

In Selected Sand and Gravel Resource Area 9, approximately 236 ha are thought to be presently available for possible extraction after allowances are made for current operations and cultural features. Deposit thickness is known to vary, but, assuming an average thickness of usable material of 6 m, sand and gravel resources are estimated to be 25 million tonnes (*see* Table 3).

Selected Sand and Gravel Resource Area 9 is located close to Flesherton and competing land uses are mainly agricultural. Part of the deposit occurs below the water table and near Eugenia Lake residential development is a competing land use. The resource area is bisected by Highway 4 and is centrally located with respect to several local demand centres.

Selected Sand and Gravel Resource Area 10

Selected Sand and Gravel Resource Area 10 is the southwest continuation of the glaciofluvial outwash spillway system associated with the Singhampton moraine. Other parts of the spillway system are noted as Selected Sand and Gravel Resource Area 5 (this report) and Selected Sand and Gravel Resource Areas 3 and 4 (Planning Initiatives Limited and the Ontario Geological Survey 1999). The deposit contains 16 unlicenced pits and 8 licenced pits (Pit Nos. 418, 423, 621, 622, 627, 632, 633 and 634). Seven samples (Sample Nos. 14, 16, 17, 23, 24, 25 and 27) were taken from the deposit at various locations during the current survey. The deposit has seen relatively little extraction activity to date as there are several good sources immediately adjacent to the 2 local markets, Durham and Mount Forest, and there has been little interest in opening additional sources.

The outwash deposits in Selected Sand and Gravel Resource Area 10 were laid down by meltwater flowing in a generally south to southwest direction from the ice margin as it stood at the Gibraltar moraine. The size of the outwash deposit and the magnitude of the channels cut into the previously deposited Singhampton moraine are indications of a major melting event at this point in the geologic history of the area. Selected Sand and Gravel Resource

Area 10 is similar to Selected Sand and Gravel Resource Area 5 except that a reduction in gravel content was observed in field exposures. Since Selected Sand and Gravel Resource Area 10 is slightly more distant from the ice front, it is reasonable to expect not only a reduction in the grain size, but possibly a thinning of the deposit in a southerly direction with greater distance from the moraine. It is likely that some of the deposits in Selected Sand and Gravel Resource Area 10 have been reworked from earlier glaciofluvial and ice-contact sediments from the Singhampton moraine (Ontario Geological Survey 1984b, 1984d, 1984e; Dieke 1978a, 1978d, 1978e; Sado 1976a, 1976c, 1976d).

Previous work in the area (Ontario Geological Survey 1984b) estimated the thickness of the deposits to be between 6 and 15 m. Water-well data suggest potentially greater thickness in many areas (up to 20 m). Numerous unlicenced pits are located in, or partially within, the deposit. Four of the 8 licenced pits within the resource area include part of Selected Sand and Gravel Resource Area 10 together with part of other surrounding resource areas. The 'dual deposit' licences are often developed in well-defined and elevated esker features that occur above the water table and later extend to adjacent outwash deposits that may extend beneath the water table.

Historical records from the MTO confirm that several of the abandoned pits in Selected Sand and Gravel Resource Area 10 have been used as a source of granular aggregate for Ministry projects. Smaller amounts of asphalt aggregate have been produced. Many of the Ministry production and investigation records date back to the 1950s to 1970s. Field observations from the current survey confirm the general belief that a variety of granular and asphalt aggregates can be manufactured from the materials in Selected Sand and Gravel Resource Area 10 provided appropriate grain size control is exercised. Laboratory testing on the 7 samples taken from the deposit confirm that test data meet normal granular, asphalt and concrete specifications, although specific testing for concrete reactivity was not conducted.

Selected Sand and Gravel Resource Area 10 has a total area of 6314 ha in the Municipality of West Grey and the Township of Southgate. Once an allowance has been made for cultural features, the available area is reduced to 2640 ha. Assuming an average deposit thickness of 9 m, the aggregate resources in Selected Sand and Gravel Resource Area 10 are estimated to be 421 million tonnes (*see* Table 3). The area is accessible by Provincial Highway 5, County Roads 9, 109, 106 and 23, and a network of township roads.

Selected Sand and Gravel Resource Area 11

Selected Sand and Gravel Resource Area 11 is an esker that trends southeasterly in the southeast corner of the county. The deposit has been named the Egerton esker because of its proximity to the settlement of Egerton. The southern extension of the Egerton esker into Wellington County has been selected for possible resource protection at the primary level (Planning Initiatives Limited and the Ontario Geological Survey 1999). The deposit consists of a single well-defined ridge with local relief of 3 to 15 m. The esker has a "beaded" appearance and a large portion of the central ridge has been removed by historical extraction.

Nine unlicenced pits have been developed in the resource area, although none are presently licenced for extraction. Faces in these pits range from 2 to 11 m and expose poorly sorted coarse sand and gravel. The aggregate has been used extensively for granular products and is capable of meeting asphalt specifications with processing. Oversized material may require selective crushing or removal. The sand fraction is coarse and dirty, and the material will require grain size control to meet higher specifications (Ontario Geological Survey 1981b). One sample taken during the current study (Sample No. 20) yielded test data indicating the material will meet granular and most asphalt specifications.

Selected Sand and Gravel Resource Area 11 has a total area of 225 ha of which 15 ha remain available for extraction. Assuming an average deposit thickness of 5 m, presently available resources of sand and gravel are estimated to be 1 million tonnes (*see* Table 3). Selected Sand and Gravel Resource Area 11 is accessible by township roads and Highway 89.

Selected Sand and Gravel Resource Area 12

Selected Sand and Gravel Resource Area 12 is an esker deposit that trends southeast from south of Flesherton to the southeast corner of the county. The esker consists of a single sharply defined ridge with local relief to 18 m. The segment at the southern boundary consists of several branching ridges and is associated with ice-contact stratified drift (i.e., kame deposits). This portion of the resource area extends south into East Luther Township where the deposit has also been selected for possible resource protection at the primary level (Planning Initiatives Limited and the Ontario Geological Survey 1999).

Eight sources are presently licenced for extraction in the resource area (Pit Nos. 624, 625, 626, 628, 629, 630, 639 and 640). Faces in the pits range in height from 5 to 9 m and expose mainly poorly stratified coarse sand and gravel. Eight unlicenced pits were identified (Pit Nos. 654, 666, 667, 680, 689, 690, 707 and 708). For most of its length, the esker ridge is "beaded", consisting of numerous ridge segments separated by short intervals of subdued or absent ridge and finer textured material. In the latter areas, the pit faces are lower and expose material that may not be suitable for crushing. In the ridges themselves, the face heights exceed 9 m and expose coarse gravel well suited for the production of a variety of aggregate products for road building and residential construction (Ontario Geological Survey 1981b). One sample was tested during the current survey (Sample No. 21) and yielded test data indicating the material was capable of meeting specifications for all granular and most asphalt and cement products. Specific testing for concrete specifications was not conducted. Occasional cementation was observed. Oversized material is present throughout the deposit. The oversize fragments must be removed by selection or reduced by crushing while the cemented material should be avoided where possible. The clay content and the presence of silt layers also limit the aggregate's usefulness in the finer grained portions of the deposit. The distribution of coarse material within the deposit varies.

Selected Sand and Gravel Resource Area 12 occupies a total area of 547 ha with approximately 108 ha remaining as potentially available for extraction. Assuming an average thickness of 6 m throughout the deposit, presently available resources of sand and gravel are estimated to be 12 million tonnes (*see* Table 3). The deposit is accessible by a number of local roads and Highway 89.

Resource Areas of Secondary Significance

There are numerous secondary deposits throughout Grey County and, since these deposits are located close to local demand areas, they have generally seen a higher level of extraction than many of the large primary resources within the county.

Beach shoreline and bar deposits occur in several areas near Georgian Bay, notably near Wiarton, Owen Sound, Meaford and Thornbury. These deposits relate to proglacial lake levels in the area and they often contain sand, sandy gravel and gravel capable of supplying a variety of construction needs for the local market. Many of these deposits have been extensively mined in the past and competing land uses have sterilized other significant areas, particularly near Meaford and Thornbury. Small areas of these secondary deposits may be relatively unconstrained and potentially available for extraction, and it is recommended that these areas be considered for protection, particularly near Meaford and Thornbury, where alternative supplies are many kilometres more distant.

The ice-contact deposits of the Tara moraine and the associated esker–kame–delta complex deposits have provided aggregate products for the local Owen Sound area for many years. While these deposits commonly exhibit variability, many contain significant fines and relatively modest amounts of gravel. These deposits remain an important supply to the Owen Sound market, but more distant sand and gravel sources south of Chatsworth and 2 bedrock quarries near Owen Sound are now supplying a major portion of the medium- to high-quality aggregate to the town. Remaining materials in the Tara moraine area will continue to provide some lower specification sand products to Owen Sound.

The southern portion of the Township of Chatsworth contains a variety of secondary deposits associated with the Banks and Gibraltar moraines. The majority of these deposits are ice-contact in nature and are characteristically dominated by sand. Numerous small pits have been opened in the area and many of these have exploited lenses of coarser granular materials within the sand. Where gravel lenses exist within these materials, they can provide a good source of sand and gravel. However, these occurrences tend to be local in nature and few pits have a lengthy history of production. Included in the secondary deposits in the Township of Chatsworth are occasional areas of outwash. These deposits tend to be either predominantly sand or they may be relatively thin. It is for these reasons that they are considered as secondary deposits. These materials are capable of providing some types of granular products and fill.

There are several clusters of secondary deposits in the immediate vicinity (approximately 5 km) of Markdale. To the north, west and southwest of town, fragments of the Singhampton moraine ice-contact deposits appear to be composed primarily of sand. Based on limited available information, these materials are probably the least likely in the Markdale area to contain commercial supplies of aggregate, although they are located close to the town and Highway 10. A cluster of deposits located to the northeast of Markdale contain both licenced and unlicenced pits. These are both outwash and ice-contact deposits and they have been used to supply local needs for many years. These deposits are relatively modest in size and are known to vary in thickness and gravel content, but they are important for the local supply.

There are several large areas of secondary deposits located to the north and south of Flesherton, straddling Highway 10. These deposits appear to be a spur of the Singhampton moraine and limited information in the form of water-well information and surface exposures implies a thick but mainly sand deposit. In the absence of better quality information, these deposits have been classified as secondary.

A continuation of the outwash deposit described as Selected Sand and Gravel Resource Area 9 continues along the Beaver River east of Selected Sand and Gravel Resource Area 9. The deposit in this area has been reassigned to a secondary level deposit based primarily on the thickness of the deposits and the modest amount of gravel. Available exposures and water-well data suggest between 1 and 6 m of material.

Two ice-contact deposits are located in the eastern portion of the Municipality of Grey Highlands. There are several licenced and unlicenced sand and gravel pits in these 2 deposits, but extraction has been limited and exposures are poor. Water-well data suggest 5 to 10 m of material may be present and the local geology suggests that bedrock may be present near the base of the deposit.

Three sizable secondary deposits were mapped in the Municipality of West Grey, just south of a line between Hanover and Durham. The 2 western features are ice-contact deposits located between the main bodies of the Gibraltar and Singhampton moraines. Sparse data from the westernmost deposit suggest 20 to 50% gravel and a thickness of 5 to 20 m. One test sample (Sample No. 7), taken during the current study, yielded data which meet medium to higher aggregate quality standards. Data from the middle deposit are less numerous, but suggest 20 to 30% gravel. Data are insufficient to warrant a primary designation for these deposits. The third secondary deposit, located approximately 5 km southwest of Durham, is an outwash deposit related to the Singhampton moraine outwash. It has been separated from Selected Sand and Gravel Resource Area 5 because there are indications of a lower gravel content based on available exposures.

A large area of the Singhampton moraine ice-contact deposit in the southern part of the Municipality of West Grey has been identified as a secondary deposit. The same designation exists to the south in Wellington County (Planning Initiatives Limited and the Ontario Geological Survey 1999). Four licenced pits (Pit Nos. 421 to 424) contain in the order of 40% gravel. Water-well data suggest varied results. Cowan (1979) has discussed the resource potential for these deposits in detail and notes that the moraine may contain large possible resources, but that variability and a lack of crushable gravel will be a concern for the development of commercial operations. The current survey supports that view, but the deposits may be worthy of reassessment should appropriate subsurface information become available. There are also several similar sections of the Singhampton moraine in the western part of the Township of Southgate that have been designated as secondary deposits for the same reasons.

The Maple Lake moraine is a poorly understood feature related by Sharpe and Broster (1977) to the Tavistock Till ice sheet. The moraine is composed primarily of sand, although pockets of gravel are exposed in several of the licenced and unlicenced pits on the feature. Water-well records suggest that the sand may be 20 m thick. Available exposures suggest that sand is dominant and that gravel occurs sporadically; however, the materials will be useful for supplying local needs. Sample Nos. 18 and 19 taken during the current survey indicate generally good physical quality for 2 occurrences of coarse materials.

There are a number of deposits of tertiary significance in the county and a number of these have been used as an aggregate source in the past. There are several licenced properties located in these deposits throughout Grey County. Generally, the tertiary deposits are relatively shallow sand deposits with little or no gravel. Many of the tertiary deposits in the north part of the county are of glaciolacustrine origin and they tend to be shallow sand patches in low areas, or related to some of the abandoned shorelines. The glaciolacustrine sands can be a source of sand fill, septic sand or fine-grained granular products. Similar sand deposits occur throughout the remainder of the county near the edges of outwash and ice-contact deposits. Although the tertiary deposits are primarily sand and they are not likely to contain significant volumes of commercial aggregate, they do provide sand for local construction projects. Additional references for secondary and tertiary deposits include Ontario Geological Survey (1985b, 1985c, 1985d, 1991, 1992a, 1992b), Dieke (1982c-f) and Sharpe and Broster (1978).

BEDROCK GEOLOGY

Grey County is underlain by a thick sequence of Paleozoic bedrock ranging from the Ordovician Lindsay Formation in the extreme northeast corner to the Silurian Salina Formation in the southwest. The formations are relatively flat lying, but do have a slight regional dip to the southwest, toward the centre of the Michigan Basin. This slight regional dip to the southwest, combined with the differing resistance to weathering of the various rock units, has given rise to the series of escarpments in the Paleozoic rocks of southern Ontario, such as the Niagara Escarpment, which is the major bedrock feature in Grey County.

The oldest bedrock unit in the county is the middle Ordovician Lindsay Formation. It occurs at surface in the extreme northeast corner of the county and underlies all of the other rock units exposed at surface in the area. The Lindsay Formation crops out over several square kilometres along the Georgian Bay shoreline near Craigleith. The rock exposed is a grey to light grey, argillaceous, very fine-grained limestone containing shaly partings. The shale portion of the rock weathers rapidly. The formation has been used elsewhere in the province for the production of aggregate and for the manufacture of cement. The upper unit of the Lindsay Formation, the Collingwood Member, was formerly known as the Lower Member of the Whitby Formation prior to the redefinition of the units by Russell and Telford (1983). The Collingwood Member of the Lindsay Formation contains shale and is not suitable for use as aggregate. It has not been selected for resource protection in Grey County.

The Lindsay Formation is overlain by the Upper Ordovician Blue Mountain Formation that underlies a narrow band of land along the Georgian Bay shoreline. The formation was redefined by Russell and Telford (1983) and was previously referred to as the Upper and Middle Members of the Whitby Formation (Liberty and Bolton 1971). The Blue Mountain Formation consists of blue-grey, non-calcareous shale that is not suitable for use as aggregate. Shale from the Blue Mountain Formation may have potential for use in structural clay products (Martini and Kwong 1986).

The Blue Mountain Formation is overlain by the Georgian Bay Formation, which consists of alternating grey limestone–dolostone beds and grey to bluish-grey shale (Liberty and Bolton 1971). In places, the formation is over 122 m thick and its chemical composition is fairly consistent throughout its occurrence (Vos 1975). Georgian Bay shale has been used for the manufacture of brick, drainage tile and lightweight aggregate in southern Ontario. The formation is generally covered by thick overburden, especially in the floor of the Beaver Valley and the Pretty River Valley. The formation has not been selected for resource protection.

The Queenston Formation overlies the Georgian Bay Formation and consists of red shale with occasional beds of mottled green shale (Liberty and Bolton 1971). The formation underlies a belt of land below the face of the Niagara Escarpment and it is exposed in numerous valleys along the escarpment. The Queenston Formation shale is considered a resource of provincial significance for the manufacture of shale products. The suitability of using the Queenston shale for manufacturing may be constrained by carbonate layers or bands in the rock, or by concentrations of gypsum or other soluble salts. Testing will be required at a site-specific level to assess suitability. Most of the Queenston Formation occurs in the lower portions of the Niagara Escarpment or is buried by a substantial thickness of overburden. The Queenston Formation has not been selected for possible resource protection.

The Whirlpool Formation of the Cataract Group disconformably overlies the Queenston Formation. This formation has been observed along the Niagara Escarpment from Niagara Falls to Duntroon. It is a grey, medium-bedded, fine- to medium-grained quartz sandstone. It is not well exposed in the county. The formation is in the order of 3 to 5 m thick (Hewitt 1969), although the upper contact with the Manitoulin Formation is gradational and the exact boundary between the 2 formations is open to interpretation. The Whirlpool Formation sandstone has a well-documented history of building stone production under the trade name of "Credit Valley Sandstone" (Martini and Kwong 1986) in the Orangeville–Milton area. Buildings such as the Ontario Legislative buildings, the Royal Ontario Museum and the old Toronto City Hall have been built from this rock. There has been no known extraction of this unit in Grey County and the limited exposure and extensive overburden cover have precluded a resource designation for this unit.

The Manitoulin Formation of the Cataract Group overlies the Whirlpool Formation north of Stoney Creek. The Manitoulin Formation is composed of a grey to brownish grey, thin- to medium-bedded, medium-crystalline dolomitic limestone to dolostone. Shale partings are common and weathered outcrops often expose flat sheets of dolostone several centimetres thick where the shale has weathered. Field work for the current study identified several previously unrecorded small historic quarries slightly outside the Grey County area, which appear to have been used as sources of rock slabs. White chert has also been noted in this formation (Vos 1969) and the formation is approximately 6 to 8 m thick.

The Manitoulin Formation is more resistant than the rocks both above and below it and, as a result, it has formed small scarps in some areas, which are usually included as a subsidiary scarp of the Niagara Escarpment. One test sample of the Manitoulin Formation (Sample No. 55) was collected during the current study. Test data confirm that the rock has poor durability and should only be used for granular aggregate or rock fill purposes. The Manitoulin Formation has not been selected for possible resource protection due to its poor physical quality.

