Rockin' In the Real World

An Introduction to Aggregate Resources in Ontario

This Study Guide is to be used to help Envirothon teams prepare for the Ontario Envirothon Program.

FORESTS ONTARIO

Acknowledgments

This educational package is designed to give Envirothon teachers and participants information on Mineral Aggregates with links and references to be used in the preparation and delivery of aggregate topics for the Ontario Envirothon program.

About The Ontario Aggregate Resource Corporation

This module was made possible by The Ontario Aggregate Resource Corporation. At the Provincial level, the management of Ontario's aggregate resources is the responsibility of the Ministry of Natural Resources and Forestry (the MNRF). In 1997, the MNRF took steps to build a partnership with private industry to manage certain administrative functions and created the Aggregate Resources Trust (the Trust) and appointed a trustee (The Ontario Aggregate Resources Corporation) to look after its affairs. Since its inception in 1997, TOARC has focused upon developing systems for the efficient collection and disbursement of aggregate resource charges, the auditing of production reports, the rehabilitation of abandoned pits and quarries through the MAAP program, the collection and publishing of production statistics and the general management of the Trust assets. The Trust is also responsible that final rehabilitation is completed at sites where the licence or permit has been revoked by the MNRF.

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Aggregates *by the* Numbers

On average, approximately **164** million tonnes of aggregate are used in Ontario each year. That's about **14** tonnes per person.

The aggregate industry creates **7,000** direct jobs and **34,000** indirect jobs.

The industry contributes **$1.6** billion to Ontario's GDP.

An average brick home requires **250** tonnes of aggregate, which equals **12** truckloads.

An average school needs **13,000** tonnes of aggregate, or **650** truckloads.

One kilometre of a six-lane road uses **51,800** tonnes of aggregate, or **2,590** truckloads.

One kilometre or a subway needs **91,200** tonnes of aggregate, or **4,560** truckloads.

The GTA consumes over **50** million tonnes of aggregate annually, and demand is growing.

Over the next **25** years, the GTA is expected to need **2.5** billion tonnes of aggregate.

Introduction

Aggregates play an important role in the daily life of everyone. From roads to buildings, to cleaning sewage systems, aggregates are used in a variety of ways to make our lives better. While the extraction does have significant impacts on the environment, the rehabilitation and restoration potential of aggregates sites provides a unique opportunity to bring back nature.

What are Aggregates?

Aggregates are defined in Ontario's Aggregate Resources Act as gravel, sand, clay, earth, shale, stone, limestone, dolostone, sandstone, marble, granite, rock or other prescribed material. Alternatively, they are described as any combination of sand, gravel, or crushed stone in a natural or processed state. Aggregates are characterized as non-renewable resources found in certain fixed locations with few viable substitutes.

Aggregate Production and Consumption in Ontario

With increasing population in Ontario comes increased demand for aggregates to build cities. Current policy and legislation favours extraction of resources "close to market" – meaning removing aggregates close to where they will be consumed. This is because of the cost associated with the transportation of aggregates. Aggregates are mined from the earth, either dug out of pits or blasted out of quarries. Gravel pits are where sand and gravel is extracted naturally. Quarries are where solid bedrock (limestone or dolostone) is blasted and then crushed. It all begins with the removal of all natural vegetation, the top soil and the subsoil from a site. This removal of natural features inevitably has an impact on the local ecosystem, therefore rehabilitation is critical to ensure the future survival of local biodiversity.

Where do Aggregates Come From?

Different aggregates are found in different locations across Ontario depending on the origin of their creation. High quality unconsolidated deposits (gravel, sand) are frequently found in eskers, kame moraines or glacial spillways. High quality limestone is in certain locations in Ontario. The fact that certain types of aggregates are found in specific areas in Ontario makes it challenging to manage expectations of production with those of the public and reducing impact to the environment. In addition, protecting certain areas from extraction means that the demand is shifted to more remote areas.

For more information about where aggregates are produced in Ontario, see *Appendix 1: Long Distance Transportation of Aggregates to the Greater Toronto Area Market – Summary & Implications*

Uses

On average, Ontarians use about 14 tonnes of aggregate per person per year. Aggregates are used in the construction of highways, water mains, dams and airports, as well as residential, industrial and institutional buildings. The primary use is in construction projects, with roads (provincial highways, municipal and private roads) accounting for the largest share.

- 18,000 tonnes per kilometre of a two-lane highway in Southern Ontario;
- 250 tonnes for a 185 m2 (2,000 sq. ft.) house;
- 114,000 tonnes per kilometre of a subway line; and
- 1,000-4,500 tonnes per kilometre of water main.

Aggregate is used in many different applications including container packaging, cosmetics, crushed glass (for water filtration), concrete aggregate, catalytic converters, carpet, buildings, bridges, bake & culinary ware, automotive & vehicular glass, aircraft parts, agricultural soil supplements, fibre glass, ice control (road sand), landscaping, light bulbs, medical research instruments, mirrors, pharmaceuticals, pulp and paper mills, recreational sand, roofing granules, subway tunnels, sugar refineries, toothpaste, TV & computer screens, washing detergent, just to name a few!

Economic Value

The aggregate industry generates economic benefits on both the primary industries (upstream - i.e. initial extraction, processing and transportation sectors) and secondary industries (downstream - i.e. industries that use aggregates to produce goods such as concrete). These effects on primary industries (upstream) include spending by the aggregate industry on its industry supply chain and the industry itself. In 2007, taking into account direct, indirect and induced effects this sector generated approximately:

- $2.9 billion of gross output
- $827 million of labour income
- $1.6 billion of GDP • 16,600 full time

Environmental Impact and Value

The extraction of any natural resource has inevitable impacts on the environment. While efforts are made to decrease this impact or rehabilitate it after, there are still challenges faced in the aggregate sector related to environmental impacts. These are related to ground water characteristics, surface water characteristics, and impact to wildlife and vegetation. The important thing to remember with aggregates is that short-term extraction can occur, leading to the possibility of rehabilitating the site even sooner. Aggregate sites, post-extraction, provide valuable restoration opportunities that can add significantly to the health of the local ecosystem.

Aggregates can also be used in projects to help achieve environmental objectives. A careful analysis of the less visible, but equally important, environmental uses of aggregate is important to balance the scale and intensity of environmental effects. Aggregates can be used for:

- landscape restoration and/or rehabilitation;
- water quality treatment; sewage treatment
- removal of anthropogenic pollutants;
- uses in mines, landfills and waste disposals;
- maintenance of biodiversity erosion control, filters

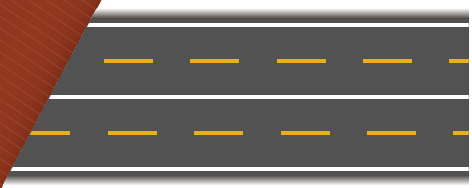
AGGREGATE RESOURCES STATISTICS IN ONTARIO

PRODUCTION STATISTICS 2015

DID YOU KNOW?

1,760 TRUCKLOADS

1KM



1 km of 4-lane highway

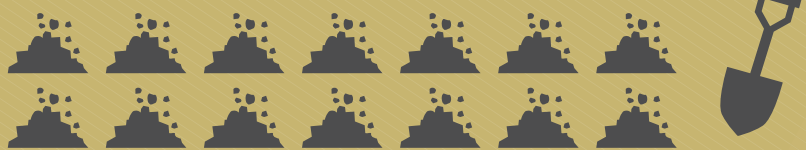
3,760 TRUCKLOADS

A 32,000m² hospital

4,560 TRUCKLOADS

1 km of subway line

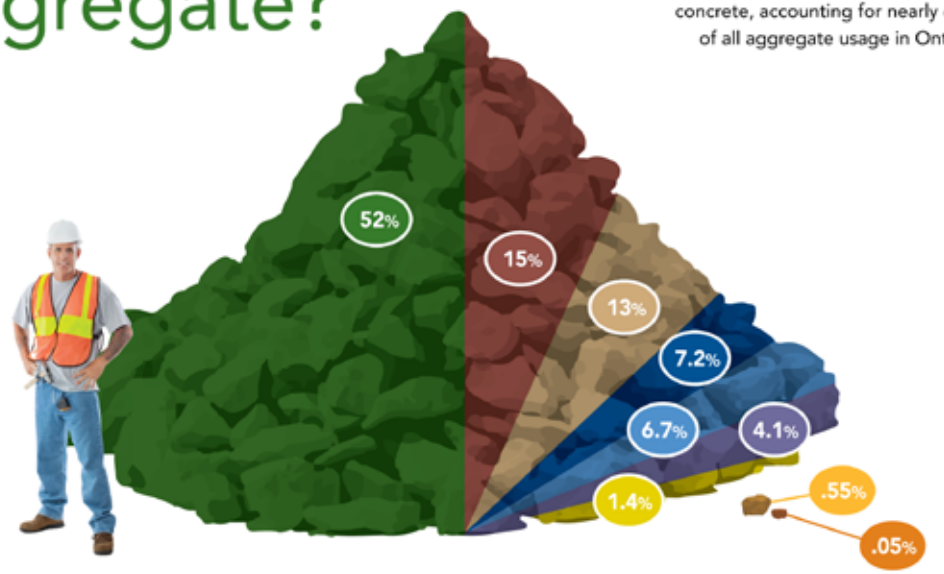
14 TONNES



Every Ontarian uses 14 TONNES of stone, sand and gravel each year.

Who uses Ontario's Aggregate?

Virtually every job and every home in Ontario relies on stone, sand and gravel. The vast majority of stone, sand and gravel produced in Ontario is used by the public sector: the municipal, provincial and federal government - with road and highway construction, including asphalt and concrete, accounting for nearly 60% of all aggregate usage in Ontario.



52%
ROADS
Sands, gravel and crushed stone used for the base of roads and highways.

15%
CONCRETE AGGREGATE
Sands, gravel and crushed stone used in the manufacture of concrete.

13%
CONSTRUCTION FILL
Sands, gravel and crushed stone used as fill in construction applications.

7.2%
CHEMICAL USE
Sands, gravel and crushed stone used in industrial or manufacturing processes, including sand for glass manufacturing, dolime used in steelmaking, and kiln feed for portland cement.

6.7%
ASPHALT AGGREGATE
Sands, gravel and crushed stone used in the manufacture of asphalt for roads.

4.1%
OTHER CONSTRUCTION & MANUFACTURING USES
Any uses not covered in other categories, including grinding abrasives and mould stands for foundry castings, etc.

1.4%
MORTAR SAND
Sand used in the manufacture of mortar.

0.55%
PULVERIZED STONE
Used as mineral fillers for cosmetics, paints, rubber products, some food additives, etc.

0.05%
DIMENSIONAL STONE
Rock and quarried stone used in architectural applications including stone cladding, paving stones, retaining walls, floor tiles, cemetery monuments, landscaping, and interior limestone, marble and slate.

OSSGA
ONTARIO STONE, SAND & GRAVEL ASSOCIATION

5720 Timberlea Blvd., Unit 103, Mississauga, ON L4W 4W2 | 905.507.0711 | www.ossga.com

STUDENT ACTIVITY 1

From the Ground to Your Home

Appendix 2: Where Does It All Go? lists the many uses for aggregates in rural, suburban and urban households.

Choose one use for aggregates from Appendix 2 and research the life cycle of that aggregate product from extraction, through manufacturing and eventual final use.

Use the following questions to guide your research:

1. What aggregates are used in making the product?
2. Are aggregates used in the manufacturing process or are they used within the product itself?
3. What is the lifespan of the product? Are aggregates the limiting factor for the product's lifespan?
4. Is the product or process recyclable? If so, how are aggregates utilized in the recycling process?

Aggregates Regulation in Ontario

Most of Ontario's pits and quarries are regulated under the Aggregate Resources Act (ARA, 1990), which is regulated by the Ministry of Natural Resources and Forestry. Some areas of private land are not covered by the Act, and in these areas, the local municipality may regulate pit and quarry operations.

The Ministry of Natural Resources and Forestry:

- oversees the rules governing aggregate management
- issues licenses, permits and changes to existing approvals
- inspects aggregate operations and responds to complaints
- enforces compliance
- ensures rehabilitation is carried out on sites

The purposes of the Aggregate Resources Act (ARA) are:

- to provide for the management of the aggregate resources of Ontario
- to control and regulate aggregate operations on Crown and private lands
- to require the rehabilitation of land from which aggregate has been excavated
- to minimize adverse impact on the environment in respect of aggregate operations

The Act requires every licensee and/or permittee to perform both progressive and final rehabilitation on the site to the satisfaction of the Ministry of Natural Resources and Forestry. This must be done in accordance with the Act, the regulators, the site plan, and the conditions of the licensee or permit. If the Ministry is not satisfied that adequate rehabilitation has been performed on the site, MNR may issue a rehabilitation order to perform the progressive or final rehabilitation that is deemed necessary.

There are two licenses provided for extraction, the Class A and Class B licenses.

- Licensing:
  - you need a Class A license if more than 20,000 tonnes of aggregate is removed annually
  - you need a Class B license if 20,000 tonnes or less of aggregate is removed annually
- Public authorities, like the Ministry of Transportation and municipalities, may obtain a wayside permit to extract aggregate for temporary road construction or maintenance projects

For a Class A license, the operator must submit a detailed site plan that outlines a description of the site, topography, mining activity, adjacent properties, the water table and surface water, sequence of development and progressive rehabilitation. For Class B licenses, similar things need to be outlined but with less detail. In addition for Class A licenses a report is also needed outlining the social and economic effects to be expected, potential hydrology and hydrogeology problems, location of top soil, land-use consideration and the environment that may be expected to be affected by the operation and actions to be taken to remediate this.

In addition to the Aggregate Resources Act (ARA), other legislation may apply during the operation of the site to further strengthen environmental protection. These may include the Conservation Authorities Act, Environmental Protection Act, Fisheries Act, Municipal Act, Endangered Species Act, Ontario Water Resources Act or the Planning Act to name a few. More information can be found in *Appendix 2.*

Anyone who applies for a license to extract aggregates are required to notify nearby landowners, municipalities and other agencies and ministries of their proposed aggregate development project. If any comments are submitted on the proposal, the applicant is obligated to work toward resolving your concern.

For a map of the pits and quarries covered by the ARA, visit the Ministry of Natural Resources and Forestry site at *https://www.ontario.ca/environment-and-energy/find-pits-and-quarries*.

Aggregate Resource Inventory

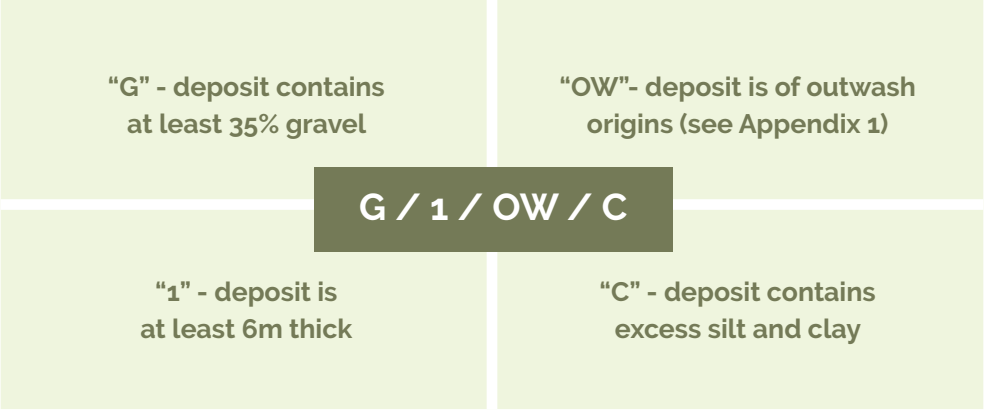
Aggregate inventories are done to identify areas of high aggregate resource potential.