The Cabot Head Formation of the Cataract Group overlies the Manitoulin Formation. The formation occurs as a subcrop band in the face of the Niagara Escarpment and it is commonly covered with talus from the overlying dolostone units. The formation consists of reddish to greenish-grey shale with calcareous carbonate interbeds. The formation is known to be between 11 and 41 m thick (Liberty and Bolton 1971). The shale is not suitable for aggregate use, but Vos (1969) has indicated the potential to use this unit for expanded lightweight aggregate, brick and tile. There are few areas where the Cabot Head Formation is exposed. No areas have been selected for possible resource protection.

The Fossil Hill Formation of the Clinton Group is a thin-bedded, brownish-grey, medium crystalline, fossiliferous dolostone. The formation is poorly exposed, but available information suggests a thickness of approximately 4 to 5 m. There are no known exposures of the Fossil Hill Formation large enough to support the development of an extraction operation and no areas are recommended for protection.

The Amabel Formation is found above the Fossil Hill Formation and it is commonly exposed along the brow of the Niagara Escarpment. The bedrock unit extends for several kilometres to the southwest of the brow. The formation consists of fine- to coarse-grained dolostone of bioclastic origins, and porous medium- to coarse-grained biohermal mounds. Small reefs are common in many areas. Minor amounts of chert have been noted, particularly near the base of the formation (Bolton 1957; Liberty and Bolton 1971; Hewitt 1960). The formation is 25 to 35 m thick.

Those areas of the Amabel Formation that are overlain by less than 8 m of overburden have been selected for possible resource protection. The Amabel Formation is a provincially significant aggregate resource and has been used to manufacture a variety of aggregate products, including crushed granular, asphalt and concrete products, building stone and lime. The presence of chert may locally limit the use of the rock and the quality of the resource may vary in Grey County due to the existence of reefs in the rock, which display different physical quality. Three samples of the Amabel Formation were taken during the current study (Sample Nos. 32, 52 and 57). Test data are not consistent, but suggest potential concerns with respect to absorption and possibly micro-Deval results. All 3 samples were subjected to accelerated mortar bar testing and results were well within specification limits. Experience from other Amabel Formation rocks in areas adjacent to Grey County has also identified relatively high absorption values, but product performance has generally been acceptable from these materials.

The Guelph Formation dolostone overlies the Amabel Formation and occurs as the uppermost bedrock unit in a broad band, approximately 25 km wide, in the vicinity of Markdale, Durham, Chatsworth and Wiarton. The formation is not continuously exposed in the map area, but information has been derived from a number of scattered bedrock outcrops and from exposures of the rock from other areas of the province. The Guelph Formation is a well-laminated tan to brown, fine to medium crystalline dolostone. There are a number of biohermal (reef) structures in the rock with a coarser texture and numerous fossil fragments. There are a number of these reefal structures exposed in roadcuts along Highways 6 and 10 in the Markdale to Wiarton area.

The Guelph Formation is generally acknowledged to have high chemical purity, but is locally soft and may not be suitable for use as aggregate particularly where the formation contains reefal material. The Guelph Formation has been used as a source for metallurgical and agricultural lime in the Guelph area. There are also a number of occurrences in the Grey County where outcrops of the Guelph Formation, or boulders of the Guelph Formation extracted from the glacial cover, were used at the turn of the century to manufacture lime for local use.

Two building stone quarries are currently licenced and operating in the Guelph Formation in the Township of Georgian Bluffs. These operations periodically crush the waste rock from the building stone extraction and use it for aggregate. A sample of this material (Sample No. 59), taken from well-bedded non-reefal rock, yielded physical test data (including accelerated mortar bar) that were acceptable for many grades of granular, asphalt and concrete aggregate. Where the Guelph Formation is overlain by less than 8 m of overburden, it has been selected for possible resource protection.

The Salina Formation is the youngest bedrock unit in Grey County and underlies several tens of square kilometres in the southwest corner of the county, southwest of Durham, where it is exposed in several deeply eroded valleys. The formation is dominantly a thin-bedded, soft, greyish-green to red shale with occasional interbeds of carbonate and evaporitic minerals. Halite and gypsum are extracted from the formation elsewhere in Ontario where the formation achieves a substantial thickness. The rock unit is unsuitable for use as aggregate.

SELECTED BEDROCK RESOURCE AREAS

Selected Bedrock Resource Area 1

Selected Bedrock Resource Area 1 is located in the Township of Georgian Bluffs and is an irregular band of land stretching from Owen Sound, northward to Wiarton. The Amabel Formation dolostone exists in the area at an interpreted depth of 8 m or less and there are numerous areas where bedrock is within a metre of the surface.

The area is dominated by gently rolling bedrock-controlled topography and much of the area is currently forested. There are relatively few houses in the area. Access is via a series of gravel township roads and several paved county roads. A large proportion of Selected Bedrock Resource Area 1 falls within the Niagara Escarpment Plan area and will be subject to additional development control.

Selected Bedrock Resource Area 1 is approximately 16 655 ha in area with 7461 ha potentially available for resource development once cultural constraints are considered. Assuming a workable thickness of 15 m, possible bedrock resources of the Amabel Formation are estimated to be 2964 million tonnes.

Selected Bedrock Resource Area 2

Selected Bedrock Resource Area 2 is located on the west side of the Township of Georgian Bluffs between Selected Bedrock Resource Area 1 and the western boundary of the county. It is immediately south of Wiarton and 5 to 15 km west of Owen Sound. The area is accessed by Highways 6 and 21, and also served by township gravel roads and paved County Roads 1 and 170.

Selected Bedrock Resource Area 2 is covered by less than 8 m of overburden, but there are several areas where bedrock is within a metre of surface. The uppermost bedrock unit is the Guelph Formation dolostone, which is underlain by the Amabel Formation dolostone at relatively shallow depths. The thickness of the Guelph Formation is estimated to be between 0 and 8 m over the resource area and it is potentially feasible for a quarry to extract both Guelph and Amabel formations. A quarry (Table 5: Q1) is currently licenced in the area and mines both bedrock units. Test data (Sample No. 59) confirms that the material meets a range of granular, asphalt and concrete specifications. The Guelph Formation is currently being mined for building stone use in the quarry noted above and, thus, there is a potential multiple use for stone products from quarries in this area.

Selected Bedrock Resource Area 2 covers 13 845 ha, but consideration of cultural features, primarily located along the 2 highways, reduces this amount to 3758 ha. It should be noted that this area falls outside the area of the Niagara Escarpment Plan area. Allowing for a combined rock thickness (Guelph and Amabel formations) of 15 m, potential resources are estimated to be approximately 1493 million tonnes.

Selected Bedrock Resource Area 3

Selected Bedrock Resource Area 3, located to the east of Owen Sound, is an area underlain by Amabel Formation dolostone that is interpreted to be within 8 m of surface. Portions of the area contain rock at or within 1 m of surface. The area is accessible by Highway 26, paved County Roads 11 and 18, and gravel township roads. The area is largely rural, but a significant portion of the area falls within the Niagara Escarpment Plan area and may be subject to development restrictions. An existing licenced quarry (*see* Table 5: Q5) is located in Selected Bedrock Resource Area 3.

There are a total of 10 287 ha in Selected Bedrock Resource Area 3 with 6101 ha remaining after reductions for cultural features and setbacks. Assuming a rock thickness of 15 m, Selected Bedrock Resource Area 3 contains an estimated 2424 million tonnes of resource.

Selected Bedrock Resource Area 4

Selected Bedrock Resource Area 4 is located west of the Beaver Valley, southeast of Meaford and Thornbury, along the top of the Niagara Escarpment. The area is underlain by Amabel Formation dolostone within 8 m of surface. The area is rural in nature and mainly agricultural. Road access is by a network of gravel township roads and paved County Roads 40, 12 and 32. Significant portions of Selected Bedrock Resource Area 4 occur within the Niagara Escarpment Plan area and will be subject to development restrictions. One quarry (*see* Table 5: Q7) is currently licenced in the area.

Selected Bedrock Resource Area 4 contains 7651 ha with approximately 4239 ha potentially available for extraction after the removal of cultural features and setbacks. Assuming a workable rock thickness of 15 m, possible bedrock resources in the area are estimated to be 1685 million tonnes.

Selected Bedrock Resource Area 5

Selected Bedrock Resource Area 5 is located above the Niagara Escarpment, largely within the Town of The Blue Mountains, and south of the town of Thornbury. The area is underlain by the Amabel Formation and has an overburden thickness less than 8 m. Substantial portions of the area contain outcrops of bedrock and less than 1 m of overburden. The area is rural in nature, contains substantial amounts of forested land and much of the area falls within the Niagara Escarpment Plan area. The area is accessed by a series of gravel township roads and paved County Roads 2, 19 and 31.

Selected Bedrock Resource Area 5 has an area of 3784 ha when cultural features and setbacks are considered. Assuming an average workable thickness of 15 m, possible bedrock resources of Amabel Formation dolostone are estimated to be 1503 million tonnes.

Selected Bedrock Resource Area 6

Selected Bedrock Resource Area 6 is located in the Municipality of Grey Highlands, east of the town of Markdale. The resource area is underlain by Amabel Formation dolostone and has an overburden thickness of less than 8 m. Several metres of Guelph Formation dolostone are interpreted to be present over the Amabel Formation in part of the area. The area is rural and largely agricultural in character and only a small portion of the area falls within the Niagara Escarpment Plan area. The area is served by a network of gravel township roads and by paved County Roads 2 and 31.

Selected Bedrock Resource Area 6 occupies an area of 3566 ha. After cultural features and setbacks are considered, 2166 ha remain potentially available for extraction. Assuming an average workable thickness of 15 m of rock, there is an estimated 861 million tonnes of Amabel Formation dolostone in the area.

Selected Bedrock Resource Area 7

Selected Bedrock Resource Area 7, located on the eastern boundary of Grey County in the Municipality of Grey Highlands, is an area underlain by the Amabel Formation dolostone and has an interpreted overburden of less than 8 m. A quarry (*see* Table 5: Q9) has recently been opened in this area. The area is generally rural in nature and is served by a network of gravel townships roads plus paved County Roads 31, 4 and 124. The area is adjacent to the Niagara Escarpment Plan area.

Selected Bedrock Resource Area 7 contains a total of 1791 ha. Cultural features and setbacks reduce the potentially available lands to 1099 ha. Assuming a workable thickness of 15 m of rock, there are estimated to be 437 million tonnes of Amabel Formation dolostone in Selected Bedrock Resource Area 7.

More detailed information on the bedrock geology and overburden thickness for Grey County are available in the following reports and maps: Armstrong (1993a, 1993b), Burwasser (1974b, 1974c), Davies and McClymont (1962a, 1962b), Gwyn and Fraser (1975a, 1975b), Kelly and Carter (1993a, 1993b), Sharpe (1982), Sharpe and Clue (1978a, 1978b), Sharpe, Hradsky and Farrell (1979), Sharpe, Hradsky and West (1979), Telford and Narain (1980) and Telford, Bond and Liberty (1974).

SUMMARY

Twelve areas have been identified as sand and gravel resource areas of primary significance within Grey County. These Selected Sand and Gravel Resource Areas occupy a total area of 35 618 ha, which is reduced to 11 984 ha after applying standard cultural constraints and considering previous extractive activity. These selected sand and gravel resource areas have possible aggregate resources of 1670 million tonnes. It should be noted that the sand and gravel deposits of Grey County are geologically complex and are often thick and poorly exposed. Resource assessments have been completed on relatively sparse data and interpretations may change as new subsurface data become available.

The Amabel Formation dolostone frequently crops out, or is present within 8 m of surface, along the Niagara Escarpment and for several kilometres to the southwest. This rock unit is thick and consistent, and is recognized as a provincially significant aggregate resource capable of producing a wide range of granular, asphalt and concrete aggregates. Six areas containing Amabel Formation bedrock within 8 m of surface have been identified for possible resource protection. A large proportion of the Selected Bedrock Resource Areas falls within the area of the Niagara Escarpment Plan area and will be subject to additional planning, environmental and cultural restraints. Additionally, one bedrock resource area contains Guelph Formation dolostone overlying Amabel Formation dolostone. The Guelph Formation rock has been used as a source of building stone and there is the potential to produce both building stone and construction aggregate from the same operation.

Other bedrock units present in Grey County have little or no value as sources of crushed rock aggregate; however, several units are potentially suitable for other industrial mineral applications.

Enquiries regarding the Aggregate Resources Inventory of Grey County should be directed to the Sedimentary Geoscience Section, Ontario Geological Survey, Mines and Minerals Division, Ontario Ministry of Northern Development, Mines and Forestry, Level B7, 933 Ramsey Lake Road, Sudbury, Ontario P3E 6B5 [Tel: (705) 670-5758]; or to the Owen Sound District Office, Ontario Ministry of Natural Resources, Owen Sound, Ontario [Tel: (705) 376-3860].

Table 1 - Total Sand and Gravel Resources Grey County			
1 Class Number	**2 Deposit Type**	**3 Areal Extent (Hectares)**	**4 Original Tonnage (Million Tonnes)**
Township of Georgian Bluffs			
1	S-IC	232	24.6
	G-IC	96	10.2
	G-LB	99	10.5
	G-ICEM	711	75.5
	S-ICEM	888	94.3
	G-E	92	9.8
	G-ICD	187	19.9
2	S-LP	429	34.2
	G-ICEM	91	7.2
	S-ICEM	276	22.0
	S-IC	168	13.4
	G-IC	88	7.0
	G-E	25	2.0
	S-LB	45	3.6
	G-LB	365	29.1
	G-ELD	38	3.0
	S-ICD	54	4.3
	G-ICD	13	1.0
3	S-LP	581	20.6
	S-OW	6	0.2
	S-IC	242	8.6
	G-IC	48	1.7
	G-LB	64	2.3
	S-LB	31	1.1
	S-E	4	0.1
	G-E	5	0.2
	S-WDLP	767	27.2
4	S-LB	29	0.5
	G-LB	388	6.9
	S-LP	645	11.4
	S-IC	12	0.2
	G-IC	18	0.3
Subtotal		**6737**	**452.8**
City of Owen Sound			
2	S-LP	776	61.8
4	G-LB	22	0.4
Subtotal		**798**	**62.2**
Municipality of Meaford			
1	S-IC	94	10.0
2	S-IC	83	6.6
	S-LB	151	12.0
	S-LP	1531	121.9
3	G-LB	591	20.9
	S-LP	131	4.6

Table 1 - Total Sand and Gravel Resources Grey County			
1 Class Number	**2 Deposit Type**	**3 Areal Extent (Hectares)**	**4 Original Tonnage (Million Tonnes)**
	S-IC	129	4.6
	S-OW	14	0.5
	S-LB	416	14.7
4	S-LB	177	3.1
	S-LP	135	2.4
	S-IC	85	1.5
	G-LB	387	6.8
Subtotal		**3924**	**209.8**
Township of Chatsworth			
1	S-IC	764	81.1
	S-ICE	45	4.8
	G-IC	227	24.1
	S-E	14	1.5
	G-E	50	5.3
	S-OW	23	2.4
	G-OW	1400	148.7
	S-K	53	5.6
	G-ICD	16	1.7
	S-ICD	16	1.7
2	S-K	3	0.2
	S-IC	5152	410.4
	G-IC	763	60.8
	S-E	145	11.5
	G-E	81	6.5
	S-OW	858	68.3
	G-OW	1808	144.0
	G-ICEM	26	2.1
	G-ICD	87	6.9
	S-AL	7	0.6
3	S-E	182	6.4
	G-K	4	0.1
	S-K	20	0.7
	S-IC	572	20.2
	G-IC	49	1.7
	S-OW	1909	67.6
	G-OW	655	23.2
	S-AL	185	6.5
	S-LP	209	7.4
	S-ICEM	1	0.0
4	S-OW	3	0.5
	G-OW	18	3.2
	G-IC	52	9.2
	S-IC	342	60.5
	S-K	10	1.8
Subtotal		**15 749**	**1197.5**

Table 1 - Total Sand and Gravel Resources Grey County			
1 Class Number	2 Deposit Type	3 Areal Extent (Hectares)	4 Original Tonnage (Million Tonnes)
Municipality of Grey Highlands			
1	S-OW	230	24.4
	G-OW	1635	173.6
	S-IC	2684	285.0
	G-IC	1449	153.9
	G-ICEM	77	8.2
2	G-E	273	21.7
	S-E	14	1.1
	G-IC	983	78.3
	S-IC	1039	82.8
	G-ICEM	106	8.4
	S-ICEM	69	5.5
	S-OW	727	57.9
	G-OW	710	56.6
	G-OW	661	52.6
	S-LP	8	0.6
3	S-IC	481	17.0
	G-IC	1151	40.7
	S-ICEM	627	22.2
	G-ICEM	26	0.9
	G-OW	866	30.7
	S-OW	1473	52.1
	S-AF	61	2.2
	S-E	28	1.0
4	G-AF	4	0.1
	S-AF	243	4.3
	S-OW	286	5.1
	G-OW	124	2.2
	S-ICEM	53	0.9
	S-ICEM	102	1.8
	G-E	11	0.2
	S-AL	108	1.9
	G-AL	9	0.2
Subtotal		**16 318**	**1194.2**
Town of The Blue Mountains			
1	S-LP	79	8.4
	G-LB	301	32.0
2	G-LB	204	16.2
	S-IC	303	24.1
	G-IC	459	36.6
	S-LP	985	78.5
	S-OW	767	61.1
3	G-IC	846	29.9
	S-IC	251	8.9
	G-LB	34	1.2

Table 1 - Total Sand and Gravel Resources Grey County			
1 Class Number	**2 Deposit Type**	**3 Areal Extent (Hectares)**	**4 Original Tonnage (Million Tonnes)**
	S-LP	198	7.0
	S-OW	623	22.1
4	S-LB	8	0.1
	S-OW	43	0.8
	S-IC	494	8.7
Subtotal		**5595**	**335.6**
Municipality of West Grey			
1	G-OW	15 398	1635.3
	S-AL	4	0.4
	S-OW	360	38.2
	S-IC	7408	786.7
	G-IC	6124	650.4
	G-E	82	8.7
2	G-OW	106	8.4
	S-OW	1450	115.5
	S-IC	2903	231.2
	G-IC	925	73.7
	S-ICE	70	5.6
	S-E	51	4.1
	G-E	91	7.2
	S-EK	11	0.9
3	S-IC	1108	39.2
	G-IC	64	2.3
	S-OW	2348	83.1
	G-OW	344	12.2
	S-E	149	5.3
	G-E	4	0.1
	S-ICE	77	2.7
	S-AL	71	2.5
4	G-IC	48	0.8
	S-IC	247	4.4
	G-OW	397	7.0
	G-E	10	0.2
	S-E	8	0.1
	S-LP	48	0.8
Subtotal		**39 906**	**3727.2**
Township of Southgate			
1	S-IC	3034	322.2
	G-IC	2978	316.3
	G-E	536	56.9
	S-OW	110	11.7
	G-OW	4221	448.3
2	G-IC	619	49.3
	S-IC	226	18.0
	G-ICE	52	4.1

Table 1 - Total Sand and Gravel Resources Grey County			
1 Class Number	**2 Deposit Type**	**3 Areal Extent (Hectares)**	**4 Original Tonnage (Million Tonnes)**
	S-ICE	76	6.1
	S-OW	434	34.6
	G-OW	333	26.5
	S-E	19	1.5
	G-E	164	13.1
3	G-IC	82	2.9
	S-IC	576	20.4
	S-OW	482	17.1
	G-OW	33	1.2
	S-E	7	0.2
	G-ICE	112	4.0
4	S-IC	131	2.3
	G-IC	45	0.8
	G-OW	4	0.1
	S-OW	250	4.4
Subtotal		**14 524**	**1361.9**
COUNTY TOTAL		**103 551**	**8541.2**

Explanation of Deposit Type:

First letter denotes gravel content:

G = >35% gravel; S = generally “sandy”, gravel-size (>4.75 mm) aggregate <35% gravel

Letters after hyphen denote the geologic deposit type (*see also* Appendix C):

AF = alluvial fan; AL = alluvium; E = esker; EK = esker–kame; ELD = esker–glaciolacustrine delta; IC = undifferentiated ice-contact stratified drift; ICD = ice-contact delta; ICE = ice-contact drift esker; ICEM = ice-contact drift end moraine; K = kame; LB = glaciolacustrine beach deposit; LP = glaciolacustrine plain; OW = outwash; WDLP = windblown glaciolacustrine plain deposit.