Several steps are taken to determine the type and distribution of aggregates in a given area. Primary information is acquired either by looking at historical information of the area or contacting the Ministry of Natural Resources and Forestry for more information. Then, sites are inspected to determine the size of the deposit and quality of aggregate content using four factors: gravel content, deposit thickness, origin geology and quality limitations.

Aggregate Deposit Information

Aggregate deposits are coded in a similar manner to soil mapping or land classification systems commonly used in North America, such as the Canadian System for Soil Classification. The deposit information code indicates the gravel content, thickness of material, origin (type) of the geologic deposit (see Appendix 1: Geology of Aggregates), and any quality limitations, if applicable.

For example, in the deposit information code, "G" indicates the gravel content, "1" represents the thickness, "OW" represents the geologic type and "C" represents aggregate quality limitations.



Gravel Content

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 a 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.

Deposit 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. Sometimes 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. The four thickness class divisions are:

- 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.

Generally, deposits in Class 1 and containing more than 35% gravel are considered to be most favourable for commercial development.

Deposit Geologic Origin

Please refer to *Appendix 3: Geology of Aggregates* for a complete list of geologic types

Aggregate Quality Limitations

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.

The final indicator of the quality of an aggregate is **lithology ("L").** Lithology refers to the general physical characteristics of rock in an area. 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 a deposit information code possesses either "C", "O" or "L", in any combination or quantity, the quality of the deposit is considered to be reduced for some aggregate uses. This information is used by private and government stakeholders to determine the value of aggregate deposits across Ontario.

Drones and Aggregates

Drones provide an easy way to get an overhead assessment on aggregate sites. They can be used to take photos of the site to help with reporting on compliance, or they may be used to give a more accurate measurement of the materials in an aggregate site. Drones can replace the ground surveys often used to see if what maps are showing actually exists on the landscape. Drones are also helpful when access to a site is limited or has not been maintained for a few years.

For more information on drones and aggregates, please see *Appendix 4: Drones in Aggregates.*

Rehabilitation

The Aggregate Resources Act requires you to rehabilitate your pit or quarry during its operational lifetime. You need to rehabilitate the parts of your site which you've completed work on, while you continue extracting aggregates in other areas. These areas can be rehabilitated into wetlands and habitat for wildlife, farmland, parks, fruit orchards, vineyards, subdivisions, golf courses and recreational fishing areas.

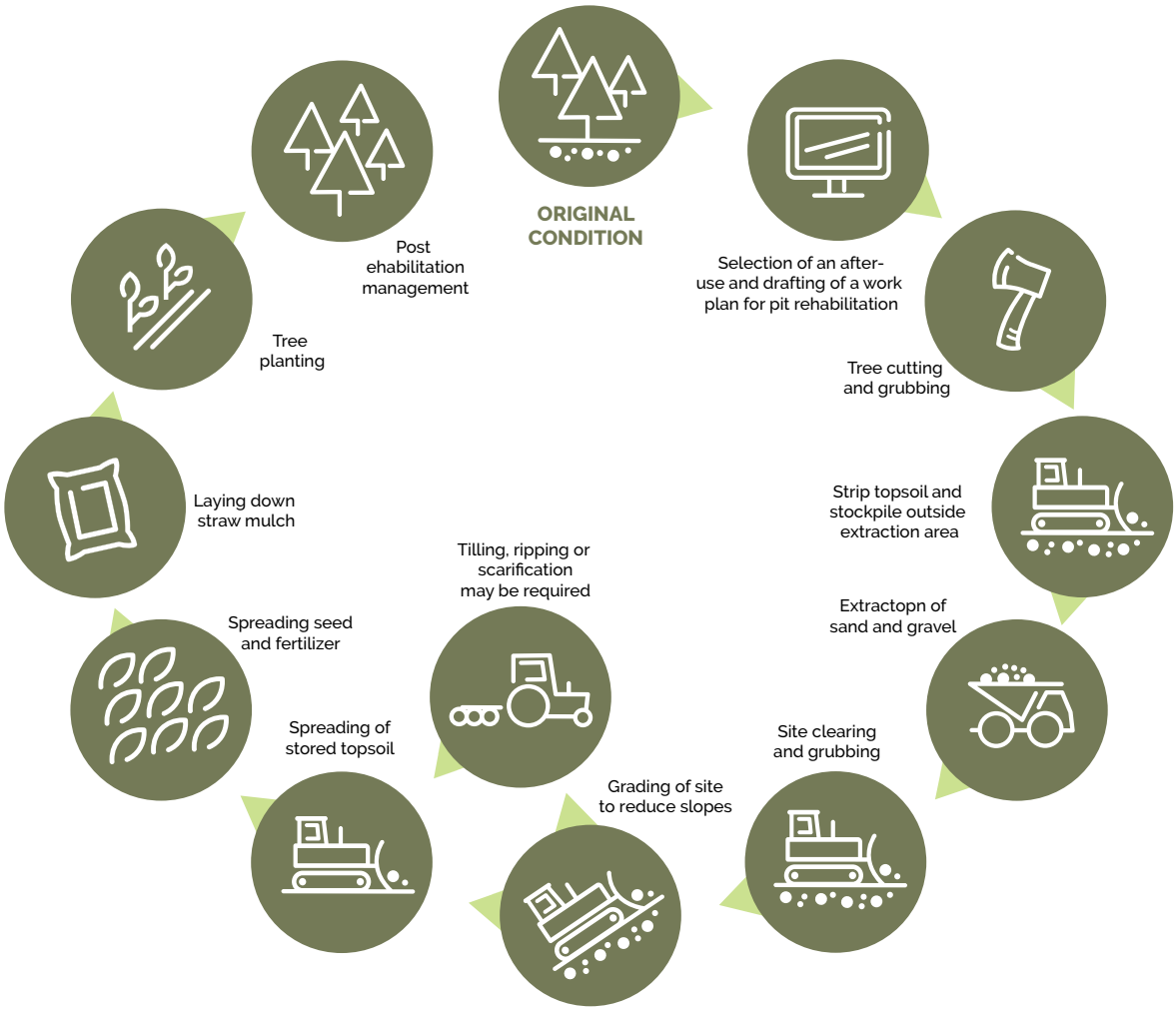
Current aggregate legislation also ensures that extraction is only a temporary land use, and that rehabilitation is undertaken to return each extracted site to its initial use or to uses compatible with surrounding land uses.

Land use trends of rehabilitated sites can range from natural, open space, water, agriculture, commercial, industrial or residential.

Abandoned aggregate sites

Pits and quarries on private land that stopped operating before they were required to obtain a license are considered abandoned or legacy sites. Where the landowner has granted permission, these sites can be rehabilitated by The Ontario Aggregate Resources Corporation under the Management of Abandoned Aggregate Properties program (MAAP).