Table 2 - Sand and Gravel Pits Grey County					
1 Pit No.	2 Owner/Operator	3 Licenced Area (Hectares)	4 Face Height (Metres)	5 % Gravel	6 Remarks
Township of Georgian Bluffs					
Licenced					
1	James Lee	10.3	2	3	sand
2	Roger Shantz	21.7	1.5	5	sand
3	Township of Georgian Bluffs	12.69	3	55	granular source
4	Margaret Bradshaw	20.2	0	-	unopened
5	Robert Legge	5.76	5	30-50	below water extraction
6	Alan Barfoot	9.8	8	10-20	silty sand, granular pockets
7	E.C. King Contracting	29.2	-	-	depleted
8	Township of Georgian Bluffs	20.5	0	-	depleted, rehabilitated
9	Al Thompson	13.2	6	20-30	silty sand, granular pockets
10	Peter Kotzeff	15	1	10-15	unopened
11	Mrs. Marie Mundle	14.8	3	10-20	sand, silty
12	Robert Legge Enterprises Ltd.	11.23	2	20	inactive, mainly sand
13	Charlie Kramer	39.6	-	-	unopened
14	Charlie Kramer Contracting	34.02	4	30	inactive
15	Harold Sutherland Construction Ltd.	20.23	4	10-15	below water extraction
16	Harold Sutherland Construction Ltd.	129	4	10-15	below water extraction
17	Frank John Coulter	3.6	4	30-35	esker with Niagara Escarpment Plan area
18	Donegan Holdings Ltd.	38	4	20-30	esker, below water extraction
19	E.C. King Contracting	22.3	4	30-35	esker
20	Bud Mervyn Construction Ltd.	23.4	4	20-30	esker
21	Allan Albright	28.5	4	10-15	esker
Unlicenced					
22	-		1.5-3	0	
23	-		3-5	60-80	depleted
24	-		3-5	60-80	partially overgrown
25	-		3-6	-	rehabilitated
26	-		1.5-2	10-40	rehabilitated
27	-		2-3	20-40	depleted
28	-		3-6	20-80	
29	-		2-3	10-30	depleted
30	-		1.5	0-20	
31	-		3-6	60-90	depleted
32	-		3-6	50-80	
33	-		1.5-6	35	variable
34	-		3	-	overgrown
35	-		2	40	variable
36	-		3	-	variable
37	-		3	5	
38	-		2	-	overgrown
39	-		6	30-50	
40	-		1.5	-	overgrown
41	-		5-6	-	variable, partially overgrown
42	-		5-6	30-50	variable
43	-		1.5-5	10-25	
44	-		3-12	-	variable, partially overgrown

Table 2 - Sand and Gravel Pits
Grey County

1 Pit No.	2 Owner/Operator	3 Licenced Area (Hectares)	4 Face Height (Metres)	5 % Gravel	6 Remarks
45	-		1.5-2	-	sand with gravel pockets
46	-		1.5-3	35	variable
47	-		8	10	rehabilitated
48	-		6	30-50	
49	-		4	-	overgrown
50	-		1.5-3	50-60	
51	-		1.5-3	-	overgrown
52	-		-	-	rehabilitated
53	-		1.5-3	-	overgrown
54	-		-	-	
55	-		6	25	
56	-		1.5-2	-	variable
57	-		1.5-6	40-60	
58	-		3	30-45	
59	-		5	-	overgrown
60	-		3	50	over till
61	-		1.5-3	10-30	
62	-		3-6	50-60	
63	-		6	25-40	
64	-		3-6	-	mainly sand, some gravel
65	-		3	35-40	
66	-		1.5	-	variable
67	-		1.5-4	30-35	
68	-		-	-	rehabilitated
69	-		1.5-4	20-40	
70	-		1.5-5	-	sand, partially overgrown
71	-		8-11	-	sand
72	-		3	-	mainly sand, overgrown
73	-		3-6	10	variable
74	-		1.5-2	-	sand over cemented gravel
75	-		3-6	10-50	
76	-		-	-	rehabilitated
77	-		1.5-3	-	mainly sand, variable
78	-		1.5-5	-	overgrown
79	-		0.6-1.5	20	over bedrock
80	-		12-15	40-50	
81	-		9-12	25-30	
Town of Meaford					
Licenced					
82	Keith Hutchinson	21.4	4	70	
83	Brad Lemon	6.9	6	-	
84	Mark Pfeiffer	2.52	6	75	
85	Dave Robertson	12.33	4	25-45	
Unlicenced					
86	-		5-6	60-70	partially overgrown
87	-		6-8	30-60	
88	-		2-3	50-60	nearly depleted
89	-		1.5-2	60-80	partially overgrown

Table 2 - Sand and Gravel Pits Grey County					
1 **Pit No.**	**2** **Owner/Operator**	**3** **Licenced Area (Hectares)**	**4** **Face Height (Metres)**	**5** **% Gravel**	**6** **Remarks**
90	-		3	10	depleted
91	-		8-9	20-60	variable, partially overgrown
92	-		3-6	-	sand, partially overgrown
93	-		-	-	
94	-		1.5-3	40	overgrown
95	-		3	-	rehabilitated
96	-		-	-	rehabilitated
97	-		4	-	depleted, overgrown
98	-		3	50-60	overgrown
99	-		3-6	-	sand
100	-		3-5	30-40	
101	-		23	60-70	
102	-		2-4	60-70	
103	-		<3	-	sand
104	-		1-3	40-60	
105	-		<1.5	-	water filled
106	-		2	40-60	
107	-		<1.5	-	variable
108	-		1.5-3	-	variable
109	-		<2	-	overgrown
Town of The Blue Mountains					
Licenced					
110	E.C. King Contracting	14.2	5	40-60	active, beach deposit
111	Ardiel Acres c/o John Ardiel	12.13	5	40-50	beach deposit
112	Georgian Aggregates and Construction	56.7	4	25	below water extraction
113	Hunter - Anderson Ltd.	22.4	-	-	unopened
114	Town of The Blue Mountains	23.5	6	40-50	
115	Bates Sand and Gravel	35.5	3	20-30	active, ice-contact
116	Ray Conn	15.5	6	20-30	
117	Mel McKean Investments Ltd.	37	4	30-40	
Unlicenced					
118	-		3-5	-	
119	-		3-4	35-60	
120	-		3-5	-	
121	-		3-5	-	
122	-		3-5	40-50	rehabilitated
123	-		5	<35	
124	-		6-9	0-75	rehabilitated
125	-		4-5	<5	
126	-		6-8	-	
127	-		6	20-30	partially overgrown
128	-		2-3	-	overgrown
129	-		2-3	20-30	overgrown
Township of Chatsworth					
Licenced					
130	Earl Ash	15.4	4-5	40-50	esker deposit, depleted
131	Arnold Kuhl	11.3	5-8	20	delta, high fines locally

Table 2 - Sand and Gravel Pits
Grey County

1 Pit No.	2 Owner/Operator	3 Licenced Area (Hectares)	4 Face Height (Metres)	5 % Gravel	6 Remarks
132	Tim Gilchrist	40	4	20-30	high fines locally, near depletion
133	Dr. Henry Feenstra	4.1	-	-	unopened
134	Harold Sutherland Construction Ltd.	28.37	6	20	high fines locally
135	Ian Gamble	7.6	4	20	
136	Gerald Wheildon	25	4	15-30	inactive
137	Blueland Farms Inc.	21.75	6	20-25	
138	Mac Taylor Corporation	22.3	6-8	5-10	below water extraction
139	Harold Sutherland Construction Ltd.	14.3	3-4	50-65	near depletion
140	Harold Sutherland Construction Ltd.	98.7	10-20	40-60	large pit, variable
141	Lavor Contracting	9.66	3	30	below water extraction
142	Wayne Lembke	5	3	30-40	small pit, near depletion
143	Township of Chatsworth	40.1	6-10	50-60	coarse
144	Harold Sutherland Construction Ltd.	32	7-8	30	
145	Harvey Stewart	12.2	4-8	20-30	near licence limits
146	Wayne Schwartz	10.6	4-8	50	below water extraction
147	Wayne Schwartz	12.5	3	30	
148	Wayne Schwartz Construction Ltd.	37.1	5-6	35-40	
149	E.C. King Contracting	14.5	4-6	30-45	below water extraction
150	Debbie Davey	40.15	4	20-30	
151	Debbie Davey	58.11	4	20-30	
152	Township of Chatsworth	18.26	6	35	poor exposure
Unlicenced					
153	-		1.5-2	20-40	partially overgrown
154	-		1.5-2	-	overgrown
155	-		3-5	-	overgrown
156	-		1.5-2	5-10	partially overgrown
157	-		2-6	10-20	
158	-		5-6	10-40	partially overgrown
159	-		5-8	30-40	
160	-		9-12	45-70	partially overgrown
161	-		1-1.5	-	overgrown
162	-		3-4	40-60	partially overgrown
163	-		9-11	50-60	rehabilitated
164	-		3	10-25	partially overgrown
165	-		1.5-4	10-35	
166	-		1.5-5	10-20	partially overgrown
167	-		3-5	10-25	partially overgrown
168	-		5-6	5-15	
169	-		5	35-50	partially overgrown
170	-		2-3	5-10	partially overgrown
171	-		1.5-6	-	rehabilitated
172	-		1.5-2	-	partially overgrown
173	-		3-4	30-65	partially overgrown
174	-		1.5-3	35-50	
175	-		1.5-5	40-50	partially overgrown
176	-		1.5-3	10-20	partially overgrown
177	-		1.5-3	40	partially overgrown
178	-		1.5-3	-	

Table 2 - Sand and Gravel Pits Grey County					
1 Pit No.	**2 Owner/Operator**	**3 Licenced Area (Hectares)**	**4 Face Height (Metres)**	**5 % Gravel**	**6 Remarks**
179	-		3-5	0-10	partially overgrown
180	-		3-5	20-80	overgrown
181	-		1.5-5	10-70	
182	-		1.5	-	overgrown
183	-		1.5-6	10-75	partially overgrown
184	-		1.5-3	10-30	
185	-		1.5-2	20-40	
186	-		1-2	30-40	partially overgrown
187	-		3	-	
188	-		8-9	-	partially slumped
189	-		5	5-15	
190	-		1.5-3	50-40	
191	-		3-5	10-45	
192	-		7-10	-	
193	-		2-4	-	overgrown
194	-		3-4	10-25	partially overgrown
195	-		5	-	partially overgrown
196	-		1.5-3	30-35	partially overgrown
197	-		3-4	30-45	
198	-		1.5-2	-	partially overgrown
199	-		1.5	5	
200	-		3-4	10-60	
201	-		5-6	25-70	partially overgrown
202	-		5-6	-	overgrown
203	-		3-6	50-70	rehabilitated
204	-		3	10	
205	-		3-5	20-75	
206	-		3	-	rehabilitated
207	-		3-5	20-50	
208	-		6-8	-	partially overgrown
209	-		3	-	overgrown
210	-		3-4	-	
211	-		1-1.5	-	overgrown
212	-		3-5	20-50	partially overgrown
213	-		5-8	40-70	partially overgrown
214	-		3-6	-	partially overgrown
215	-		-	-	
216	-		3	50-70	
217	-		1.5-3	-	partially overgrown
218	-		1.5	40-60	partially rehabilitated
219	-		1.5-3	5-10	partially overgrown
220	-		1.5-3	5-10	partially rehabilitated
221	-		1.5-3	5-10	partially overgrown
222	-		2-5	40-70	partially overgrown
223	-		2-3	-	overgrown
224	-		2-3	5-15	slumped
225	-		5	0-10	partially overgrown
226	-		3-4	20-30	rehabilitated

Table 2 - Sand and Gravel Pits Grey County					
1 Pit No.	2 Owner/Operator	3 Licenced Area (Hectares)	4 Face Height (Metres)	5 % Gravel	6 Remarks
227	-		2	50	overgrown
228	-		2-4	50-70	partially overgrown
229	-		1.5-3	10-40	overgrown
230	-		1.5-3	20-40	slumped
231	-		1.5-3	20-40	partially overgrown
232	-		2	-	overgrown
233	-		1-2	10-15	partially overgrown
234	-		3-4	50-65	partially overgrown
235	-		1.5-2	30-55	partially overgrown
236	-		1.5-2	30-40	partially overgrown
237	-		1.5-2	30-40	partially overgrown
238	-		1.5-2	30-40	partially overgrown
239	-		1-1.5	30-45	partially overgrown
240	-		5	50-60	partially overgrown
241	-		3-4	50-70	
242	-		4	25-35	partially overgrown
243	-		5	25-40	partially overgrown
244	-		3	-	overgrown
245	-		1	-	overgrown
246	-		3-9	25	partially overgrown
247	-		5	-	overgrown
248	-		1.5-5	5-20	partially overgrown
249	-		3-9	0-30	overgrown
250	-		5-6	-	overgrown
251	-		1-2	25-30	
252	-		3-4	25	partially overgrown
253	-		3-6	30-40	rehabilitated
254	-		1.5-3	-	rehabilitated
255	-		3-5	-	depleted
256	-		3-6	40-70	
257	-		3-4	30-50	partially overgrown
258	-		5	-	overgrown
259	-		4	-	overgrown
260	-		-	35-50	partially overgrown
261	-		1.5	-	partially overgrown
262	-		3-5	-	partially overgrown
263	-		1.5-3	10-20	
264	-		3-5	-	overgrown
265	-		5-9	30-50	partially overgrown
266	-		1.5	40	partially overgrown
267	-		1-1.5	-	partially overgrown
268	-		3-5	20-25	partially overgrown
269	-		8-11	-	overgrown
270	-		1-1.5	5-10	
271	-		2-4	-	partially overgrown
272	-		5	-	overgrown
273	-		3	10-20	overgrown
274	-		3	60-80	overgrown

Table 2 - Sand and Gravel Pits Grey County					
1 Pit No.	2 Owner/Operator	3 Licenced Area (Hectares)	4 Face Height (Metres)	5 % Gravel	6 Remarks
275	-		3	80	overgrown
276	-		9	5-10	slumped
277	-		1.5-6	50-75	partially overgrown
278	-		1.5-2	50-60	partially overgrown
279	-		1.5-3	60-75	
280	-		1.5-3	40-50	partially overgrown
281	-		2-4	5-40	slumped
282	-		1.5-2	10-50	slumped
283	-		2-3	-	partially overgrown
284	-		11-15	25-40	municipal landfill site
285	-		1.5-4	10-20	partially overgrown
286	-		3-4	10-20	slumped
Municipality of Grey Highlands					
Licenced					
287	Mike Croft Contracting Inc.	22.3	8-10	40	
288	Gerald Madill	55.32	3-6	30-40	near licence limits
289	Harold Sutherland Construction Ltd.	7	6-8	50-60	near licence limits
290	Harold Sutherland Construction Ltd.	9	6-8	50-60	
291	McIntyre Aggregates Ltd.	12.8	3	20-35	below water extraction
292	Robert Ottewell	11.8	-	-	below water extraction
293	Municipality of Grey Highlands	14	6	40-60	near licence limits
294	Mike Croft Contracting Inc.	9.2	2-4	35-50	below water extraction
295	Flesherton Concrete Products Inc.	24.8	2-4	60-70	below water extraction
296	Allen Lowe	18.5	2-4	40-50	
297	E.C. King Contracting	27.2	4-5	50-70	
298	Great Lakes Aggregates Inc.	21.4	4-5	40-60	also licenced quarry
299	Den-Jo Sand and Gravel	34.2	4-6	10-20	
300	Ken Winters	10	5-6	50-65	
301	Anna Akitt	31.5	5-10	30-40	near licence limits
302	Harold Sutherland Construction Ltd.	12	5-6	45-60	
303	Jack Winters	20	-	-	unopened
304	Winter’s Aggregate Limited	22.61	-	-	unopened
305	John D. Winters	2.8	1.5	0-5	inactive
306	Peter Hayes	11.6	-	-	unopened
Unlicenced					
307	-		1.5-4	30-50	partially overgrown
308	-		1.5-3	-	partially overgrown
309	-		3-6	-	partially overgrown
310	-		1.5-5	-	partially overgrown
311	-		1.5-2	<20	overgrown
312	-		1.5-3	<10	overgrown
313	-		1.5	<10	overgrown
314	-		1.5-3	<10	overgrown
315	-		1.5-3	-	variable
316	-		3	<20	partially overgrown
317	-		1.5-3	-	partially overgrown
318	-		1.5-3	-	partially overgrown
319	-		1.5-3	-	partially overgrown