For more information about the Management of Abandoned Aggregate Properties program, please visit *http://www.toarc.com/maap-1/about-maap.html.*



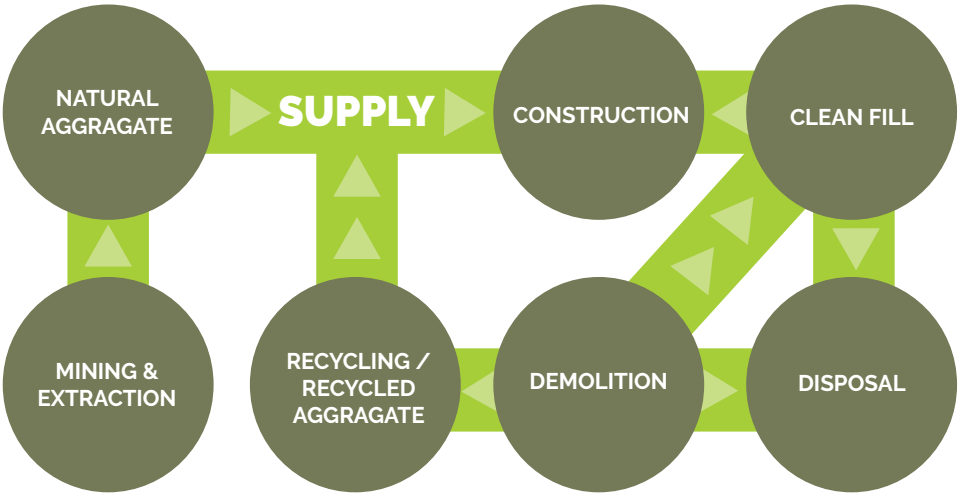
Reuse and Recycling

Aggregate Reuse and Recycling in Ontario

Ontario uses about 184 million tonnes of aggregate (2007) a year, of which about 13 million tonnes comes from recycled sources. Approximately three-quarters of the aggregate consumed in Ontario is used in road construction, building construction, and installing water mains and sewer pipes. Enhanced recycling and reuse of excess materials and by-products in bulk applications can be a key contributor to the sustainability for aggregate resources.

Used asphalt and concrete products are the largest source of recycled aggregate. Low volume wastes and by-products such as waste glass, roofing shingles, spent foundry sands and municipal solid waste bottom ash have some promise as alternative sources of aggregates but will have limited impact in reducing primary aggregate demand.

Currently almost all steel slag, blast furnace slag and spent foundry sand, which accounted for about one million tonnes of recycled aggregates prior to 1991, are now used for other purposes. Therefore the reuse and recycling of conventional by-product aggregates such as used asphalt and concrete has increased substantially.



Benefits of Reuse and Recycling

Aggregate reuse and recycling:

- Reduces land use pressures – most pits and quarries are located near urban centres to minimize the cost of shipping aggregates to construction projects, which brings them into competition and conflict with housing, commercial and industrial development and recreational land.
- Reduces energy consumption – it takes energy to produce primary aggregate and even more energy to transport it to where it is used. Reuse and recycling conserves energy and reduces greenhouse gases.
- Reduces waste – reusing aggregates and recycling other waste products as aggregate substitutes reduces the amount of waste
- Reduces costs – in some cases, recycled aggregates may cost less than primary aggregates depending on the distance of transportation and the cost of energy.

Careers in Aggregates

If you are passionate about the environment, there are a variety of careers available in the aggregate sector.

- Geologists
- Mining Engineers
- Mechanical Engineers
- Quarry Engineer
- Environmental Technician
- Seismologist
- Surveyor
- GIS Technician
- Water Quality Analyst
- Hydrologist
- Biologist

For more information about careers in aggregates, visit the Ontario Stone, Sand and Gravel Association's Career Profiles page at *http://ossga.com/career_profiles/*.

STUDENT ACTIVITY 2

Grain Sieve Analysis

Purpose: This test is performed to determine the percentage of different grain sizes contained within a soil. The mechanical or sieve analysis is performed to determine the distribution of the coarser, larger-sized particles.

Significance: The distribution of different grain sizes affects the engineering properties of soil. Grain size analysis provides the grain size distribution, and it is required in classifying the aggregate.

Equipment: Balance, Set of sieves, Cleaning brush, Sieve shaker (optional)

Background

A sieve analysis (or **gradation test**) is a practice or procedure used (commonly used in civil engineering) to assess the particle size distribution (also called *gradation*) of an aggregate material.

The size distribution is often of critical importance to how the material is used. A sieve analysis can be performed on any type of non-organic or organic granular materials including sands, crushed rock, clays, granite, feldspars, coal, soil, and a wide range of manufactured powders, grain and seeds, down to a minimum size depending on the exact method.

Sieves are used to sort out different sizes of materials. Sieves are composed of a number of wires that make up a screen. The mesh size refers to the number of openings in one linear inch of the sieve's screen. The more wires a screen has, the lower the size of each opening in the screen. Therefore material with a higher mesh size (#200) is smaller than a material with a lower mesh size (#100).

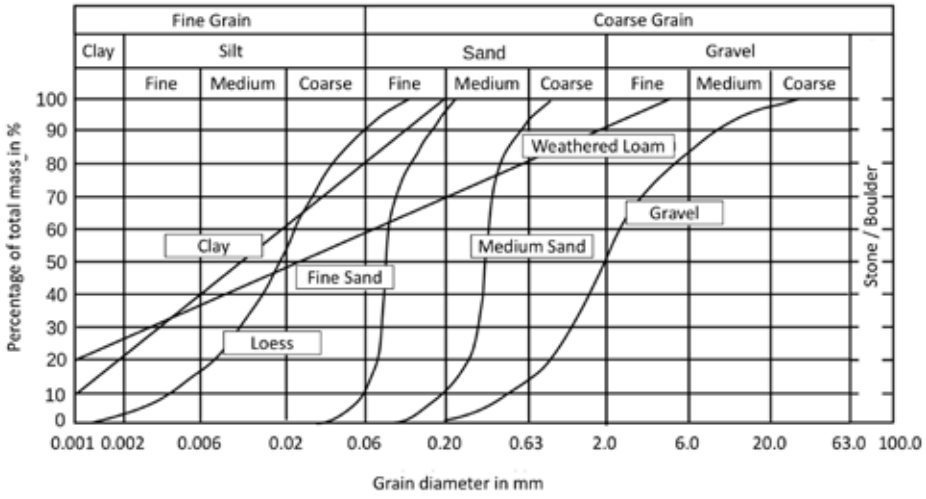
Procedure

1. Write down the weight of each sieve as well as the bottom pan to be used in the analysis before putting any samples inside.
2. Record the weight of the dry soil sample.
3. Make sure that all the sieves are clean, and assemble them in the ascending order of sieve numbers (#4 sieve at top and #200 sieve at bottom). Place the pan below #200 sieve. Carefully pour the sand and gravel sample into the top sieve and place the cap over it.
4. Shake by hand or place the sieve stack in the mechanical shaker and shake for 20 minutes (10 for mechanical), then remove from machine.
5. Carefully weigh and record the weight of each sieve with its retained soil. In addition, remember to weigh and record the weight of the bottom pan with its retained fine soil.

Table 1: Grain size scale

ϕ Scale	Size range (metric)	Aggregate name (Wentworth class)	Other names
<–8	>256 mm	Boulder	
–6 to –8	64–256 mm	Cobble	
–5 to –6	32–64 mm	Very coarse gravel	Pebble
–4 to –5	16–32 mm	Coarse gravel	Pebble
–3 to –4	8–16 mm	Medium gravel	Pebble
–2 to –3	4–8 mm	Fine gravel	Pebble
–1 to –2	2–4 mm	Very fine gravel	Granule
0 to –1	1–2 mm	Very coarse sand	
1 to 0	0.5–1 mm	Coarse sand	
2 to 1	0.25–0.5 mm	Medium sand	
3 to 2	125–250 µm	Fine sand	
4 to 3	62.5–125 µm	Very fine sand	
8 to 4	3.9–62.5 µm	Silt	Mud
10 to 8	0.98–3.9 µm	Clay	Mud
20 to 10	0.95–977 nm	Colloid	Mud

Figure 2: Percentage of material passing through each level of sieve in a sieve grain analysis (grain size is logarithmic)



Results

The results can be presented in a graph of percent of the total mass versus the sieve size. On the graph the sieve size scale is logarithmic (see Fig. 1).