Table 2 - Sand and Gravel Pits
Grey County

1 Pit No.	2 Owner/Operator	3 Licenced Area (Hectares)	4 Face Height (Metres)	5 % Gravel	6 Remarks
320	-		1.5-3	-	partially overgrown
321	-		1.5-3	<20	partially overgrown
322	-		1.5-3	30-40	partially overgrown
323	-		1.5-3	30-40	partially overgrown
324	-		1.5-3	30-40	partially overgrown
325	-		1.5-3	-	partially overgrown
326	-		3-6	-	variable
327	-		1.5-5	-	sand source
328	-		1.5-3	-	overgrown
329	-		1.5-4	20-30	partially overgrown
330	-		1.5-4	20-30	partially overgrown
331	-		1.5-5	-	partially overgrown
332	-		1.5-5	30-40	partially overgrown
333	-		1.5-3	<10	partially overgrown
334	-		1	<10	
335	-		1.5-2	40-60	overgrown
336	-		1.5-2	30-50	overgrown
337	-		1.5-6	40-70	
338	-		1.5-3	<20	overgrown
339	-		1.5	-	overgrown
340	-		2-4	0-50	variable
341	-		3-5	<20	overgrown
342	-		1.5-4	30-60	variable
343	-		3-6	30-60	variable
344	-		3-5	-	partially overgrown
345	-		3-6	30-50	partially overgrown
346	-		2-3	40-60	
347	-		2-3	-	partially overgrown
348	-		3-5	30-60	variable
349	-		1.5-3	-	variable
350	-		3-6	-	variable
351	-		6-8	30-70	
352	-		1.5	40	partially overgrown
353	-		1.5-2	40-70	partially overgrown
354	-		1.5-3	40-70	variable
355	-		1.5	30-50	overgrown
356	-		1.5	30-50	overgrown
357	-		1	30-40	variable
358	-		3	-	
359	-		-	-	rehabilitated
360	-		5-8	-	partially overgrown
361	-		5	30	till
362	-		5	40	
363	-		-	-	rehabilitated
364	-		3	20	
365	-		3	60	
366	-		5	50	
367	-		4	50	

1 Pit No.	2 Owner/Operator	3 Licenced Area (Hectares)	4 Face Height (Metres)	5 % Gravel	6 Remarks
Table 2 - Sand and Gravel Pits Grey County					
368	-		6	45	
369	-		6	60	
370	-		-	5	partially overgrown
371	-		5	25	
372	-		5	40	
373	-		4	50	
374	-		-	-	rehabilitated
375	-		6-8	65	
376	-		5	35-55	
377	-		6-8	40-60	
378	-		8	45	
379	-		5	15	
380	-		3	55	
381	-		3	50	
382	-		-	-	MTO test site
383	-		5-8	40	
384	-		3-8	35	
385	-		5-6	35	partially overgrown
386	-		5-6	40-60	rehabilitated
387	-		3	20	
388	-		-	-	rehabilitated
389	-		-	-	rehabilitated
390	-		2	25	
391	-		-	-	rehabilitated
392	-		5	30	
393	-		-	-	rehabilitated
394	-		2-3	20-40	
395	-		5-8	30-40	
396	-		2-3	-	overgrown
397	-		3-5	25-40	
398	-		-	-	partially rehabilitated
399	-		5-8	45	
400	-		6	35	
401	-		3	50	
402	-		4	60	
403	-		-	-	rehabilitated
404	-		2-4	10-20	
Municipality of West Grey					
Licenced					
405	Cedarwell Excavating Ltd.	61	9-10	40-55	
406	MacDonald Building Supplies Ltd.	6.07	2	20-30	
407	Mike Croft Contracting Inc.	14.2	8	-	below water extraction, near licence limits
408	Municipality of West Grey	7.6	4-8	40-50	
409	E.C. King Contracting	4.3	6-8	30-55	
410	Lafarge Canada Inc.	70.8	-	-	unopened
411	Georgian Aggregates and Construction	85.5	9-20	50	
412	E.C. King Contracting	31.7	5-10	30-60	

Table 2 - Sand and Gravel Pits
Grey County

1 Pit No.	2 Owner/Operator	3 Licenced Area (Hectares)	4 Face Height (Metres)	5 % Gravel	6 Remarks
413	Cedarwell Excavating Ltd.	38.4	10	30-45	
414	Mr & Mrs David Schutz	10.35	6-10	30	
415	Durham Stone and Paving Inc.	35.71	4-6	40-55	
416	Georgian Aggregates and Construction	109.5	2-3	30-40	below water extraction
417	Lafarge Canada Inc.	40.5	-	-	below water extraction, unopened
418	Lafarge Canada Inc.	259.8	-	-	below water extraction, unopened
419	The Glen Aggregates	32.3	4-5	20-30	
420	Gordon Klages	11.64	8-10	35-45	
421	Murray Lembke	8.1	5-7	30-40	
422	Municipality of West Grey	20.23	6	40-50	
423	Watson Properties 1879 Ltd.	18.26	1.5	35-45	unopened
424	H. Bye Construction Ltd.	10.1	4	40-50	
Unlicenced					
425	-		6	35	
426	-		1.5-3	20	
427	-		3-8	40	
428	-		2	35	overgrown
429	-		1.5	40	partially overgrown
430	-		5	35	partially overgrown
431	-		4	40	partially overgrown
432	-		5	25	partially overgrown
433	-		5-11	70	
434	-		5	20	overgrown
435	-		1.5-5	40	
436	-		6	40	overgrown
437	-		3	60	overgrown
438	-		3-5	70	overgrown
439	-		6-12	10-65	
440	-		1.5-3	40	overgrown
441	-		3	5-15	overgrown
442	-		4	-	overgrown
443	-		6	60	overgrown
444	-		8	60	
445	-		2	40	overgrown
446	-		1.5-3	20	partially overgrown
447	-		3-5	30	partially overgrown
448	-		1.5-5	15-30	partially overgrown
449	-		1.5-3	20-30	partially overgrown
450	-		5-6	20	
451	-		3-5	20	partially overgrown
452	-		5	70	overgrown
453	-		3-5	20-30	
454	-		3	-	overgrown
455	-		1.5-5	30-50	partially overgrown
456	-		1.5-3	-	overgrown
457	-		3	50-60	partially rehabilitated
458	-		5-6	30-60	partially overgrown

Table 2 - Sand and Gravel Pits Grey County					
1 Pit No.	**2 Owner/Operator**	**3 Licenced Area (Hectares)**	**4 Face Height (Metres)**	**5 % Gravel**	**6 Remarks**
459	-		3-5	50-75	
460	-		3	35	partially overgrown
461	-		1.5-3	-	
462	-		5	40-45	partially overgrown
463	-		3	30	
464	-		3	25	
465	-		1.5-3	10	
466	-		2	5	
467	-		4	40	
468	-		2	25	
469	-		5	10	partially rehabilitated
470	-		2	70	overgrown
471	-		5	20	partially overgrown
472	-		2	55	overgrown
473	-		3	50	overgrown
474	-		5	60	overgrown
475	-		3	45	overgrown
476	-		6	-	
477	-		3	60	overgrown
478	-		12	35	overgrown
479	-		3	25	overgrown
480	-		6-8	40	rehabilitated
481	-		3-5	30-50	partially overgrown
482	-		1.5-3	30-40	partially overgrown
483	-		3-8	40	partially rehabilitated
484	-		3-5	50-60	
485	-		1.5-3	50-60	overgrown
486	-		1.5-3	20	partially rehabilitated
487	-		3-5	30-40	partially overgrown
488	-		3-4	70	overgrown
489	-		5	25	overgrown
490	-		2	55	overgrown
491	-		2	60	overgrown
492	-		6	35	overgrown
493	-		5	50	
494	-		1.5	40	overgrown
495	-		3	25	overgrown
496	-		2	55	overgrown
497	-		2	40	overgrown
498	-		1.5	40	overgrown
499	-		1.5	35	overgrown
500	-		3-5	55	partially overgrown
501	-		3	55	partially overgrown
502	-		11-12	30-40	partially overgrown
503	-		6	30	partially overgrown
504	-		3	30	overgrown
505	-		3-5	25	partially overgrown
506	-		3-6	40	partially rehabilitated

Table 2 - Sand and Gravel Pits Grey County					
1 Pit No.	2 Owner/Operator	3 Licenced Area (Hectares)	4 Face Height (Metres)	5 % Gravel	6 Remarks
507	-		6	40-50	partially rehabilitated
508	-		1.5-8	30-40	partially overgrown
509	-		3-5	30-50	wayside
510	-		8	10	
511	-		5	-	
512	-		5	25	overgrown
513	-		5-9	40	partially overgrown
514	-		3	40	
515	-		6	55	partially overgrown
516	-		2	10	overgrown
517	-		-	-	overgrown
518	-		1.5	35	overgrown
519	-		3	20-60	overgrown
520	-		5	50	overgrown
521	-		1.5-6	40	partially overgrown
522	-		5	30	overgrown
523	-		3-5	35-60	partially overgrown
524	-		3	40	overgrown
525	-		3	30	partially overgrown
526	-		2-3	40	overgrown
527	-		1.5	40	overgrown
528	-		1.5-4	10-30	partially overgrown
529	-		3	30	rehabilitated
530	-		1.5-5	35	
531	-		1.5	25	overgrown
532	-		3	15-60	overgrown
533	-		6	35-85	overgrown
534	-		2	20	overgrown
535	-		1.5	15	overgrown
536	-		3	15	overgrown
537	-		8	40	overgrown
538	-		3-9	20	partially overgrown
539	-		5	15	overgrown
540	-		2	50	partially overgrown
541	-		2	25	overgrown
542	-		1.5	20	overgrown
543	-		3-5	25-50	overgrown
544	-		5-6	40-60	overgrown
545	-		1.5-3	40	partially overgrown
546	-		2-3	40	overgrown
547	-		5	30-40	overgrown
548	-		1.5	40	overgrown
549	-		3	35	overgrown
550	-		3	35	overgrown
551	-		3	35	overgrown
552	-		1.5	25	
553	-		3	40	partially overgrown
554	-		3-6	30-60	partially overgrown

Table 2 - Sand and Gravel Pits Grey County					
1 Pit No.	2 Owner/Operator	3 Licenced Area (Hectares)	4 Face Height (Metres)	5 % Gravel	6 Remarks
555	-		1.5-5	35	partially overgrown
556	-		3-5	10-30	partially overgrown
557	-		5	35	overgrown
558	-		5	20	overgrown
559	-		4	20	overgrown
560	-		1.5-8	40-50	
561	-		1.5	40	
562	-		2	60	
563	-		3	65	
564	-		3	40	
565	-		1.5	30	
566	-		3	25	
567	-		3	15-30	overgrown
568	-		3	40-65	overgrown
569	-		3-5	20-60	overgrown
570	-		1.5-3	40	partially overgrown
571	-		1.5	35	partially overgrown
572	-		1.5-3	35	partially overgrown
573	-		3-4	50	overgrown
574	-		1.5	30-35	partially overgrown
575	-		3	55	partially overgrown
576	-		5-9	30-35	partially overgrown
577	-		9	55	partially overgrown
578	-		5	30	partially overgrown
579	-		1.5	5	partially overgrown
580	-		6	30	partially overgrown
581	-		9	20	
582	-		5	30-55	partially overgrown
583	-		3	20-50	partially overgrown
584	-		8	40	partially overgrown
585	-		2	50	overgrown
586	-		5	25	partially overgrown
587	-		3	20	partially overgrown
588	-		9	70	
589	-		12	40	
590	-		3	70	partially overgrown
591	-		6	50	
592	-		6	30	
593	-		18	30	
594	-		10	30-55	on road right-of-way
595	-		4	25	partially overgrown
596	-		12	50	
597	-		5	35	partially overgrown
598	-		6	25	partially overgrown
599	-		5	45	partially overgrown
600	-		5	40	overgrown
601	-		6	45	overgrown
602	-		3	-	overgrown

Table 2 - Sand and Gravel Pits
Grey County

1 Pit No.	2 Owner/Operator	3 Licenced Area (Hectares)	4 Face Height (Metres)	5 % Gravel	6 Remarks
603	-		5	40	partially overgrown
604	-		6	20	partially overgrown
605	-		5	25	partially overgrown
606	-		2	30	partially overgrown
607	-		3	-	wayside, overgrown
608	-		2	40	overgrown
609	-		3	30-40	wayside
610	-		2	25	rehabilitated
611	-		5	-	partially overgrown
612	-		5	25	overgrown
613	-		2	40	partially overgrown
614	-		3-5	30-35	wayside
615	-		3	70	overgrown
616	-		1.5	25	overgrown
617	-		2	20	overgrown
618	-		1.5	10	overgrown
619	-		1.5	10	overgrown
620	-		1.5	5	overgrown
Township of Southgate					
Licenced					
621	John Moore	1.88	4-5	25	near licence limits
622	Ken Leith	10.2	2-5	30-40	
623	Murray McKenzie	14.2	5-10	40-70	
624	Terry Mather	13.3	5-10	30-40	
625	Township of Southgate	12.2	5-6	30-40	
626	Township of Southgate	5.7	5-6	45	below water extraction
627	Township of Southgate	8.2	3-4	30-50	
628	Edward Jack	15	9	40-60	below water extraction
629	Frank's Brothers	18.67	6	-	below water extraction, near licence limits
630	Township of Southgate	6.2	2	-	licence cancelled Nov. 4, 2002
631	Peter I. Ferguson	3	8	-	
632	H. Bye Construction Ltd.	15.6	8	40-50	below water extraction, near licence limits
633	Reeves Construction	21.2	10	40	
634	H. Bye Construction Ltd.	7.7	-	-	depleted, under redevelopment
635	H. Bye Construction Ltd.	7.95	-	-	below water extraction, near licence limits
636	Howard B. Frey	6.3	8	45	
637	Claylen Investments Inc.	24.5	10	35	below water extraction
638	H. Bye Construction Ltd.	10.5	10	20-30	
639	Township of East Luther Grand Valley	7.84	2	-	below water extraction
640	Mike Croft Contracting Inc.	7.9	7	20-30	
Unlicenced					
641	-		3	55	partially overgrown
642	-		8	10	partially rehabilitated
643	-		6	25	partially overgrown
644	-		5-11	20-50	wayside
645	-		3	30	overgrown
646	-		2	40	

Table 2 - Sand and Gravel Pits Grey County					
1 Pit No.	2 Owner/Operator	3 Licenced Area (Hectares)	4 Face Height (Metres)	5 % Gravel	6 Remarks
647	-		5	30	
648	-		3	55	overgrown
649	-		5	-	overgrown
650	-		6	65	overgrown
651	-		3	55	
652	-		8	75	
653	-		3	70	
654	-		6	55	rehabilitated
655	-		3	20-30	
656	-		6	-	
657	-		6	20	overgrown
658	-		3	50	partially overgrown
659	-		3	40	overgrown
660	-		2	20	overgrown
661	-		3-8	30-80	wayside
662	-		3	60	partially overgrown
663	-		5	50	overgrown
664	-		4	35	
665	-		3	60	overgrown
666	-		8	55	
667	-		9	65-70	
668	-		5	60	overgrown
669	-		3	55	overgrown
670	-		5	70	
671	-		3	60	partially overgrown
672	-		5	70	partially overgrown
673	-		6	40	partially overgrown
674	-		5	15	
675	-		5	75	overgrown
676	-		6-9	-	partially overgrown
677	-		3	60	
678	-		5	35	
679	-		6	70	overgrown
680	-		3-5	60	
681	-		3	65	overgrown
682	-		5	35	
683	-		3	60	overgrown
684	-		5	60	overgrown
685	-		5	20	partially overgrown
686	-		5	10	
687	-		5	40	wayside
688	-		8-9	65-75	
689	-		11	60	
690	-		3	60	
691	-		3	45	overgrown
692	-		-	70	overgrown
693	-		5	25	
694	-		5	65	overgrown

Table 2 - Sand and Gravel Pits Grey County					
1 Pit No.	2 Owner/Operator	3 Licenced Area (Hectares)	4 Face Height (Metres)	5 % Gravel	6 Remarks
695	-		-	-	
696	-		6	10	partially rehabilitated
697	-		8	15	
698	-		2-3	40	partially overgrown
699	-		8	0-10	sand source
700	-		8	0-10	sand source
701	-		2	15	
702	-		3	30	overgrown
703	-		9-12	30-35	wayside
704	-		3	15	
705	-		6	35	partially overgrown
706	-		11	70	partially overgrown
707	-		3-5	40-50	
708	-		2	10-20	
709	-		3	40	overgrown
710	-		4	40	overgrown
711	-		5-6	35-55	overgrown
712	-		6	35-55	
713	-		3-5	35-55	overgrown

Table 3 - Selected Sand and Gravel Resource Areas

Grey County

1 Deposit No.	2 Unlicenced Area (Hectares)*	3 Cultural Setbacks (Hectares)**	4 Extracted Area (Hectares)***	5 Possible Resource Area (Hectares)	6 Estimated Deposit Thickness (Metres)	7 Possible Aggregate Resources**** (Million Tonnes)
Township of Georgian Bluffs			NONE			
City of Owen Sound			NONE			
Municipality of Meaford			NONE			
Town of The Blue Mountains			NONE			
Township of Chatsworth						
1	1318	823	0	495	5	44
2	918	450	0	468	8	66
3	392	182	0	210	5	19
4	742	410	0	333	7	41
5	35	9	0	26	8	4
7	10	5	0	5	8	1
Subtotal	**3415**	**1878**	**0**	**1537**		**174**
Municipality of Grey Highlands						
4	181	106	0	75	7	9
5	191	100	0	91	8	13
7	1233	851	0	382	8	54
8	1144	925	0	219	8	31
9	661	425	0	236	6	25
Subtotal	**3410**	**2407**	**0**	**1003**		**132**
Municipality of West Grey						
4	2491	1601	0	890	7	110
5	9962	7648	0	2314	8	328
6	513	476	0	37	8	5
7	5782	3696	0	2086	8	295
10	2082	1224	0	859	9	137
Subtotal	**20 830**	**14 644**	**0**	**6186**		**875**
Township of Southgate						
7	2960	1606	0	1354	8	192
10	4232	2451	0	1781	9	284
11	225	210	0	15	5	1
12	547	439	0	108	6	12
Subtotal	**7964**	**4706**	**0**	**3259**		**488**
COUNTY TOTAL	**35 618**	**23 634**	**0**	**11 984**		**1670**

Minor variations in the tables are caused by the rounding of the data.

* Excludes areas licenced under the *Aggregate Resources Act*.

** Cultural setbacks include heavily populated urban areas, roads (including a 100 m wide strip centred on each road), water features (e.g., lakes, streams), 1 ha for individual houses. NOTE: This provides a preliminary and generalized constraint application only. Additional environmental and social constraints will further reduce the deposit area.

*** Extracted area is a rough estimate of areas that are not licenced, but, due to previous extractive activity, are largely depleted.

**** Further environmental, resource, social and economic constraints will greatly reduce the selected resource quantity realistically available for potential extraction.