Determining the percentage of materials in each sieve

1. To find the percent of aggregate passing through each sieve, first **find the percent retained** in each sieve. To do so, the following equation is used:

$$\% \text{ Retained} = \frac{W_{Sieve}}{W_{Total}} \times 100\%$$

   Where

   - W_{Sieve} = the weight of aggregate in the sieve
   - W_{Total} = the total weight of the aggregate

2. The next step is to find the **cumulative percent of aggregate retained** in each sieve. To do so, add up the total amount of aggregate that is retained in each sieve and the amount in the previous sieves. The cumulative percent passing of the aggregate is found by subtracting the percent retained from 100%.

   % Cumulative Passing = 100% - % Cumulative Retained

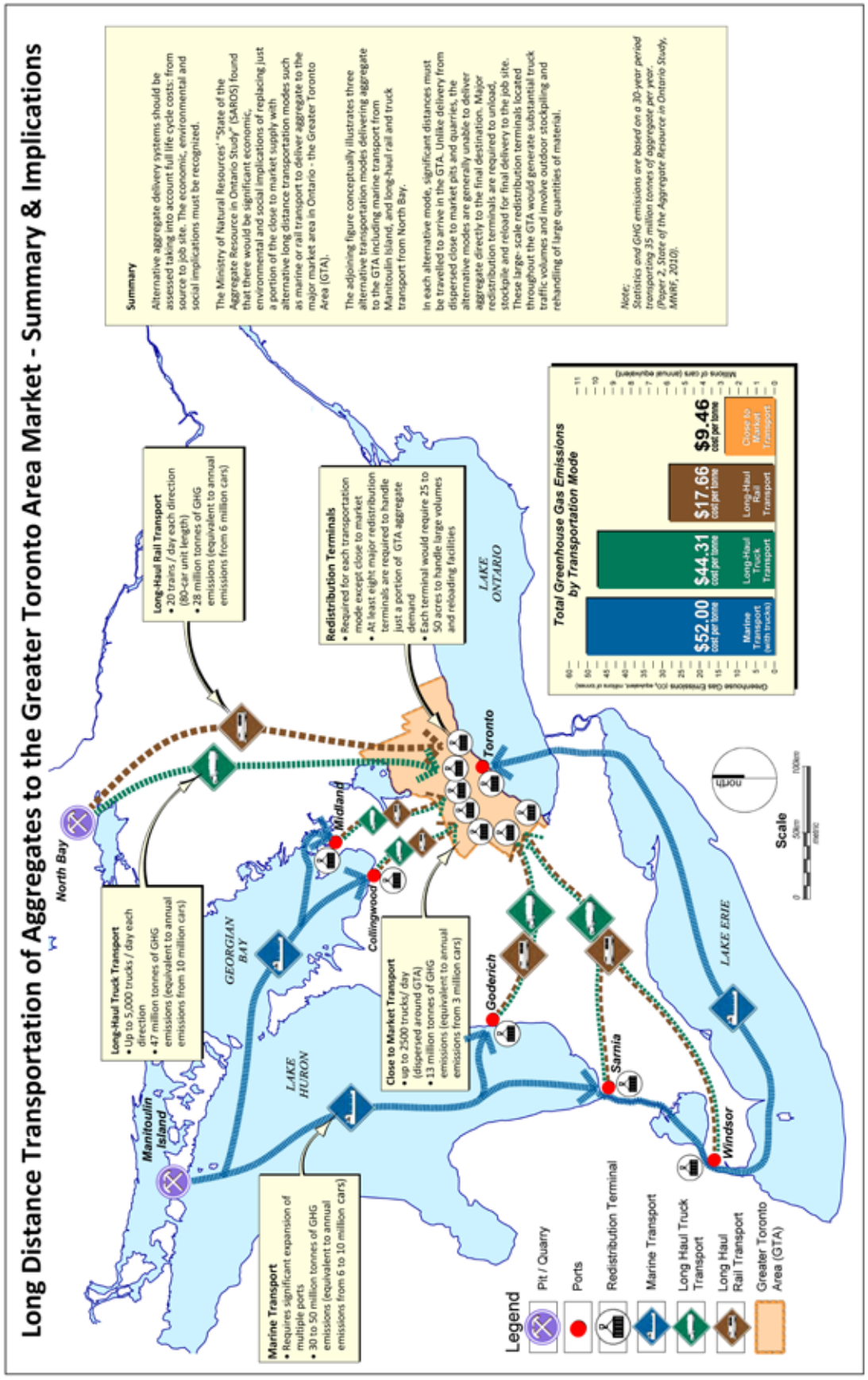
3. Use the **percent passing formula** to find the percentage of material passing through each sieve at each level.

$$\%\text{Passing} = \frac{W_{Below}}{W_{Total}} \times 100\%$$

   Where:

   - W_{Below} = the total mass of the aggregate within the sieves below the current sieve, not including the current sieve's aggregate.
   - W_{Total} = the total mass of all of the aggregate in the sample.

4. The values can then be plotted on a graph with cumulative percent passing on the y axis and logarithmic sieve size on the x axis (see Fig. 2).


Long Distance Transportation of Aggregates to the Greater Toronto Area Market - Summary & Implications
Summary
Alternative aggregate delivery systems should be assessed taking into account full life cycle costs: from source to job site. The economic, environmental and social implications must be recognized.
The Ministry of Natural Resources' "State of the Aggregate Resource in Ontario Study" (SAROS) found that there would be significant economic, environmental and social implications of replacing just a portion of the close to market supply with alternative long distance transportation modes such as marine or rail transport to deliver aggregate to the major market area in Ontario - the Greater Toronto Area (GTA).
The adjoining figure conceptually illustrates three alternative transportation modes delivering aggregate to the GTA including marine transport from Manitoulin Island, and long-haul rail and truck transport from North Bay.
In each alternative mode, significant distances must be travelled to arrive in the GTA. Unlike delivery from dispersed close to market pits and quarries, the alternative modes are generally unable to deliver aggregate directly to the final destination. Major redistribution terminals are required to unload, stockpile and reload for final delivery to the job site. These large- scale redistribution terminals located throughout the GTA would generate substantial truck traffic volumes and involve outdoor stockpiling and rehandling of large quantities of material.
Note:
Statistics and GHG emissions are based on a 30-year period transporting 35 million tonnes of aggregate per year. (Paper 2, State of the Aggregate Resource in Ontario Study, MNRF, 2010).
Total Greenhouse Gas Emissions by Transportation Mode
Marine Transport (with trucks)
$52.00 cost per tonne
Long-Haul Truck Transport
$44.31 cost per tonne
Long-Haul Rail Transport
$17.66 cost per tonne
Close to Market Transport
$9.46 cost per tonne
Long-Haul Rail Transport
• 20 trains / day each direction (80-car unit length)
• 28 million tonnes of GHG emissions (equivalent to annual emissions from 6 million cars)
Redistribution Terminals
• Required for each transportation mode except close to market
• At least eight major redistribution terminals are required to handle just a portion of GTA aggregate demand
• Each terminal would require 25 to 50 acres to handle large volumes and reloading facilities
Long-Haul Truck Transport
• Up to 5,000 trucks / day each direction
• 47 million tonnes of GHG emissions (equivalent to annual emissions from 10 million cars)
Close to Market Transport
• up to 2500 trucks/ day (dispersed around GTA)
• 13 million tonnes of GHG emissions (equivalent to annual emissions from 3 million cars)
Marine Transport
• Requires significant expansion of multiple ports
• 30 to 50 million tonnes of GHG emissions (equivalent to annual emissions from 6 to 10 million cars)
North Bay
Manitoulin Island
Midland
Collingwood
Goderich
Sarnia
Windsor
Toronto
GEORGIAN BAY
LAKE HURON
LAKE ONTARIO
LAKE ERIE
Scale
North
Legend
Pit / Quarry
Ports
Redistribution Terminal
Marine Transport
Long Haul Truck Transport
Long Haul Rail Transport
Greater Toronto Area (GTA)

Where Does It All Go?

Rural Environment

We all use stone, sand and gravel virtually every minute of every day. It's part of the buildings we live and work in, the roads we drive on... even the water we drink is filtered and purified by aggregate.

FIREPLACE (STONE OR BRICK):
- Chimney
- Interior fireplace façade
- Mantle

ROOFING MATERIALS:
- Clay or asphalt shingles (includes filler plus grit on surface)

WINDOWS:
- Glass in buildings and cars, etc.

YARD AND FIELDS:
- Culverts on open roads with open ditches and on field entrances
- Rock armour to stop erosion of these ditches
- Horse track and barnyard
- Acid neutralization agents for farmers' fields
- Fertilizers

HOME AND OUTBUILDING STRUCTURES:
- Building foundation
- Bricks & mortar, stone, and/or stucco exterior
- Concrete block support walls in basement
- Fiberglass insulation (sand)
- Drywall (gypsum)

HOME INTERIOR (CONSUMER PRODUCTS):
- Glassware
- CorningWare
- Ceramic plates, vases, etc.
- Clay in porcelain for sinks and toilets
- Tiles for bathroom and kitchen
- Glass in mirrors
- Cosmetics
- Toothpaste
- Paint
- Cleaning agents
- Paper
- Chewing gum
- Aggregate used to produce plastic and vinyl products

ROADWAYS:
- Gravel driveways leading to house
- Service driveways leading to fields

HARDSCAPING:
- Decorative armour stone
- Stone retaining walls for gardens
- Water features and fish ponds
- Stone or concrete walkways and paths
- Clay pots for plants

OTHER STRUCTURES AND FOUNDATIONS:
- Foundations for agricultural wind turbines
- Concrete silos
- Wells

BUILDING BEDDING & SEPTIC:
- Compacted gravel bed below house, barn and other outbuildings
- Bedding and fill for water pipes
- Septic and leaching beds (requires approximately 200 to 400 tonnes of septic sand to construct)

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Where Does It All Go?

Suburban Environment

We all use stone, sand and gravel virtually every minute of every day. It's part of the buildings we live and work in, the roads we drive on... even the water we drink is filtered and purified by aggregate. It's used in everything from paper and paint to chewing gum and household cleansers.

RECREATION:
- Concrete for swimming pools
- Sand boxes and sand under swing set

FIREPLACE (STONE OR BRICK):
- Chimney
- Interior fireplace façade
- Mantle

ROOFING MATERIALS:
- Asphalt shingles (includes filler plus grit on surface)

WINDOWS:
- Glass in buildings, cars, subways, etc.

PAVED ROADWAYS & EXTERIOR INFRASTRUCTURE:
- Paved driveways
- Paved parking lots for business and retail
- Curbs in parking lots, driveways and on roads
- Sidewalks
- Storm drains
- Street lamp bases

HOME INTERIOR (CONSUMER PRODUCTS):
- Glassware
- CorningWare
- Ceramic plates, vases, etc.
- Clay in porcelain for sinks and toilets
- Tiles for bathroom and kitchen
- Glass in mirrors
- Cosmetics
- Toothpaste
- Paint
- Cleaning agents
- Paper
- Chewing gum
- Aggregate used to produce plastic and vinyl products

HARDSCAPING:
- Decorative armour stone
- Stone retaining walls for gardens
- Water features and fish ponds
- Stone or concrete walkways and paths
- Clay pots for plants
- Concrete to anchor fence posts and deck structures

WATER:
- Municipal water that enters building is filtered through a purification system that uses aggregate

BUILDING BEDDING:
- Compacted gravel bed below building, including bedding and fill for water and sewer pipes

HOME STRUCTURE:
- Building foundation
- Bricks & mortar, stone, and/or stucco exterior
- Concrete block support walls in basement
- Fiberglass insulation (sand)
- Drywall (gypsum)

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Where Does It All Go?

Urban Environment

We all use stone, sand and gravel virtually every minute of every day. It's part of the buildings we live and work in, the roads we drive on... even the water we drink is filtered and purified by aggregate. It's used in everything from paper and paint to chewing gum and household cleansers.

RECREATION:
- Gravel on baseball diamonds
- Gravel or sand in playgrounds
- Sand for sand boxes
- Skateboard and bike parks
- Bike and walking trails

PAVED ROADWAYS & EXTERIOR INFRASTRUCTURE:
- Paved driveways
- Paved parking lots
- Curbs in parking lots, driveways and on roads
- Street lamp bases

ROOFING MATERIALS:
- Tar roof with stone layer

WINDOWS:
- Glass in buildings, cars, subways, etc.

BUILDING INTERIOR (CONSUMER PRODUCTS):
- Glassware
- CorningWare
- Ceramic plates, vases, etc.
- Clay in porcelain for sinks and toilets
- Tiles for bathroom and kitchen
- Glass in mirrors
- Cosmetics
- Toothpaste
- Paint
- Cleaning agents
- Paper
- Chewing gum
- Aggregate used to produce plastic and vinyl products

HARDSCAPING:
- Decorative armour stones
- Stone retaining walls for gardens
- Water features
- Stone and concrete walkways and paths
- Clay pots for plants

BUILDING STRUCTURE (CONCRETE AND BRICK):
- Building foundation
- Exterior brick or concrete blocks
- Mortar
- Columns
- Underground parking lots
- Concrete roof
- Balconies
- Floors
- Interior walls
- Drywall (gypsum)
- Fiberglass insulation (sand)

SUBWAY AND STREETCAR SYSTEMS:
- Concrete tunnels and platforms
- Gravel around tracks

WATER:
- Municipal water that enters building is filtered through system that uses aggregate

BUILDING BEDDING:
- Compacted gravel bed below building, including bedding and fill for water, sewer and storm drain pipes

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Appendix 3: Geology of Aggregates

Quarried Bedrock Deposits

A variety of aggregates come from either solid Pre Cambrian (1-3 billion year old) rock (e.g. granite, gneiss, quartzite, marble) or younger Paleozoic (250-550 million year old) rock (e.g. limestone, dolomite, salt). Typical extraction involves drilling, blasting, crushing and sorting (sieving) of the material to create a wide variety of product.

Glacial Deposits

All other significant deposits are a result of extensive glacial and glacially influenced activity during the most recent glacial period and glacial retreat (approximately 85,000 to 7,000 years ago). These deposits reflect the different environments that existed during the advance, melting and retreat of the continental ice masses, and they can readily be differentiated on the basis of their morphology, structure and texture.

Glacialfluvial (River) Deposits

Ice Contact Terraces (ICT) - Glacialfluvial (meltwater) features deposited between the glacial margin and a confining topographical high such as the side of a valley or hill. These are similar to outwash deposits but in most cases the sorting and grading is variable and the bedding is discontinuous. The possibility of finding a large amount of crushable aggregate is moderate.

Kames (K) - Mounds of poorly sorted sand and gravel deposited by meltwater in depressions on the ice surface. Since they commonly contain large amounts of fine material (clay and silt) and are quite variable, they can pose problems during extraction.

Eskers (E) - Narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of the glacier. The deposits have a high probability of containing high quality crushable material within easily extractable ridges.

Outwash (OW) - Consists of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. They occur as sheets or as terraced valley fills. Well-developed outwash deposits have good horizontal bedding and uniform grain size distribution. Economic viability often depends on thickness of the overall feature.

Glaciolacustrine (Lake) Deposits

Lacustrine Beaches (LB) - Relatively narrow linear features formed by wave action at the shores of glacial lakes which are often above and away from present day beaches. The aggregate is stratified, well sorted, and contains mostly sand and gravel of economic value. They tend to be shallow (under 6m) in depth but quite extensive over several kilometers.

Lacustrine Deltas (LD) - These features were formed where streams and rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In Ontario such deposits tend to consist of mostly silt with some sand making them less attractive economically, however, coarser material has been deposited close to the ice margins.