Table 4 - Total Identified Bedrock Resources
Grey County

1 Drift Thickness (Metres)	2 Formation	3 Estimated Deposit Thickness (Metres)	4 Areal Extent (Hectares)	5 Original Tonnage (Million Tonnes)
Township of Georgian Bluffs				
<1	Amabel	15	3961	1574
1-8	Amabel	15	12 974	5155
8-15	Amabel	15	5	2
<1	Guelph	15	1172	466
1-8	Guelph	15	12 679	5038
8-15	Guelph	15	2201	875
Subtotal			**32 992**	**13 109**
City of Owen Sound				
1-8	Amabel	15	64	25
Subtotal			**64**	**25**
Municipality of Meaford				
<1	Amabel	15	1879	747
1-8	Amabel	15	8121	3227
8-15	Amabel	15	170	68
Subtotal			**10 170**	**4041**
Township of Chatsworth				
1-8	Amabel	15	102	41
Subtotal			**102**	**41**
Town of The Blue Mountains				
<1	Amabel	15	1600	636
1-8	Amabel	15	4410	1752
Subtotal			**6010**	**2388**
Municipality of Grey Highlands				
<1	Amabel	15	409	163
1-8	Amabel	15	13 230	5257
8-15	Amabel	15	164	65
Subtotal			**13 803**	**5485**
Township of Southgate		NONE		
COUNTY TOTAL			**63 141**	**25 089**

Minor variations in the tables are caused by the rounding of data.

The above figures represent a comprehensive inventory of all bedrock resources in the map area. Some of the material included in the estimate has no aggregate potential and some is unavailable for extraction due to land use restrictions.

Table 5 - Quarries
Grey County

No.	Owner/Operator	Licenced Area (Hectares)	Face Height (Metres)	Remarks
Township of Georgian Bluffs				
Licenced				
Q1	A. Dawn Forbes	12.05	7	licence recently granted - no data available
Q2	Harold Sutherland Construction Limited	22.75	17	2 m of Guelph Formation over Amabel Formation
Q3	E.C. King Contracting	33.40	-	active
Q4	Owen Sound Ledgerock Limited	36.50	7	inactive and flooded
Municipality of Meaford				
Licenced				
Q5	E.C. King Contracting	101.89	16	dimension stone operation - some crushing
Q6	Harold Sutherland Construction Limited	22.76	4-7	active
Municipality of Grey Highlands				
Licenced				
Q7	County of Grey	202.90	12	Manitoulin Formation
Q8	Great Lakes Aggregates Inc.	21.40	5	
Q9	Georgian Aggregates and Construction Inc.	26.10	-	not opened

Table 6 - Selected Bedrock Resource Areas
Grey County

1 Formation and Area Number	2 Depth of Overburden (Metres)	3 Area (Hectares)*	4 Cultural Setbacks (Hectares)**	5 Extracted Area (Hectares)***	6 Possible Resource Area (Hectares)	7 Estimated Workable Thickness (Metres)	8 Possible Bedrock Resources**** (Million Tonnes)
Township of Georgian Bluffs							
Amabel Formation							
1	<1	3956	1690	0	2266	15	900
	1-8	12 658	7463	0	5195	15	2064
3	<1	5	5	0	0	15	0
	1-8	316	250	0	66	15	26
Guelph/Amabel Formation							
2	<1	1172	726	0	446	15	177
	1-8	12 673	9361	0	3312	15	1316
Subtotal		**30 780**	**19 495**	**0**	**11 285**		**4484**
City of Owen Sound							
Amabel Formation							
1	1-8	41	41	0	0	15	0
3	1-8	23	23	0	0	15	0
Subtotal		**64**	**64**	**0**	**0**		**0**
Municipality of Meaford							
Amabel Formation							
3	<1	1879	717	0	1162	15	462
	1-8	8064	3191	0	4873	15	1936
4	1-8	57	38	0	19	15	8
Subtotal		**10 000**	**3946**	**0**	**6054**		**2406**
Township of Chatsworth							
Amabel Formation							
4	1-8	102	102	0	0	15	0
Subtotal		**102**	**102**	**0**	**0**		**0**
Town of The Blue Mountains							
Amabel Formation							
5	<1	1600	596	0	1004	15	399
	1-8	4189	1948	0	2241	15	890
6	1-8	221	83	0	138	15	55
Subtotal		**6010**	**2627**	**0**	**3383**		**1344**
Municipality of Grey Highlands							
Amabel Formation							
4	<1	202	79	0	123	15	49
	1-8	7290	3193	0	4097	15	1628
5	<1	91	69	0	22	15	9
	1-8	920	403	0	517	15	205
6	1-8	3345	1317	0	2028	15	806
7	<1	116	1	0	115	15	46
	1-8	1675	691	0	984	15	391
Subtotal		**13 639**	**5753**	**0**	**7886**		**3134**
Township of Southgate			NONE				
COUNTY TOTAL		**60 595**	**31 987**	**0**	**28 608**		**11 367**

Table 6 - Selected Bedrock Resource Areas
Grey County

Minor variations in all tables are caused by the rounding of data.

* Excludes areas licenced under the *Aggregate Resources Act* (1989).

** Cultural setbacks include heavily populated urban areas, roads (including a 100 m strip centred on each road), water features (e.g., lakes, streams), 1 ha for individual houses. NOTE: This provides a preliminary and generalized constraint application only. Additional environmental and social constraints will further reduce the deposit area.

*** Extracted area is a rough estimate of areas that are not licenced, but, due to previous extractive activity, are largely depleted, such as abandoned and wayside quarries.

**** Further environmental, resource, social and economic constraints will greatly reduce the selected resource quantity realistically available for potential extraction.

Table 7 - Additional Information Grey County
- NONE -

Table 8 - Summary of Geophysical Data Grey County
- NONE -

Table 9 - Aggregate Quality Test Data, Grey County

Sample Number	Deposit Association	Deposit Type	MgSO4 Soundness	Absorption	Micro-Deval Abrasion	Freeze–Thaw	Accelerated Mortar Bar
1	Banks Moraine	Outwash	3	1.656	9.7	2	
2	Banks Moraine	Outwash	3	1.655	12.0	12	
3	Banks Moraine	Ice-contact	2	1.121	10.1	3	
4	Gibraltar Moraine	Outwash	1	1.120	9.3	2	
5	Gibraltar Moraine	Outwash	1	1.171	11.7	3	
6	Gibraltar Moraine	Outwash	2	1.003	7.9	3	
7	Allen Park	Ice-contact	5	1.507	11.8	4	
8	Gibraltar Moraine	Outwash	2	1.254	8.5	2	
9	Gibraltar Moraine	Outwash	3	1.120	9.1	3	
10	–	Ice-contact	2	1.371	9.1	3	
11	Singhampton Moraine	Ice-contact	1	1.071	8.6	1	
12	Singhampton Moraine	Ice-contact	1	1.004	7.7	2	
13	Singhampton Moraine	Ice-contact	3	1.154	9.3	2	
14	Singhampton Moraine	Outwash	2	1.457	9.8	2	
15	Singhampton Moraine	Ice-contact	2	0.971	7.6	2	
16	Singhampton Moraine	Outwash	6	1.408	10.2	5	
17	Singhampton Moraine	Outwash	3	1.056	7.9	3	
18	Maple Lake Moraine	Ice-contact	2	1.256	8.8	4	
19	Maple Lake Moraine	Ice-contact	9	1.343	10.2	2	
20	Esker	Ice-contact	1	1.220	9.0	2	
21	Esker	Ice-contact	2	1.459	10.4	2	
22	Singhampton Moraine	Ice-contact	14	2.011	13.7	14	
23	Singhampton Moraine	Ice-contact	9	1.677	14.8	4	
24	Singhampton Moraine	Outwash	7	1.304	9.2	5	
25	Singhampton Moraine	Outwash	4	1.389	8.9	3	
26	Singhampton Moraine	Ice-contact	1	1.103	7.7	3	
27	Singhampton Moraine	Outwash	2	1.473	9.0	2	
28	Singhampton Moraine	Ice-contact	-	2.199	12.4	5	
29	Banks Moraine	Outwash	2	2.180	11.7	2	
30	Banks Moraine	Outwash	7	1.979	15.3	4	
31	–	Outwash	3	2.283	14.4	5	
32	Bedrock	Amabel Formation	6	3.212	13.0	1	0.016
33	Singhampton Moraine	Ice-contact	3	1.909	10.9	4	
34	Gibraltar Moraine	Outwash	2	1.825	11.1	4	
35	Gibraltar Moraine	Outwash	1	1.693	10.5	3	
36	Near Markdale	Ice-contact	9	1.871	10.6	4	
37	Gibraltar Moraine	Outwash	3	2.228	10.4	1	
38	Banks Moraine	Outwash	3	1.708	13.3	3	
39	Banks Moraine	Outwash	7	1.727	17.5	5	
40	–	Ice-contact	3	1.323	12.0	4	
41	–	Ice-contact	7	1.392	13.7	7	
42	Tara Strands	Ice-contact	6	1.795	13.4	12	
43	Tara Strands	Ice-contact	8	1.423	12.7	4	
44	Banks Moraine	Outwash	2	1.053	9.8	2	
45	Banks Moraine	Outwash	2	1.055	12.2	4	
46	Gibraltar Moraine	Outwash	3	1.287	9.8	3	
47	Allen Park	Ice-contact	7	1.120	9.0	5	
48	Singhampton Moraine	Ice-contact	1	1.238	9.3	2	
49	Singhampton Moraine	Ice-contact	–	1.340	10.2	–	

Table 9 - Aggregate Quality Test Data, Grey County

Sample Number	Deposit Association	Deposit Type	MgSO4 Soundness	Absorption	Micro-Deval Abrasion	Freeze–Thaw	Accelerated Mortar Bar
50	Singhampton Moraine	Ice-contact	6	1.694	13.2	3	
51	Gibraltar Moraine	Outwash	3	1.571	9.2	2	
52	Bedrock	Amabel Formation	4	2.031	12.0	1	0.017
53	–	Ice-contact	1	1.914	21.8	7	
54	–	Beach	11	1.714	24.5	12	
55	Bedrock	Manitoulin Formation	6	2.331	20.4	16	0.051
56	–	Beach	5	2.823	24.0	4	
57	Bedrock	Amabel Formation	1	1.527	9.5	2	0.028
58	Gibraltar Moraine	Ice-contact	6	1.256	8.3	3	
59	Bedrock	Guelph Formation	1	1.504	8.6	1	0.024

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Appendix B – Glossary

Abrasion resistance: Tests such as the Los Angeles abrasion test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

Absorption capacity: Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

Acid-Soluble Chloride Ion Content: This test measures total chloride ion content in concrete and is used to judge the likelihood of re-bar corrosion and susceptibility to deterioration by freeze-thaw in concrete structures. There is a strong positive correlation between chloride ion content and depassivation of reinforcing steel in concrete. Depassivation permits corrosion of the steel in the presence of oxygen and moisture. Chloride ions are contributed mainly by the application of de-icing salts.

Aggregate: Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various-sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

Aggregate Abrasion Value: This test directly measures the resistance of aggregate to abrasion with silica sand and a steel disk. The higher the value, the lower the resistance to abrasion. For high-quality asphalt surface course uses, values of less than 6 are desirable.

Alkali-aggregate reaction: A chemical reaction between the alkalis of Portland cement and certain minerals found in rocks used for aggregate. Alkali-aggregate reactions are undesirable because they can cause expansion and cracking of concrete. Although perfectly suitable for building stone and asphalt applications, alkali-reactive aggregates should be avoided for structural concrete uses.

Beneficiation: Beneficiation of aggregates is a process or combination of processes that improves the quality (physical properties) of a mineral aggregate and is not part of the normal processing for a particular use, such as routine crushing, screening, washing, or classification. Heavy media separation, jigging, or application of special crushers (e.g., "cage mill") are usually considered processes of beneficiation.

Blending: Required in cases of extreme coarseness, fineness, or other irregularities in the gradation of unprocessed aggregate. Blending is done with approved sand-sized aggregate in order to satisfy the gradation requirements of the material.

Bulk Relative Density: The density of a material related to water at 4°C and atmospheric pressure at sea level. An aggregate with low relative density is lighter in weight than one with a high relative density. Low relative density aggregates (less than about 2.5) are often non-durable for many aggregate uses.

Cambrian: The first period of the Paleozoic Era, thought to have covered the time between 540 and 500 million years age. The Cambrian precedes the Ordovician Period.

Chert: Amorphous silica, generally associated with limestone. Often occur as irregular masses or lenses, but can also occur finally disseminated through limestones. It may be very hard in unleached form. In leached form, it is white and "chalky" and is very absorptive. It has deleterious effect for aggregates to be used in Portland cement concrete due to reactivity with alkalis in Portland cement.

Clast: An individual constituent, grain or fragment of a sediment or rock, produced by the mechanical weathering of larger rock mass. Synonyms include particle and fragment.

Crushable Aggregate: Unprocessed gravel containing a minimum of 35% coarse aggregate larger than the No. 4 sieve (4.75 mm) as well as a minimum of 20% greater than the 26.5 mm sieve.

Deleterious lithology: A general term used to designate those rock types that are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

Devonian: A period of the Paleozoic Era thought to have covered the span of time between 410 and 355 million years ago, following the Silurian Period. Rocks formed in the Devonian Period are among the youngest Paleozoic rocks in Ontario.

Dolostone: A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

Drift: A general term for all unconsolidated rock debris, transported from one place and deposited in another, distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

Drumlin: A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were formed beneath an advancing ice sheet, and were shaped by its flow.

Eolian: Pertaining to the wind, especially with respect to landforms the constituents of which were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

Fines: A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (0.075 mm). Also described informally as “dirt”, these particles are in the silt and clay size range.

Glacial lobe: A tongue-like projection from the margin of the main mass of an ice cap or ice sheet. During the Pleistocene Epoch, several lobes of the Laurentide continental ice sheet occupied the Great Lakes basins. These lobes advanced then melted back numerous times during the Pleistocene, producing the complex arrangement of glacial material and landforms found in Ontario.

Gneiss: A coarse-textured metamorphic rock with the minerals arranged in parallel streaks or bands. Gneiss is relatively rich in feldspar. Other common minerals found in this rock include quartz, mica, amphibole and garnet.

Gradation: The proportion of material of each particle size, or the frequency distribution of the various sizes that constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulder	more than 200 mm
Cobbles	75-200 mm
Coarse Gravel	26.5-75 mm
Fine Gravel	4.75-26.5 mm
Coarse Sand	2-4.75 mm
Medium Sand	0.425-2 mm
Fine Sand	0.075-0.425 mm
Silt, Clay	less than 0.075 mm

Granite: A coarse-grained, light-coloured rock that ordinarily has an even texture and is composed of quartz and feldspar with either mica, hornblende or both.

Granular Base and Subbase: Components of a pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability and drainage, as well as support for surfacing materials. Four types have been defined: Granular A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular B, which is usually pit-run or other unprocessed aggregate; Granular M is a shouldering and surface dressing material with quality requirements similar to Granular A; Select Subgrade Material has similar quality requirements to Granular B and it provides a stable platform for the overlying pavement structure. (For more specific information, the reader is referred to Ontario Provincial Standard Specification OPSS 1010).

Heavy Duty Binder: Second layer from the top of hot mix asphalt pavements, used on heavily travelled (especially by trucks) expressways, such as Highway 401. Coarse and fine aggregates are to be produced from high-quality bedrock quarries, except when gravel is permitted by special provisions.

Hot-laid (or Asphaltic) Paving Aggregate: Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (HL 1, 3 and 4), or as binder course (HL 2, 4 and 8) used to bind the surface course to the underlying granular base.

Limestone: A carbonate sedimentary rock consisting chiefly of the mineral calcite. It may contain the mineral dolomite up to about 40%.

Lithology: The description of rocks on the basis of such characteristics as colour, structure, mineralogic composition and grain size. Generally, the description of the physical character of a rock.

Los Angeles Abrasion and Impact Test: This test measures the resistance to abrasion and the impact strength of aggregate. This gives an idea of the breakdown that can be expected to occur when an aggregate is stockpiled, transported and placed. Values less than about 35% indicate potentially satisfactory performance for most concrete and asphalt uses. Values of more than 45% indicate that the aggregate may be susceptible to excessive breakdown during handling and placing.

Magnesium Sulphate Soundness Test: This test is designed to simulate the action of freezing and thawing on aggregates. Those aggregates susceptible to freezing and thawing will usually break down and give high losses in this test. Values greater than about 12 to 15% indicate potential problems for concrete and asphalt coarse aggregate.

Medium Duty Binder: Second layer from the top of hot mix asphalt pavements used on heavily travelled, usually four-lane highways and municipal arterial roads. It may be constructed with high-quality quarried rock or high-quality gravel with a high percentage of fractured faces or polymer modified asphalt cements.

Meltwater Channel: A drainage way, often terraced, produced by water flowing away from a melting glacier margin.

Ordovician: An early period of the Paleozoic Era thought to have covered the span of time between 500 and 435 million years ago.

Paleozoic Era: One of the major divisions of the geologic time scale thought to have covered the time period between 540 and 250 million years ago, the Paleozoic Era (or Ancient Life Era) is subdivided into 6 geologic periods, of which only 4 (Cambrian, Ordovician, Silurian and Devonian) can be recognized in southern Ontario.

Petrographic Examination: An aggregate quality test based on known field performance of various rock types. In Ontario, the test result is a petrographic number (PN). The higher the PN, the lower the quality of the aggregate.

Pleistocene: An epoch of the recent geological past including the time from approximately 2 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity and is popularly referred to as the “Great Ice Age”.

Polished Stone Value: This test measures the frictional properties of aggregates after 6 hours of abrasion and polishing with an emery abrasive. The higher the PSV, the higher the frictional properties of the aggregate. Values less than 45 indicate marginal frictional properties, whereas values greater than 55 indicate excellent frictional properties.

Possible Resource: Reserve estimates based largely on broad knowledge of the geological character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications, but do not take into account many site-specific natural and environmental constraints that could render the resource unaccessible.

Precambrian: The earliest geological period extending from the consolidation of the earth's crust to the beginning of the Cambrian Period.

Sandstone: A clastic sedimentary rock consisting chiefly of sand-sized particles of quartz and minor feldspar, cemented together by calcareous minerals (calcite or dolomite) or by silica.

Shale: A fine-grained, sedimentary rock formed by the consolidation of clay, silt or mud and characterized by well-developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone and mudstone.

Siltstone: A clastic sedimentary rock consisting chiefly of silt-sized particles, cemented together by calcareous minerals (calcite and dolomite) or by silica.

Silurian: An early period of the Paleozoic era thought to have covered the time between 435 and 410 million years ago. The Silurian follows the Ordovician Period and precedes the Devonian Period.

Soundness: The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

Till: Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

Wisconsinan: Pertaining to the last glacial period of the Pleistocene Epoch in North America. The Wisconsinan began approximately 100 000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

Appendix C – Geology of Sand and Gravel Deposits

The type, distribution and extent of sand and gravel deposits in Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 100 000 to 7000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and can readily be differentiated on the basis of their morphology, structure and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

Ice-Contact Terraces (ICT): These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure of the deposits may be similar to that of outwash deposits, but, in most cases, the sorting and grading of the material is more variable and the bedding is discontinuous because of extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive because of the variability of the deposits both in terms of quality and grain size distribution.

Kames (K): Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits, producing internal structures characterized by bedding discontinuities. The deposits consist mainly of irregularly bedded and cross-bedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as “undifferentiated ice-contact stratified drift” (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the rare presence of excess fines (silt- and clay-sized particles).

Eskers (E): Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. Eskers vary greatly in size. Many, though not all eskers, consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons, esker deposits have been traditional aggregate sources throughout Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

Undifferentiated Ice-Contact Stratified Drift (IC): This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits because of their lack of continuity and grain size variability. They are given a qualitative rating based on existing pit and other subsurface data.

Outwash (OW): Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. The deposits occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well-developed outwash deposits have good horizontal bedding and are uniform in grain size distribution. Outwash deposited near the glacier’s margin is much more varied in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

Subaqueous Fans (SF): Subaqueous fans are formed within or near the mouths of meltwater conduits when sediment-laden meltwaters are discharged into a standing body of water. The geometry of the resulting deposit is fan or lobe shaped. Several of these lobes may be joined together to form a larger, continuous sedimentary body. Internally, subaqueous fans consist of stratified sands and gravels which may exhibit wide variations in grain size distribution. As these features were deposited under glacial lake waters, silt and clay that settled out of these lakes may be associated in varying amounts with these deposits. The variability of the sediments and presence of fines are the main extractive problems associated with these deposits.

Alluvium (AL): Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and they have generally low value because of the presence of excess silt- and clay-sized material. There are few large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

Glaciolacustrine Beach Deposits (LB): These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of Ontario. Well-developed lacustrine beaches are usually less than 6 m thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the source material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

Glaciolacustrine Deltas (LD): These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In Ontario, such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

Glaciolacustrine Plains (LP): The nearly level surface marking the floor of an extinct glacial lake is called a glaciolacustrine plain. The sediments that form the plain are predominantly fine to medium sand, silt and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources because of their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular subbase aggregate.

GLACIAL DEPOSITS

End Moraines (EM): These are belts of glacial drift deposited at, and parallel to, glacier margins. End moraines commonly consist of ice-contact stratified drift and, in such instances are usually called kame moraines. Kame moraines commonly result from deposition between 2 glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

Windblown Deposits (WD): Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well-developed linear and crescentic ridges known as dunes. Most windblown deposits in Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments almost always consist of fine to coarse sand and are usually well sorted. The probability of locating crushable aggregate in windblown deposits is very low.

Appendix D – Geology of Bedrock Deposits

The purpose of this appendix is to familiarize the reader with the general bedrock geology of southern Ontario (Figure D1) and, where known, the potential uses of the various bedrock formations. The reader is cautioned against using this information for more specific purposes. The stratigraphic chart (Figure D2) is intended only to illustrate the stratigraphic sequences in particular geographic areas and should not be used as a regional correlation table.

The following description is arranged in ascending stratigraphic order, on a group and formation basis. Precambrian rocks are not discussed. Additional stratigraphic information is included for some formations where necessary. The publications and maps of the Ontario Geological Survey (e.g., Johnson et al. 1992) and the Geological Survey of Canada should be referred to for more detailed information. The composition, thickness and uses of the formations are discussed. If a formation may be suitable for use as aggregate and aggregate suitability test data are available, the data have been included in the form of ranges. The following short forms have been used in presenting this data: PSV = Polished Stone Value, AAV = Aggregate Abrasion Value, $MgSO_4$ = Magnesium Sulphate Soundness Test (loss in percent), LA = Los Angeles Abrasion and Impact Test (loss in percent), Absn = Absorption (percent), BRD = Bulk Relative Density, PN (Asphalt & Concrete) = Petrographic Number for Asphalt and Concrete use. The ranges are intended as a guide only and care should be exercised in extrapolating the information to specific situations. Aggregate suitability test data has been provided by the Ontario Ministry of Transportation.

Covey Hill Formation (Cambrian)

STRATIGRAPHY: lower formation of the Potsdam Group. COMPOSITION: interbedded non-calcareous feldspathic conglomerate and sandstone. THICKNESS: 0 to 14 m. USES: has been quarried for aggregate in South Burgess Township, Leeds County.

Nepean Formation (Cambro-Ordovician)

STRATIGRAPHY: part of the Potsdam Group. COMPOSITION: thin- to massive-bedded quartz sandstone with some conglomerate interbeds and rare shaly partings. THICKNESS: 0 to 30 m. USES: suitable as dimension stone; quarried at Philipsville and Forfar for silica sand; alkali-silica reactive in Portland cement concrete. AGGREGATE SUITABILITY TESTING: PSV = 54-68, AAV = 4-15, $MgSO_4$ = 9-32, LA = 44-90, Absn = 1.6-2.6, BRD = 2.38-2.50, PN (Asphalt & Concrete) = 130-140.

March Formation (Lower Ordovician)

STRATIGRAPHY: lower formation of the Beekmantown Group. COMPOSITION: interbedded quartz sandstone, dolomitic quartz sandstone, sandy dolostone and dolostone. THICKNESS: 6 to 64 m. USES: quarried extensively for aggregate in area of subcrop and outcrop; alkali-silica reactive in Portland cement concrete; lower part of formation is an excellent source of skid-resistant aggregate. Suitable for use as facing stone and paving stone. AGGREGATE SUITABILITY TESTING: PSV = 55-60, AAV = 4-6, $MgSO_4$ = 1-17, LA = 15-38, Absn = 0.5-0.9, BRD = 2.61-2.65, PN (Asphalt & Concrete) = 110-150.

Oxford Formation (Lower Ordovician)

STRATIGRAPHY: upper formation of the Beekmantown Group. COMPOSITION: thin- to thick-bedded, microcrystalline to medium-crystalline, grey dolostone with thin shaly interbeds. THICKNESS: 61 to 102 m. USES: quarried in the Brockville and Smith Falls areas and south of Ottawa for use as aggregate. AGGREGATE SUITABILITY TESTING: PSV = 47-48, AAV = 7-8, $MgSO_4$ = 1-4, LA = 18-23, Absn = 0.7-0.9, BRD = 2.74-2.78, PN (Asphalt & Concrete) = 105-120.

Rockcliffe Formation (Middle Ordovician)

STRATIGRAPHY: divided into lower member and upper (St. Martin) member. COMPOSITION: interbedded quartz sandstone and shale; interbedded shaly bioclastic limestone and shale predominating in upper member to the east. THICKNESS: 0 to 125 m. USES: upper member has been quarried east of Ottawa for aggregate; lower member has been used as crushed stone; some high-purity limestone beds in upper member may be suitable for use as fluxing stone and in lime production. AGGREGATE SUITABILITY TESTING: PSV = 58-63, AAV = 10-11, $MgSO_4$ = 12-40, LA = 25-28, Absn = 1.8-1.9, BRD = 2.55-2.62, PN (Asphalt & Concrete) = 122-440.

Shadow Lake Formation (Middle Ordovician)

STRATIGRAPHY: eastern Ontario - the basal unit of the Ottawa Group; central Ontario - overlain by the Simcoe Group. COMPOSITION: in eastern Ontario - silty and sandy dolostone with shale partings and minor interbeds of sandstone; in central Ontario - conglomerates, sandstones, and shales. THICKNESS: eastern Ontario - 2 to 3 m; central Ontario - 0 to 12 m. USES: potential source of decorative stone; very limited value as aggregate source.

Gull River Formation (Middle Ordovician)

STRATIGRAPHY: part of the Simcoe Group (central Ontario) and Ottawa Group (eastern Ontario). In eastern Ontario, the formation is subdivided into upper and lower members; in central Ontario, it is presently subdivided into upper, middle and lower members. COMPOSITION: in central and eastern Ontario, the lower member consists of alternating units of limestone, dolomitic limestone and dolostone, the upper member consists of thin-bedded limestones with thin shale partings; west of Lake Simcoe, the lower member is thin- to thick-bedded, interbedded, grey argillaceous limestone and buff to green dolostone, whereas the upper and middle members are dense microcrystalline limestones with argillaceous dolostone interbeds. THICKNESS: 7.5 to 136 m. USES: quarried in the Lake Simcoe, Kingston, Ottawa and Cornwall areas for crushed stone. Rock from certain layers in eastern and central Ontario has proven to be alkali-reactive when used in Portland cement concrete (alkali-carbonate reaction). AGGREGATE SUITABILITY TESTING: PSV = 41-49, AAV = 8-12, $MgSO_4$ = 3-13, LA = 18-28, Absn = 0.3-0.9, BRD = 2.68-2.73, PN (Asphalt & Concrete) = 100-153.

Bobcaygeon Formation (Middle Ordovician)

STRATIGRAPHY: part of the Simcoe Group (central Ontario) and the Ottawa Group (eastern Ontario), subdivided into upper, middle and lower members; members in eastern and central Ontario are approximately equivalent. COMPOSITION: homogeneous, massive to thin-bedded fine-crystalline limestone with numerous shaly partings in the middle member. THICKNESS: 7 to 87 m. USES: quarried at Brechin, Marysville and in the Ottawa area for crushed stone. Generally suitable for use as granular base course aggregate. Rock from certain layers has been found to be alkali-reactive when used in Portland cement concrete (alkali-silica reaction). AGGREGATE SUITABILITY TESTING: PSV = 47-51, AAV = 14-23, $MgSO_4$ = 1-40, LA = 18-32, Absn = 0.3-2.4, BRD = 2.5-2.69, PN (Asphalt & Concrete) = 100-320.

Verulam Formation (Middle Ordovician)

STRATIGRAPHY: part of Simcoe and Ottawa groups. COMPOSITION: fossiliferous, pure to argillaceous limestone interbedded with calcareous shale. THICKNESS: 32 to 65 m. USES: quarried at Picton and Bath for use in cement manufacture. Quarried for aggregate in Ramara Township, Simcoe County and in the Belleville–Kingston area. May be unsuitable for use as aggregate in some areas because of its high shale content. AGGREGATE SUITABILITY TESTING: PSV = 43-44, AAV = 9-13, $MgSO_4$ = 4-45, LA = 22-29, Absn = 0.4-2.1, BRD = 2.59-2.70, PN (Asphalt & Concrete) = 120-255.

Lindsay Formation (Middle Upper Ordovician)

STRATIGRAPHY: part of Simcoe and Ottawa groups; in eastern Ontario is divisible into an unnamed lower member and the Eastview Member; in central Ontario is divisible into the Collingwood Member (equivalent to portions of the Eastview Member) and a lower member. COMPOSITION: eastern Ontario - the lower member is interbedded, very fine- to coarse-crystalline limestone with undulating shale partings and interbeds of dark grey calcareous shale, whereas the Eastview Member is an interbedded dark grey to dark brown calcareous shale and very fine- to fine-crystalline, petroliferous limestone; central Ontario – Collingwood Member is a black, calcareous shale, whereas the lower member is a very fine- to coarse-crystalline, thin-bedded limestone with very thin, undulating shale partings. THICKNESS: 25 to 67 m. USES: eastern Ontario - lower member is used extensively for aggregate production; central Ontario - quarried at Picton, Ogden Point and Bowmanville for cement. May be suitable or unsuitable for use as concrete and asphalt aggregate. AGGREGATE SUITABILITY TESTING: $MgSO_4$ = 2-47, LA = 20-28, Absn = 0.4-1.3, BRD = 2.64-2.70, PN (Asphalt & Concrete) = 110-215.

Blue Mountain and Billings Formations (Upper Ordovician)

STRATIGRAPHY: central Ontario – Blue Mountain Formation includes the upper and middle members of the former Whitby Formation; eastern Ontario – Billings Formation is equivalent to part of the Blue Mountain Formation. COMPOSITION: Blue Mountain Formation - blue-grey, noncalcareous shales; Billings Formation - dark grey to black, noncalcareous to slightly calcareous, pyritiferous shale with dark grey limestone laminae and grey siltstone interbeds. THICKNESS: Blue Mountain Formation - 43 to 61 m; Billings Formation - 0 to 62 m. USES: Billings Formation may be a suitable source for structural clay products and expanded aggregate; Blue Mountain Formation may be suitable for structural clay products.

Georgian Bay and Carlsbad Formations (Upper Ordovician)

COMPOSITION: central Ontario – Georgian Bay Formation composed of interbedded limestone and shale; eastern Ontario – Carlsbad Formation composed of interbedded shale, siltstone and bioclastic limestone. THICKNESS: Georgian Bay Formation - 91 to 170 m. Carlsbad Formation - 0 to 186 m. USES: Georgian Bay Formation - used by several producers in Metropolitan Toronto area to produce brick and structural tile, as well as for making Portland cement; at Streetsville, expanded shale was used in the past to produce lightweight aggregate. Carlsbad Formation - used as a source material for brick and tile manufacturing, has potential as a lightweight expanded aggregate.

Queenston Formation (Upper Ordovician)

COMPOSITION: red, thin- to thick-bedded, sandy to argillaceous shale with green mottling and banding. THICKNESS: 45 to 335 m. USES: There are several large quarries developed in the Queenston Formation in the Toronto–Hamilton region and one at Russell, near Ottawa. All extract shale for brick manufacturing. The Queenston Formation is the most important source material for brick manufacture in Ontario.

Whirlpool Formation (Lower Silurian)

STRATIGRAPHY: lower formation in the Cataract Group in the Niagara Peninsula and the Niagara Escarpment as far north as Duntroon. COMPOSITION: massive, medium- to coarse-grained, argillaceous white to light grey quartz sandstone with thin grey shale partings. THICKNESS: 0 to 8 m. USES: building stone, flagstone.

Manitoulin Formation (Lower Silurian)

STRATIGRAPHY: part of the Cataract Group, occurs north of Stoney Creek. COMPOSITION: thin-bedded, blue-grey to buff-brown dolomitic limestones and dolostones. THICKNESS: 0 to 25 m. USES: extracted for crushed stone in St. Vincent and Sarawak townships, Grey County, and for decorative stone on Manitoulin Island.

Cabot Head Formation (Lower Silurian)

STRATIGRAPHY: part of the Cataract Group, occurs in subsurface throughout southwestern Ontario and crops out along the length of the Niagara Escarpment. COMPOSITION: green, grey and red shales. THICKNESS: 10 to 39 m. USES: potential source of coated lightweight aggregate and raw material for use in manufacture of brick and tile. Extraction limited by lack of suitable exposures.

Grimsby Formation (Lower Silurian)

STRATIGRAPHY: upper formation of the Cataract Group, is identified on the Niagara Peninsula as far north as Clappison's Corners. COMPOSITION: interbedded sandstone and shale, mostly red. THICKNESS: 0 to 15 m. USES: no present uses.

Thorold Formation (Middle Silurian)

STRATIGRAPHY: lower formation in the Clinton Group on the Niagara Peninsula. COMPOSITION: thick-bedded quartz sandstone. THICKNESS: 2 to 3 m. USES: no present uses.

Neagha Formation (Middle Silurian)

STRATIGRAPHY: part of the Clinton Group on the Niagara Peninsula. COMPOSITION: dark-grey to green shale with minor interbedded limestone. THICKNESS: 0 to 2 m. USES: no present uses.

Dyer Bay Formation (Middle Silurian)

STRATIGRAPHY: on Manitoulin Island and northernmost Bruce Peninsula. COMPOSITION: highly fossiliferous, impure dolostone. THICKNESS: 0 to 7.5 m. USES: no present uses.

Wingfield Formation (Middle Silurian)

STRATIGRAPHY: on Manitoulin Island and northernmost Bruce Peninsula. COMPOSITION: olive green to grey shale with dolostone interbeds. THICKNESS: 0 to 15 m. USES: no present uses.

St. Edmund Formation (Middle Silurian)

STRATIGRAPHY: occurs on Manitoulin Island and northernmost Bruce Peninsula, upper portion previously termed the Mindemoya Formation. COMPOSITION: pale grey to buff-brown, micro- to medium-crystalline, thin- to medium-bedded dolostone. THICKNESS: 0 to 25 m. USES: quarried for fill and crushed stone on Manitoulin Island. AGGREGATE SUITABILITY TESTING: $MgSO_4$ = 1-2, LA = 19-21, Absn = 0.6-0.7, BRD = 2.78-2.79, PN (Asphalt & Concrete) = 105.

Fossil Hill and Reynales Formations (Middle Silurian)

STRATIGRAPHY: Fossil Hill Formation occurs in the northern part of the Niagara Escarpment and is approximately equivalent in part to the Reynales Formation that occurs on the Niagara Peninsula and the Escarpment as far north as the Forks of the Credit. COMPOSITION: Fossil Hill Formation - fine- to coarse-crystalline dolostone with high silica content; Reynales Formation - thin- to thick-bedded shaly dolostone and dolomitic limestone. THICKNESS: Fossil Hill Formation – 6 to 26 m; Reynales Formation – 0 to 3 m. USES: both formations quarried for aggregate with overlying Amabel and Lockport formations. AGGREGATE SUITABILITY TESTING: (Fossil Hill Formation on Manitoulin Island) $MgSO_4$ = 41, LA = 29, Absn = 4.1, BRD = 2.45, PN (Asphalt & Concrete) = 370.

Irondequoit Formation (Middle Silurian)

STRATIGRAPHY: part of Clinton Group on the Niagara Peninsula south of Waterdown. COMPOSITION: massive, coarse-crystalline crinoidal limestone. THICKNESS: 0 to 2 m. USES: not utilized extensively.

Rochester Formation (Middle Silurian)

STRATIGRAPHY: part of Clinton Group along the Niagara Peninsula. COMPOSITION: black to dark grey calcareous shale with numerous limestone lenses. THICKNESS: 5 to 24 m. USES: not utilized extensively. AGGREGATE SUITABILITY TESTING: PSV = 69, AAV = 17, $MgSO_4$ = 95, LA = 19, Absn = 2.2, BRD = 2.67, PN (Asphalt & Concrete) = 400.

Decew Formation (Middle Silurian)

STRATIGRAPHY: part of Clinton Group south of Waterdown along the Niagara Peninsula. COMPOSITION: sandy to shaly dolomitic limestone and dolostone. THICKNESS: 0 to 5 m. USES: too shaly for high-quality uses, but is quarried along with Lockport Formation in places. AGGREGATE SUITABILITY TESTING: PSV = 67, AAV = 15, $MgSO_4$ = 55, LA = 21, Absn = 2.2, BRD = 2.66, PN (Asphalt & Concrete) = 255.