Lacustrine Plain (LP) - Nearly level surface marking the base of an extinct glacial lake consist of predominantly fine sand, silt and clay. Lacustrine deposits are generally of low value and are extracted only where aggregates are scarce or the clay has a market.

Other Glacial Deposits

End Moraines (EM) - Belts of glacial drift deposited at and parallel to glacial margins or between lobes of the ice sheet. Moraines may be very large and can contain vast aggregate resources but locating specific economic deposits is difficult due to their variability.

Aeolian Deposits

Windblown Forms (WD) - Windblown deposits are those formed by the transportation and deposition of sand by wind. They can form flat lying extensive layers or concentric ridges called dunes. In Ontario they are formed usually from the reworking of existing lacustrine sand deposits. They are well sorted but small in extent and fine grained.

Drones in aggregates

Unmanned aerial vehicles prove useful in assessing remote and abandoned aggregates sites

By Jay Millington

They may look like small invading aliens in the sky, and they may sound like a swarm of bees, but unmanned aerial vehicles (UAVs) – or drones – are increasingly coming to aggregate sites across Ontario.

The extraction of sand, stone and gravel from the ground beneath us has been going on for generations, but the use of drones to help the aggregate industry map, measure and otherwise analyze pits and quarries is something that has become prevalent over a shorter time span than the average cell phone contract. "Canada has been a leader in the world in remote sensing, out of necessity," says John Fair, associate with Dillon Consulting Limited.

As the dependence on drones takes off, both in the consumer and commercial world, there are seemingly more and more uses for drones in the aggregate industry every day, depending on whether operators just want to be able to take some aerial photos for compliance assessment reports, or whether they want GPS accuracy down to the centimetre and accurate stockpile measurement.

On the lower end, operators could spend less than $100 and give their company some inexpensive aerial photos of their sites. But if they have more than $50,000 to spend, operators can get heavy-duty drone copters with the power to carry feature movie-quality cameras, and fixed-wing UAVs with sensors for thermal imaging, LiDar for 3D image-modeling, hyperspectral, and, soon, even ground-penetrating radar!

IMPROVED ACCESSIBILITY

Typically, conducting a ground survey of an active pit or quarry on foot can be time-consuming, dirty and potentially even dangerous. Trying to get detailed information from relinquished sites can

be even more difficult and possibly more dangerous. For Erica Rumbolt, senior field technician for the Ontario Aggregate Resources Corporation (TOARC), her job often takes her to abandoned pits and quarries across Ontario, where there can be little or no chance of gaining access to the property where the site is located to conduct a survey.

"Another main difficulty is accessibility in regards to remote sites located in forested areas," says Rumbolt. "Sometimes roads have been washed out or the walking path is extremely overgrown. A drone could access these sites and complete an inventory."

Because of the obstacles faced by TOARC in surveying abandoned sites, they now use a drone company called HighEye Aerial Imaging to conduct some of their surveys from the air, particularly when doing a survey on foot would be dangerous or difficult due to inaccessibility. Murray Hunt, owner of HighEye, uses an eight-rotor commercial grade UAV called CineStar 8. Hunt says that with the GPS accuracy that a drone can provide and all of the aerial photos it can take, plus the help of some computer post-processing, he can produce a photo-quality 3D model of a site and even use the data collected to measure stockpiles at the sites.

NEW APPROACH

Hunt says he wouldn't be surprised if the Ministry of Natural Resources and Forestry started using drones to conduct inspections of sites in the near future. When asked about this, Stephen Douglas, acting policy advisor for aggregates with the Ministry of Natural Resources and Forestry, agreed. "Some consultants will on occasion rent a plane and fly a site to get photos of the operation or to map the site," Douglas said. "I can see drones replacing such expensive ventures."

Drones can help map, measure and analyze pits and quarries

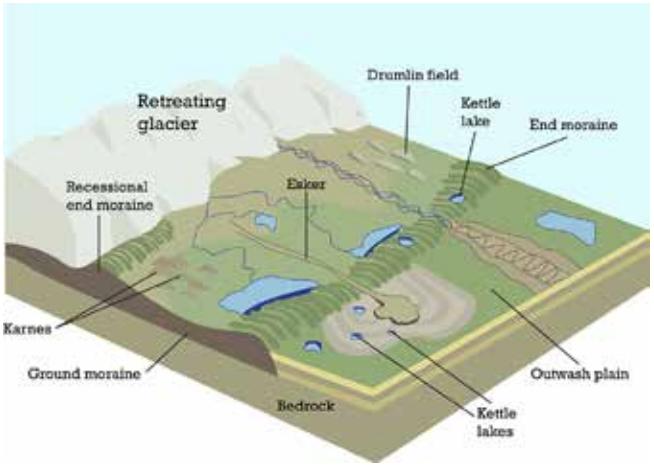
VicDom Sand & Gravel recently purchased the DJI Phantom II, a high-end consumer-level quad-copter UAV carrying a camera capable of high resolution photography and live-streaming high-definition video. Mainly they are using the drone for aerial photography to assist them in compliance assessment reporting, to document completed rehabilitation of a site, or even to show progressive rehabilitation over time.

Most Canadians aren't fully aware of the regulations regarding flying drones in Canada, particularly for any type of commercial use. In most cases, you are required to apply to the federal government for a Special Flight Operations Certificate at least 20 working days before flying the UAV. This application contains location and time of flight, a security plan, an emergency contingency plan, altitudes, routes and much more. Clearly, the government understands that there are risks to safety and privacy inherent in the use of drones and is seeking to minimize those risks. Licensing drone pilots is another step under consideration.

All of this poses a number of questions about the new frontier in aviation and its commercial use, but one thing is clear: the use of drones in the aviation industry has advantages and the increasing use and adoption of this technology is expected to grow significantly in the future. The 'aliens' are taking over. ●

Jay Millington is communications manager with the Ontario Stone, Sand & Gravel Association.

Appendix 5: Regulatory Acts that Impact Aggregate Production



BEACH PROTECTION ACT

The Beach Protection Act regulates the taking of any sand and gravel from the bed, bank, beach, shore or waters of any lake, river, or stream, or from any bar or flat in these waters, on both public and privately owned lands. A license is required for extraction under this Act, issued by the local District Office of the Ministry of Natural Resources.

PLANNING ACT

Within certain areas of Ontario, The Planning Act governs the use of land, through delegation of responsibility for land use planning to municipalities. Official plans and zoning by-laws are the primary planning tools used by municipalities to control land uses within their boundaries. Rehabilitation must be addressed in these official plans. Various provincial government policies, including the Mineral Aggregate Resources Policy Statement (discussed previously) and the Food Land Guidelines, must be taken into consideration in drawing up municipal zoning by- laws with respect to pits and quarries. The Planning Act does not apply to actions taken by the Crown on Crown land within municipalities. The Crown will, however, consult with, and consider the planning policies of the municipality concerned.

PITS AND QUARRIES CONTROL ACT

In certain parts of northern Ontario the Aggregate Resources Act regulates and controls the operation of pits and quarries, and requires their rehabilitation, through a licensing process for private lands. This Act applies at the present time to southern Ontario, but also includes parts of central and northern Ontario, such as Muskoka and Parry Sound areas, Regional Municipality of Sudbury, the City of Sault Ste. Marie, Wawa and Thunder Bay. A pit or quarry license on private lands cannot be issued in these areas in contravention of a municipal official plan or zoning by-law. The license must be accompanied by a site plan which describes the operation of the pit or quarry and includes detailed plans for the rehabilitation of the site.

ENVIRONMENTAL PROTECTION ACT

The Environmental Protection Act, administered by the Ministry of the Environment, looks at minimizing the impacts of man's actions on the environment. This includes surface and ground water impacts, dust, noise and vibration, air quality, incompatible or conflicting land uses, soil contamination, and site drainage impacts.