Lockport and Amabel Formations (Middle Silurian)

STRATIGRAPHY: Lockport Formation occurs from Waterdown to Niagara Falls, subdivided into 3 formal members: Gasport, Goat Island and Eramosa members, and an informal member (the "Vinemount shale beds"); the approximately equivalent Amabel Formation, found from Waterdown to Cockburn Island, has been subdivided into Lions Head, Wiarton/Colpoy Bay and Eramosa members. On the Bruce Peninsula and in the subsurface of southwestern Ontario, the Eramosa Member is considered to be part of the overlying Guelph Formation. COMPOSITION: Lockport Formation is thin- to massive-bedded, fine- to medium-crystalline dolostone; Amabel Formation is thin- to massive-bedded, fine- to medium-crystalline dolostone with reef facies developed near Georgetown and on the Bruce Peninsula. The Eramosa Member is thin bedded and bituminous. THICKNESS: (Lockport–Amabel) 3 to 40 m. USES: both formations have been used to produce lime, crushed stone, concrete aggregate and building stone throughout their area of occurrence, and are a resource of provincial significance. AGGREGATE SUITABILITY TESTING: PSV = 36-49, AAV = 10-17, $MgSO_4$ = 2-6, LA = 25-32, Absn = 0.4-1.54, BRD = 2.61-2.81, PN (Asphalt & Concrete) = 100-105.

Guelph Formation (Middle Silurian)

STRATIGRAPHY: exposed south and west of the Niagara Escarpment from the Niagara River to the tip of the Bruce Peninsula, mostly present in the subsurface of southwestern Ontario. COMPOSITION: fine- to medium-crystalline, medium- to thick-bedded, porous dolostone, characterized in places by extensive vuggy, porous reefal facies of high chemical purity. THICKNESS: 4 to 100 m. USES: some areas appear soft and unsuitable for use in the production of load-bearing aggregate. This unit requires additional testing to fully establish its aggregate suitability. Main use is for dolomitic lime for cement manufacture. Quarried near Hamilton and Guelph.

Salina Formation (Upper Silurian)

STRATIGRAPHY: present in the subsurface of southwestern Ontario; only rarely exposed at surface. COMPOSITION: grey and maroon shale, brown dolostone and, in places, salt, anhydrite and gypsum; consists predominantly of evaporitic-rich material with up to 8 units identifiable. THICKNESS: 113 to 330 m. USES: gypsum mines at Hagersville, Caledonia and Drumbo. Salt is mined at Goderich and Windsor and is produced from brine wells at Amherstburg, Windsor and Sarnia.

Bertie and Bass Islands Formations (Upper Silurian)

STRATIGRAPHY: Bertie Formation found in southern Niagara Peninsula; Bass Islands Formation, the Michigan Basin equivalent of the Bertie Formation, rarely crops out in Ontario, but is present in the subsurface in southwestern Ontario; Bertie Formation represented by Oatka, Falkirk, Scajaquanda, Williamsville and Akron members. COMPOSITION: medium- to massive-bedded, micro-crystalline, brown dolostone with shaly partings. THICKNESS: 14 to 28 m. USES: quarried for crushed stone on the Niagara Peninsula; shaly intervals are unsuitable for use as high specification aggregate because of low freeze–thaw durability. Has also been extracted for lime. AGGREGATE SUITABILITY TESTING: PSV = 46-49, AAV = 8-11, $MgSO_4$ = 4-19, LA = 14-23, Absn = 0.8-2.8, BRD = 2.61-2.78, PN (Asphalt & Concrete) = 102-120.

Oriskany Formation (Lower Devonian)

STRATIGRAPHY: basal Devonian clastic unit, found in Niagara Peninsula. COMPOSITION: thick- to massive-bedded, coarse-grained, grey-yellow sandstone. THICKNESS: 0 to 5 m. USES: has been quarried for silica sand, building stone and armour stone. May be acceptable for use as rip rap, and well-cemented varieties may be acceptable for some asphaltic products. AGGREGATE SUITABILITY TESTING: (of a well-cemented variety of the formation) PSV = 64, AAV = 6, $MgSO_4$ = 2, LA = 29, Absn = 1.2-1.3, BRD = 2.55, PN (Asphalt & Concrete) = 107.

Bois Blanc Formation (Lower Devonian)

STRATIGRAPHY: Springvale Sandstone Member forms the lower portion of formation. COMPOSITION: a cherty limestone with shale partings and minor interbedded dolostones; Springvale Sandstone Member is a medium- to coarse-grained, green glauconitic sandstone with interbeds of limestone, dolostone and brown chert. THICKNESS: 3 to 40 m. USES: quarried at Hagersville, Cayuga and Port Colborne for crushed stone. Material generally unsuitable for concrete aggregate because of high chert content. AGGREGATE SUITABILITY TESTING: PSV = 48-53, AAV = 3-7, $MgSO_4$ = 3-18, LA = 15-22, Absn = 1.3-2.8, BRD = 2.50-2.70, PN (Asphalt & Concrete) = 102-290.

Onondaga Formation (Lower to Middle Devonian)

STRATIGRAPHY: correlated to part of the Detroit River Group; occurs on the Niagara Peninsula from Simcoe to Niagara Falls; contains the Edgecliff, Clarence and Moorehouse members. COMPOSITION: medium-bedded, fine- to coarse-grained, dark grey-brown or purplish-brown, variably cherty limestone. THICKNESS: 8 to 25 m. USES: quarried for crushed stone on the Niagara Peninsula at Welland and Port Colborne. High chert content makes much of the material unsuitable for use as concrete aggregate and asphaltic concrete. Has been used as a raw material in cement manufacture. AGGREGATE SUITABILITY TESTING: (Clarence and Edgecliff members) $MgSO_4$ = 1-6, LA = 16.8-22.4, Absn = 0.5-1.1, PN (Asphalt & Concrete) = 190-276.

Amherstburg Formation (Lower to Middle Devonian)

STRATIGRAPHY: part of Detroit River Group; correlated to Onondaga Formation in Niagara Peninsula; contains Sylvania Sandstone Member and Formosa Reef Limestone. COMPOSITION: bituminous, bioclastic, stromatoporoid-rich limestone with grey chert nodules; Formosa Reef Limestone - high-purity (calcium-rich) limestone; Sylvania Sandstone Member - quartz sandstone. THICKNESS: 0 to 60 m; Formosa Reef Limestone - up to 26 m. USES: cement manufacture, agricultural lime, aggregate. AGGREGATE SUITABILITY TESTING: PSV = 57, AAV = 19, $MgSO_4$ = 9-35, LA = 26-52, Absn = 1.1-6.4, BRD = 2.35-2.62, PN (Asphalt & Concrete) = 105-300.

Lucas Formation (Middle Devonian)

STRATIGRAPHY: part of the Detroit River Group in southwestern Ontario; includes the Anderdon Member which, in the Woodstock–Beachville area, may constitute the bulk of the formation. COMPOSITION: light brown or grey-brown dolostone with bituminous laminations and minor chert; Anderdon Member consists of very high-purity (calcium-rich) limestone and locally, sandy limestone. THICKNESS: 40 to 75 m. USES: most important source of high-purity limestone in Ontario. Used as calcium lime for metallurgical flux and for the manufacture of chemicals. Rock of lower purity is used for cement manufacture, agricultural lime and aggregate. Anderdon Member is quarried at Amherstburg for crushed stone. AGGREGATE SUITABILITY TESTING: PSV = 46-47, AAV = 15-16, $MgSO_4$ = 2-60, LA = 22-47, Absn = 1.1-6.5, BRD = 2.35-2.40, PN (Asphalt & Concrete) = 110-160.

Dundee Formation (Middle Devonian)

STRATIGRAPHY: few natural outcrops, mostly in the subsurface of southwestern Ontario. COMPOSITION: fine- to medium-crystalline, brownish-grey, medium- to thick-bedded, dolomitic limestone with shaly partings, sandy layers, and chert in some areas. THICKNESS: 15 to 45 m. USES: quarried near Port Dover and on Pelee Island for crushed stone. Used at St. Marys as a raw material for Portland cement. AGGREGATE SUITABILITY TESTING: $MgSO_4$ = 1-28, LA = 22-46, Absn = 0.6-6.8, PN (Asphalt & Concrete) = 125-320.

Marcellus Formation (Middle Devonian)

STRATIGRAPHY: subsurface unit, mostly found below Lake Erie and extending into the eastern USA, pinches out in the Port Stanley area. COMPOSITION: black, bituminous shales. THICKNESS: 0 to 12 m. USES: no present uses.

Bell Formation (Middle Devonian)

STRATIGRAPHY: lowest formation of the Hamilton Group, no outcrop in Ontario. COMPOSITION: soft, blue and grey calcareous shale. THICKNESS: 0 to 14.5 m. USES: no present uses.

Rockport Quarry Formation (Middle Devonian)

STRATIGRAPHY: part of the Hamilton Group; no outcrop in Ontario. COMPOSITION: grey-brown, very fine-grained limestone with occasional shale layers. THICKNESS: 0 to 6 m. USES: no present uses.

Arkona Formation (Middle Devonian)

STRATIGRAPHY: part of the Hamilton Group. COMPOSITION: blue-grey, plastic, clay shale with occasional thin and laterally discontinuous limestone lenses. THICKNESS: 5 to 37 m. USES: has been extracted at Thedford and near Arkona for the production of drainage tile.

Hungry Hollow Formation (Middle Devonian)

STRATIGRAPHY: part of the Hamilton Group. COMPOSITION: grey crinoidal limestone and soft, fossiliferous calcareous shale. THICKNESS: 0 to 2 m. USES: suitable for some crushed stone and fill with selective quarrying.

Widder Formation (Middle Devonian)

STRATIGRAPHY: part of the Hamilton Group. COMPOSITION: mainly soft, grey, fossiliferous calcareous shale interbedded with blue-grey, fine-grained fossiliferous limestone. THICKNESS: 0 to 21 m. USES: no present uses.

Ipperwash Formation (Middle Devonian)

STRATIGRAPHY: upper formation of the Hamilton Group; very limited distribution. COMPOSITION: medium- to coarse-grained, grey-brown, bioclastic limestone. THICKNESS: 2 to 14 m. USES: no present uses.

Kettle Point Formation (Upper Devonian)

STRATIGRAPHY: occurs in a northwest-trending band between Sarnia and Erieau; small part overlain by Port Lambton Group rocks in extreme northwest. COMPOSITION: black, highly fissile, organic-rich shale with minor interbeds of grey-green silty shale. THICKNESS: 0 to 75 m. USES: possible source of material for use as sintered lightweight aggregate or fill.

Bedford Formation (Upper Devonian or Mississippian)

STRATIGRAPHY: lower formation of the Port Lambton Group. COMPOSITION: soft, grey shale. THICKNESS: 0 to 30 m. USES: no present uses.

Berea Formation (Upper Devonian or Mississippian)

STRATIGRAPHY: middle formation of the Port Lambton Group; not known to occur at surface in Ontario. COMPOSITION: grey, fine- to medium-grained sandstone, often dolomitic and interbedded with grey shale and siltstone. THICKNESS: 0 to 60 m. USES: no present uses.

Sunbury Formation (Upper Devonian or Mississippian)

STRATIGRAPHY: upper formation of the Port Lambton Group; not known to occur at surface in Ontario. COMPOSITION: black shale. THICKNESS: 0 to 20 m. USES: no present uses.

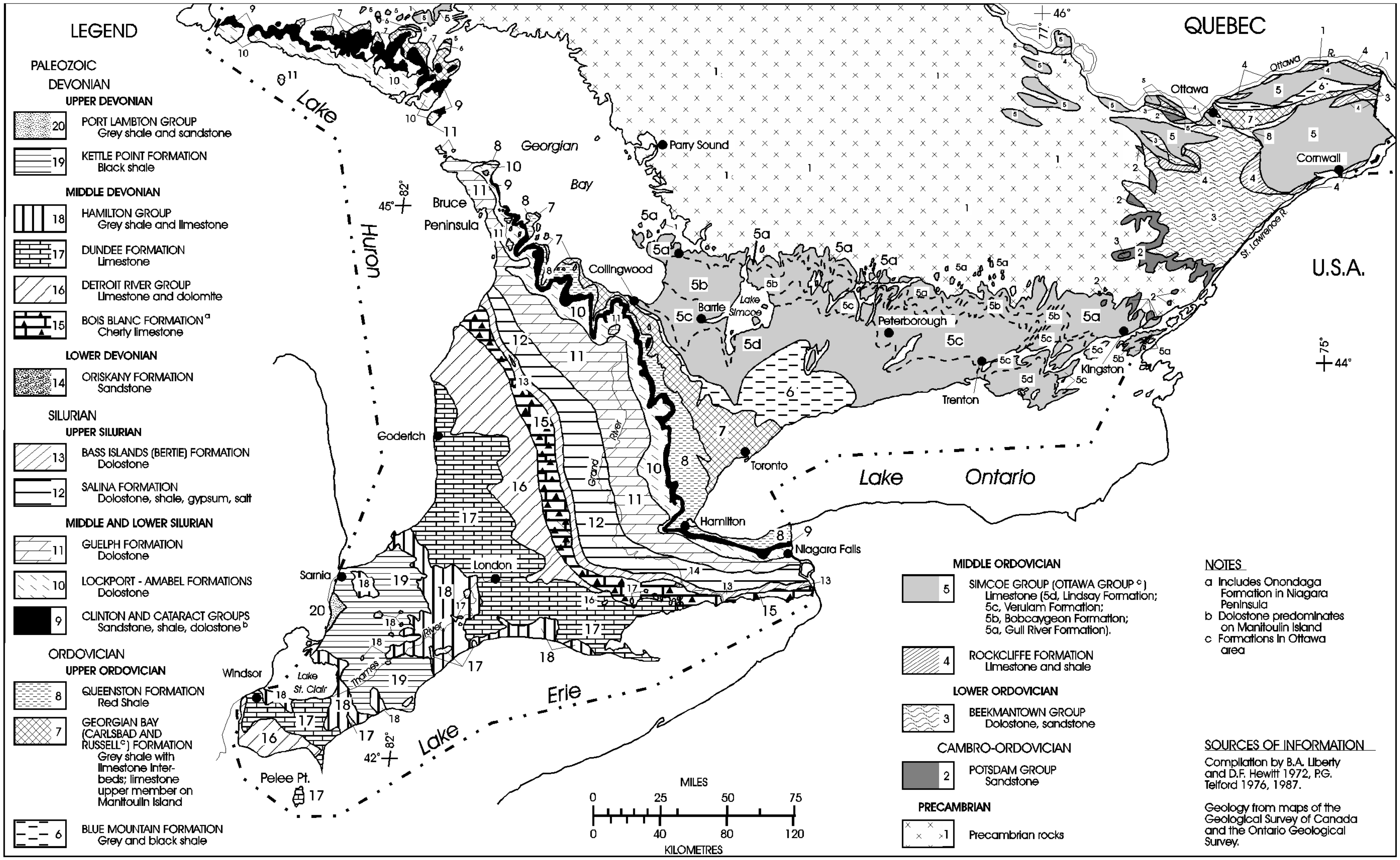

Figure D1. Bedrock geology of southern Ontario.

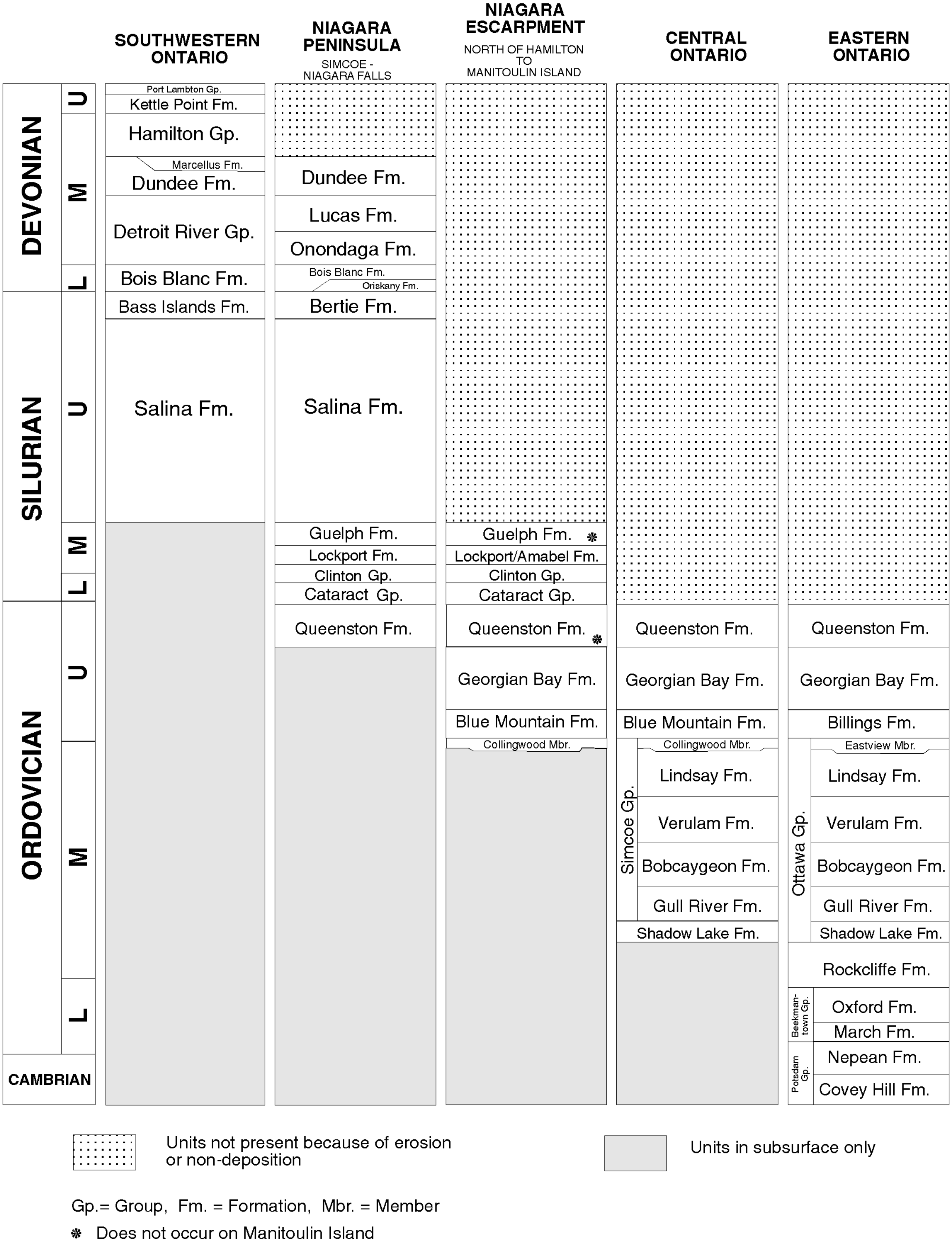

Figure D2. Exposed Paleozoic stratigraphic sequences in southern Ontario (*adapted from* Bezys, R.K. and Johnson, M.D. 1988. The geology of the Paleozoic formations utilized by the limestone industry of Ontario; The Canadian Institute of Mining and Metallurgical, CIM Bulletin,v.81, no. 912, p.49-58.)

Appendix E – Aggregate Quality Test Specifications

Six types of aggregate quality tests are often performed by the Ontario Ministry of Transportation on sampled material. A description and the specification limits for each test are included in this appendix. Although a specific sample meets or does not meet the specification limits for a certain product, it may or may not be acceptable for that use based on field performance. Additional quality tests other than the 6 tests listed in this appendix can be used to determine the suitability of an aggregate. The tests are performed by the Ontario Ministry of Transportation.

Absorption Capacity: Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate. This test is conducted in conjunction with the determination of the sample's relative density.

Los Angeles Abrasion and Impact Test: This test measures the resistance to abrasion and the impact strength of aggregate. This gives an idea of the breakdown that can be expected to occur when an aggregate is stockpiled, transported and placed. Values less than about 35% indicate potentially satisfactory performance for most concrete and asphalt uses. Values of more than 45% indicate that the aggregate may be susceptible to excessive breakdown during handling and placing.

Magnesium Sulphate Soundness Test: This test is designed to simulate the action of freezing and thawing on aggregate. Those aggregates which are susceptible will usually break down and give high losses in this test. Values greater than about 12 to 15% indicate potential problems for concrete and asphalt coarse aggregate.

Micro-Deval Abrasion Test: The micro-Deval abrasion test is an accurate measure of the amount of hard, durable materials in sand-sized particles. This abrasion test is quick, cheap and more precise than the fine aggregate magnesium sulphate soundness test that suffers from a wide multilaboratory variation. The maximum loss for HL 1/HL 3 is 20%; for HL 2 and HL 4/HL 8, it is 25%; and for structural and pavement concrete, it is 20%. It is anticipated that this test will replace the fine aggregate magnesium sulphate soundness test.

Mortar Bar Accelerated Expansion Test: This is a rapid test for detecting alkali-silica reactive aggregates. It involves the crushing of the aggregate and the creation of standard mortar bars. For coarse and fine aggregates, suggested expansion limits of 0.10 to 0.15% are indicated for innocuous aggregates, greater than 0.10% but less than 0.20% indicates that it is unknown whether a potentially deleterious reaction will occur, and greater than 0.20% indicates that the aggregate is probably reactive and should not be used for Portland cement concrete. If the expansion limit exceeds 0.10% for coarse and fine aggregates, it is recommended that supplementary information be developed to confirm that the expansion is actually because of alkali-reactivity. If confirmed deleteriously reactive, the material should not be used for Portland cement concrete unless corrective measures are undertaken such as the use of low- or reduced-alkali cement.

Petrographic Examination: Individual aggregate particles in a sample are divided into categories good, fair, poor and deleterious, based on their rock type (petrography) and knowledge of past field performance. A petrographic number (PN) is calculated. The higher the PN, the lower the quality of the aggregate.

Table E1. Selected quality requirements for major aggregate products.

TYPE OF TEST						
COARSE AGGREGATE					FINE AGGREGATE	
TYPE OF MATERIAL	**Petrographic Number Maximum**	**Magnesium Sulphate Soundness Maximum% Loss**	**Absorption Maximum%**	**Los Angeles Abrasion Maximum% Loss**	**Micro-Deval Abrasion Maximum % Loss**	**Magnesium Sulphate Soundness Maximum % Loss**
Granular A	**200**	**-**	**-**	**60**		**-**
Granular B Type 1	**250***	**-**	**-**	**-**		**-**
Granular B Type 2	**250**	**-**	**-**	**60**		**-**
Granular M	**200**	**-**	**-**	**60**		**-**
Granular S	**200**	**-**	**-**	**-**		**-**
Select Subgrade Material	**250**	**-**	**-**	**-**		**-**
Open Graded Drainage Layer (1)	**160**	**15**	**2.0**	**35**		**-**
Hot Mix-HL 1, DFC, OFC	**See OPSS 1149 and Special Provision No. 313S10**					
Surface Treatment Class 1	**135**	**12**	**1.75**	**35**		**-**
Surface Treatment Class 2	**160**	**15**	**-**	**35**		**-**
Surface Treatment Class 3	**160**	**12**	**2.0**	**35**		**-**
Surface Treatment Class 4	**-**	**-**	**-**	**-**		**20**
Surface Treatment Class 5	**135**	**12**	**1.75**	**35**		**-**
Hot Mix - HL 1	**100**	**5**	**1.0**	**15**	**20**	**16**
Hot Mix - HL 2	**-**	**-**	**-**	**-**	**25**	**20**
Hot Mix - HL 3	**135**	**12**	**1.75**	**35**	**20**	**16**
Hot Mix - HL 4	**160**	**12**	**2.0**	**35**	**20**	**20**
Hot Mix - HL 8	**160**	**15**	**2.0**	**35**	**25**	**20**
Structural Concrete, Sidewalk, Curb, Gutter and Base	**140**	**12**	**2.0**	**50**	**20**	**16**
Pavement Concrete	**125**	**12**	**2.0**	**35**	**20**	**16**

*** requirement waived if the material has more than 80% passing the 4.75 mm sieve**
(1) Hot mix and concrete petrographic number applies
(Ontario Provincial Standard Specifications OPSS 304, OPSS 1002, OPSS 1003, OPSS 1010 and OPSS 1149)

Metric Conversion Table

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
			LENGTH		
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
			AREA		
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
			VOLUME		
1 cm^3	0.061 023	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.307 951	cubic yards	1 cubic yard	0.764 554 86	m^3
			CAPACITY		
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
			MASS		
1 g	0.035 273 962	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 747	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 622 6	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311 3	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 90**	t
			CONCENTRATION		
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
1 ounce (troy) per ton (short)	31.103 477	grams per ton (short)
1 gram per ton (short)	0.032 151	ounces (troy) per ton (short)
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.

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Aggregate Resources Inventory Paper 180

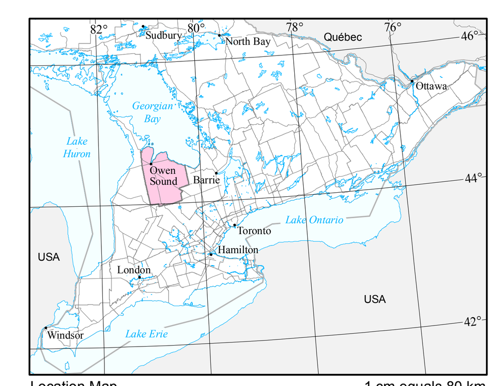
MAP 1

Sand and Gravel Resources for Grey County

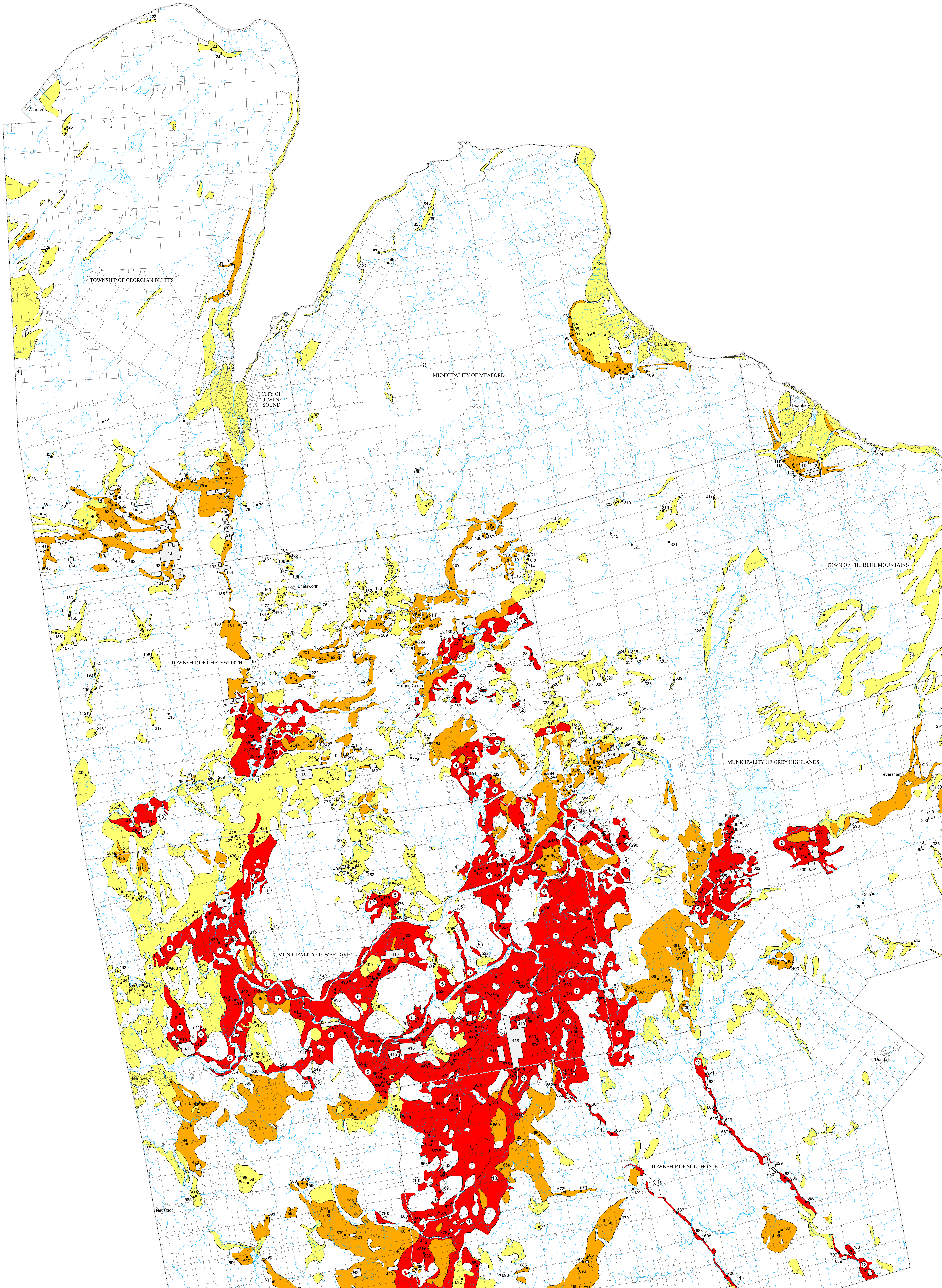
Scale 1:100 000

2000 m 0 2 4 km

NTS References: 40 P/15; 41 A/1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 15



Location Map 1 cm equals 80 km



SAND AND GRAVEL RESOURCES

- Selected Sand and Gravel Resource Area, primary significance; deposit number (*see* Table 3)
- Selected sand and gravel resource area, secondary significance
- Sand and gravel deposit, tertiary significance
- Other surficial deposits or exposed bedrock

SYMBOLS

- Licenced property boundary: property number (*see* Table 2)
- Unlicenced sand or gravel pit (i.e., abandoned pit or wayside pit operating on demand under authority of a permit). Property number (*see* Table 2).
- Geological and aggregate thickness boundary of sand and gravel deposits
- Administrative boundary

SOURCES OF INFORMATION

Base map information derived from National Topographic System (NTS) maps, Natural Resources Canada, scale 1:50 000, and from the Ontario Land Information Warehouse, Land Information Ontario, Ontario Ministry of Natural Resources, scale 1:50 000, with modifications by staff of the Ministry of Northern Development, Mines and Forestry. Projection: North American Datum 1983 (NAD83), Zone 17.

Aggregate suitability data from the Ontario Ministry of Transportation. Selected drilled water well data from the Ontario Ministry of the Environment. Test hole data from the Ontario Geological Survey, Ministry of Northern Development, Mines and Forestry.

Geology based on
- Burwasser, G.J. 1974a
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Additional geology by Jagger Hims Limited, D.J. Rowell and C. Gao, 2009. Compilation by Jagger Hims Limited, D.J. Rowell and C. Gao. Drafting by Jagger Hims Limited. This map is published with the permission of the Director, Ontario Geological Survey.

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Jagger Hims Limited and Rowell, D.J. 2009. Aggregate resources inventory for Grey County, southern Ontario; Ontario Geological Survey, Aggregate Resources Inventory Paper 183, Map 1–Sand and Gravel Resources, scale 1:100 000.

Aggregate Resources Inventory Paper 180

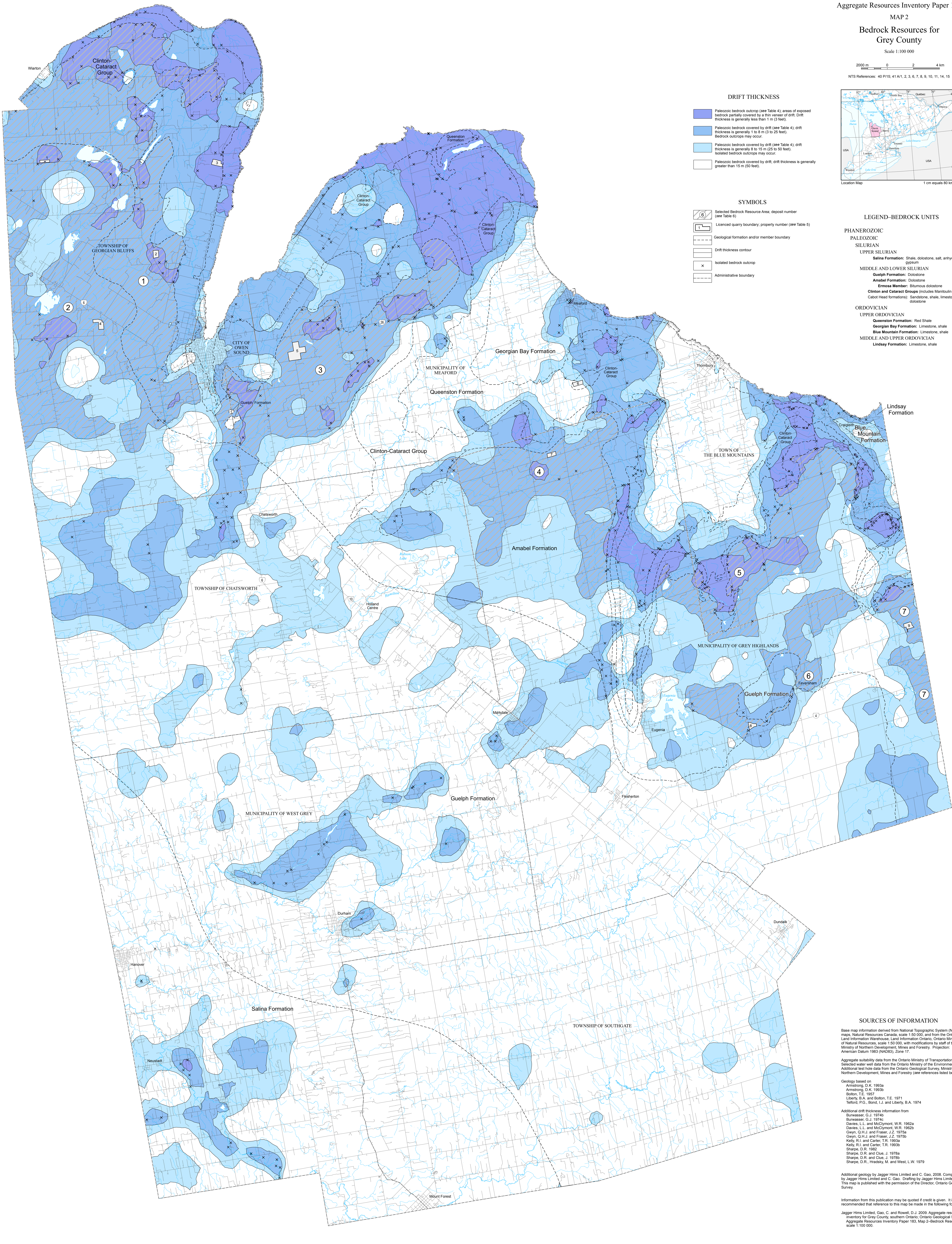
MAP 2

Bedrock Resources for Grey County

Scale 1:100 000

2000 m 0 2 4 km

NTS References: 40 P/15; 41 A/1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 15



Location Map 1 cm equals 80 km

DRIFT THICKNESS

- Paleozoic bedrock outcrop (*see* Table 4); areas of exposed bedrock partially covered by a thin veneer of drift. Drift thickness is generally less than 1 m (3 feet).
- Paleozoic bedrock covered by drift (*see* Table 4); drift thickness is generally 1 to 8 m (3 to 25 feet). Bedrock outcrops may occur.
- Paleozoic bedrock covered by drift (*see* Table 4); drift thickness is generally 8 to 15 m (25 to 50 feet). Isolated bedrock outcrops may occur.
- Paleozoic bedrock covered by drift; drift thickness is generally greater than 15 m (50 feet).

SYMBOLS

- 6 — Selected Bedrock Resource Area; deposit number (*see* Table 6)
- 1 — Licenced quarry boundary; property number (*see* Table 5)
- Geological formation and/or member boundary
- Drift thickness contour
- × — Isolated bedrock outcrop
- Administrative boundary

LEGEND–BEDROCK UNITS

PHANEROZOIC

PALEOZOIC

SILURIAN

UPPER SILURIAN

Salina Formation: Shale, dolostone, salt, anhydrite, gypsum

MIDDLE AND LOWER SILURIAN

Guelph Formation: Dolostone

Amabel Formation: Dolostone

Ermosa Member: Bitumous dolostone

Clinton and Cataract Groups (includes Manitoulin and Cabot Head formations): Sandstone, shale, limestone, dolostone

ORDOVICIAN

UPPER ORDOVICIAN

Queenston Formation: Red Shale

Georgian Bay Formation: Limestone, shale

Blue Mountain Formation: Limestone, shale

MIDDLE AND UPPER ORDOVICIAN

Lindsay Formation: Limestone, shale

SOURCES OF INFORMATION

Base map information derived from National Topographic System (NTS) maps, Natural Resources Canada, scale 1:50 000, and from the Ontario Land Information Warehouse, Land Information Ontario, Ontario Ministry of Natural Resources, scale 1:50 000, with modifications by staff of the Ministry of Northern Development, Mines and Forestry. Projection: North American Datum 1983 (NAD83), Zone 17.

Aggregate suitability data from the Ontario Ministry of Transportation. Selected water well data from the Ontario Ministry of the Environment. Additional test hole data from the Ontario Geological Survey, Ministry of Northern Development, Mines and Forestry (*see* references listed below).

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Jagger Hims Limited, Gao, C. and Rowell, D.J. 2009. Aggregate resources inventory for Grey County, southern Ontario; Ontario Geological Survey, Aggregate Resources Inventory Paper 183, Map 2–Bedrock Resources, scale 1:100 000.