Appendix 6: Glossary

Active Licence	A licence that has been issued, being transferred, or under suspension at the end of the calendar year.
Aggregate	Includes sand, gravel, limestone, dolostone, crushed stone, rock other than metallic ores, and other prescribed material.
Aggregate Permit	A permit for a pit or quarry issued under the Aggregate Resources Act allowing for the excavation of aggregate that is the property of the Crown, on land where the surface rights are the property of the Crown, or from land under water.
ALPS	The Aggregate Licence and Permit System (ALPS) is an automated data base that facilitates the management of mineral aggregate production and related information, for individual licences, aggregate permits and wayside permits across the province.
Bedrock	In-place Precambrian or Paleozioc material exposed at the surface or underlying the surficial material.
Boulder	A detached rock having a diameter greater than 250 mm (i.e. very coarse gravel).
Building Dimension	A slab or block of rock, flagstone if foliated and dimension stone if massive, generally rectangular, and cut to specified measurements for ornamental surfacing in buildings or other construction applications.
Class A Licence	A licence under the Aggregate Resources Act to allow excavation of more than 20,000 tonnes of aggregate annually from a pit or quarry within parts of Ontario that have been designated under the Aggregate Resources Act.
Class B Licence	A licence under the Aggregate Resources Act to allow excavation of 20,000 tonnes or less of aggregate annually from a pit or quarry within parts of Ontario that have been designated under the Aggregate Resources Act.
Clay/Shale	Clay is a fine-grained, natural, earthy material composed primarily of hydrous aluminum silicates. It is plastic when moist and hardens when dried. Shale is fine-grained sedimentary laminated rock predominantly composed of clay grade and other fine minerals.
Clean Fill	Sand or gravel that contains less than 5% fines.
Cobble	Gravel having a size range of 75 mm to 250 mm (i.e. coarse gravel).
Crown Land	Ownership of land which is vested in the Crown or owned by the Province of Ontario.
Crushed Stone	Rock or stone mechanically crushed to specified sizes and grading.
Designated Area	An area of the Province identified by regulation under the Aggregate Resources Act where a person requires a licence for the excavation of aggregate from private land.

Disturbed Area	An area within a site that has been, or is being excavated to operate a pit or quarry, and has not been rehabilitated.
Esker	A narrow ridge ,often long and sinuous composed of sand and/or gravel deposited by a meltwater stream flowing on or in a glacier
Fines	Sediment with a particle diameter less than .075 mm.
Fluvial	Pertaining to rivers or streams.
Foundry Sand	High quality silica sand with uniform characteristics that is used in and is a byproduct of metalcasting.
Glacial	Distinctive features and materials derived from glaciers and ice sheets.
Glacial Spillway	A deep valley made by large amounts of flowing water from a melting glacier
Glaciofluvial	Material deposited by streams flowing from, on or within melting glacial ice; generally well-sorted layers of sand and gravel.
Glaciolacustrine	Material deposited in lakes supplied by glacial meltwater.
Gneiss	A layered rock formed by metamorphism.
Grain Size	Refers to the diameter of individual grains of sediment (also known as particle size).
Granite	A coarse grained igneous rock composed mainly of quartz and feldspar mineral.
Gravel	Small stones and pebbles or a mixture of sand and small stones. More specifically, fragments of rock worn by the action of air and water, larger and coarser than sand. MTO specifications define gravel as unconsolidated granular material greater than 4.75mm.
Ground Water	Water found underground in the cracks and spaces in soil, sand and rock. It is stored in and moves slowly through geologic formations of soil, sand and rock called aquifers.
Grubbing	The removal of trees, shrubs, stumps and rubbish from an extraction area.
Housing Starts	The number of housing units started where construction has advanced to 100 per cent of footings. In case of multiple dwellings, a "start" implies the commencement of individual structures.
Ice-Contact Deposits	Poorly sorted material deposited in contact with glacial ice and meltwater.
Inactive Licence	A licence that has been revoked or surrendered prior to the end of the calendar year.
Kame	A steep sided irregular mound deposited in contact with glacial ice and meltwater; composed of sand gravel and occasional till.
Lacustrine	Material deposited in a lake.

Licence	A licence for a pit or quarry issued under the Aggregate Resources Act allowing for the extraction of aggregate in designated areas.
Licensed Area	A specific area for which a licence has been issued for the extraction of mineral aggregates under the Aggregate Resources Act.
Limestone	A sedimentary rock usually containing more than 95% calcite and under 5% dolomite.
Lithology	The general characteristics of the rocks in a particular area.
Moraine	Glacially-formed accumulation of unconsolidated glacial debris (soil and rock) that occurs in both currently and formerly glaciated regions.
Outwash	A glaciofluvial deposit formed in front of a melting glacier.
Pebble	A small rounded rock fragment having a diameter of 4 mm to 64 mm.
Pit	Land or land under water from which unconsolidated aggregate is being or has been excavated, and has not been rehabilitated.
Pit run	Material which is sold directly from the pit face (not crushed washed or screened).
Pits & Quarries Control Act	An Act to manage and regulate mineral aggregate extraction in Ontario. The Act had been automatically repealed and replaced by the Aggregate Resources Act as of January 1, 1990.
Plain	A large area of flat land with few trees or other geographic features.
Poorly Sorted	Sediment which consists of particle of many sizes mixed together is a random pattern.
Private Land	Land owned by an individual or corporation, as opposed to land which is owned by the Crown.
Progressive Rehabilitation	As per the requirements of the Aggregate Resources Act, sequential rehabilitation completed within reasonable time over disturbed land from which aggregate has been extracted. The rehabilitation is carried out according to the Act, the regulations, the site plan, and the conditions of the licence or permit during the period that aggregate is being extracted.
Quarry	Land or land under water from which consolidated rock is or has been excavated and the site has not been rehabilitated.
Rehabilitation	To treat the land from which aggregate has been excavated to a pre-excavation condition or use, or to a condition compatible with adjacent land.
Ripping	A method of loosening soil and rock close to the surface in order for it to be removed; developed as an alternative to blasting rock.
Royalty	A payment made to the Crown in recognition of the extraction of aggregates owned by the Crown. Under the Aggregate Resources Act, the royalty is set at a minimum of 50 cents per tonne. The Minister may set a higher rate or may allow exemption.

Sand	Any hard granular rock material finer than gravel and coarser than dust. MTO specifications define sand as granular material ranging in size from .075 mm to 4.75 mm.
Sandstone	A sedimentary rock comprised mainly of sand sized fragments united by silica, calcium or iron oxide.
Scarification	Human-induced mass erosion of soil and rock, primarily down a slope using gravity as an aid.
Schist	A strongly layered metamorphic rock which splits into thin flakes and crumbles when disturbed.
Sieves	Screens with a variety of hole sizes used to evaluate sand and gravel deposits.
Silt	Made up of small rock or mineral fragments having a diameter range of 1/256 mm to 1/16 mm.
Slag	Stony waste matter separated from metals during the smelting or refining of ore.
Surface Water	Water that collects on the surface of the ground, such as in lakes and rivers.
Till	Unsorted sediment deposited directly by the glacier; used as earth fill.
Valley Train	Outwash confined within a valley.
Wayside Permit	A permit issued to a public authority or a person who has a contract with a public authority for a temporary road project or an urgent project for which no alternative source of aggregate is available under licence or permit. A wayside permit expires 18 months from the date of issue or upon completion of the project, whichever comes first.
Well Sorted	Said of sediment which consists of particles all having approximately the same sized particles.

Appendix 7: Other Resources

The Ontario Aggregate Resources Corporation

The Ontario Stone, Sand & Gravel Association

Aggregate Resources Act and Regulations

Aggregate resources policies and procedures manual

State of the Aggregate Resource in Ontario Study

Management of abandoned aggregate properties