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THE LONG HAUL

Examining the Implications of Far-From-Market Aggregates

A report commissioned by the Ontario Stone, Sand & Gravel Association

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For more than a century, the OCC has undertaken important research on Ontario's most pressing policy issues, advocating for solutions that will foster the growth of Ontario businesses and lead to the creation of jobs in the province.

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About the Ontario Stone, Sand & Gravel Association (OSSGA)

OSSGA is a not-for-profit industry association representing over 280 sand, gravel, and crushed stone producers and suppliers of valuable industry products and services. Collectively, its members supply the substantial majority of the approximately 164 million tonnes of aggregate consumed annually in the province to build and maintain Ontario's infrastructure needs. OSSGA works in partnership with government and the public to promote a safe and competitive aggregate industry contributing to the creation of strong communities in the province.

OSSGA
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Preface

Commissioned by the Ontario Stone, Sand & Gravel Association (OSSGA), this report was prepared by the Ontario Chamber of Commerce (OCC) with the intention of providing an independent and impartial quantitative and qualitative analysis on the implications of far-from-market aggregate production. As such, the study is divided into four parts: Part One assesses the upstream and downstream economic value of Ontario's aggregates industry; Part Two identifies the relationship between transportation costs and distance and examines the implications of transportation costs for select infrastructure projects; Part Three qualitatively evaluates the environmental implications of a longer haul distance; and Part Four presents a case study to illustrate the economic and environmental impact of closing the Nelson Aggregate Co. quarry in Burlington, Ontario. This report is not intended to be a comprehensive review of all existing far-from-market implications.

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Assumptions and Limitations

This commissioned report was prepared solely for the purposes specified herein and is not to be used by any other party or for any other purposes without the prior consent of the OCC.

The report relies on data and information obtained from a number of primary and secondary sources. Though every effort is made to validate the accuracy of our modelling and qualitative analyses, our results will be limited by the accuracy of inputs. Furthermore, due to the lack of comprehensive data available for some of the series analyzed in our assessments, it was necessary to prepare forecasts and other estimates based on available information and various assumptions.

The data, information, and conclusions contained in the report:

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- Should not be used or read out of context and must be read as a whole; and
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Executive Summary

Ontario's aggregates industry supports a multitude of economic sectors that collectively generate billions of dollars in annual gross domestic product (GDP) and thousands of jobs across the province. The aggregates supply chain includes many industries such as mining and quarrying, transportation, construction, and manufacturing.

In 2019, $1.7 billion worth of total new aggregates production in Ontario generated the following estimated **upstream (production-related)** economic outputs through direct, indirect, and induced effects:

- $2.9 billion in gross output ($196 per capita)
- $1.6 billion in GDP ($107 per capita)
- $806 million in labour income ($54 per capita)
- $150 million in tax revenue ($10 per capita)
- 13,400 jobs

It also resulted in the following estimated **downstream (consumption-related)** economic outputs through direct, indirect, and induced effects:

- $3.7 billion in gross output ($250 per capita)
- $1.8 billion in GDP ($124 per capita)
- $1 billion in labour income ($67 per capita)
- $103 million in tax revenue ($7 per capita)
- 14,000 jobs

Moreover, the aggregates industry is critical for many other industries **further downstream**, such as construction, and therefore contributes to their economic outputs as well. **Ontario's construction industry alone generated $51 billion in GDP** and employed 540,000 people in 2019[1] – and is largely dependent on aggregates as an input given the lack of readily apparent substitutes.

The location of aggregate extraction sites has significant micro- and macroeconomic implications. When pits and quarries are sited farther away from market, aggregates must be transported over a longer distance, leading to higher transportation costs and greenhouse gas emissions.

1 Chained 2012 dollars.

Currently, 25 million tonnes of aggregates are produced annually within the Greater Toronto and Hamilton Area (GTHA). According to our analysis, if that volume were to be transported from sites farther away from market at an average additional haul distance of 75 kilometres, the cost of sourcing aggregates would increase by $169 million, more than doubling total transportation costs (representing a 114 percent increase). The public sector would incur an additional $101 million in transportation costs. For more context, this longer haul distance would add $6.2 million to the cost of an average subway extension project and $510,000 to the cost of an average hospital build.

From an environmental perspective, approximately 89,000 metric tonnes of GHG emissions would be produced because of the added haul distance. In addition to the climate impacts, this amounts to an added $2.7 million in economic costs under the current carbon price ($30 per tonne). By 2030, when the carbon price reaches $170 per tonne, the added emissions will cost more than $15 million.

Against a backdrop of declining close-to-market aggregate production, we present a case study on the implications of closing a single site within the GTHA, namely, the Nelson Aggregate Co. quarry located in Burlington, Ontario, which is home to significant, high-quality aggregate resources. Our case study analysis further exemplifies the economic and environmental implications outlined in parts two and three and assesses the impact that a closure of the Burlington quarry would have on the close-to-market aggregate depletion timeline. Our findings indicate this would produce the following total additional costs and impacts over a 10-year period:

- $206 million in transportation costs (average of $20.6 million per year)
- 5.8 million litres of diesel fuel consumed (average of 580,000 litres per year)
- 16,000 metric tonnes of CO_2 emissions (average of 1,600 metric tonnes per year)

Evidently, longer haul distances raise costs for construction and infrastructure, burn more fossil fuels, and generate higher emissions.

Glossary

Aggregate: gravel, sand, clay, earth, shale, stone, limestone, dolostone, sandstone, marble, granite, rock, or other prescribed material.

Basic prices: the amount received by the producer from the purchaser for a unit of a good or service produced as output minus any tax payable, and plus any subsidy receivable, on that unit because of its production or sale; it excludes any transport charges invoiced separately by the producer. Unlike market or purchasers' prices, which are paid by final consumers, basic prices do not include government taxes and subsidies applied to the goods. They only include factor and other production-level expenses.

Carbon dioxide (CO2): a colourless, odorless gas produced by burning carbon and organic compounds and by respiration. It is naturally present in air (about 0.03 percent) and is absorbed by plants in photosynthesis. It is the primary greenhouse gas emitted through human activities and contributes to climate change.

Carbon offset: an action intended to compensate for the emission of carbon dioxide into the atmosphere as a result of industrial or other human activity, especially when quantified and traded as part of a commercial program.

Direct effects: initial changes in employment, income and output resulting from production spending in a subject sector.

Downstream effects: effects in sectors that purchase goods and services from a subject sector where initial production spending took place.

Economic outputs: includes gross output, gross domestic product (GDP), labour income, and jobs.

Emissions intensity: greenhouse gas emissions intensities are based on the physical flow account for direct and indirect greenhouse gas emissions. Emission sources included in these estimates are combustion of fossil fuels and biomass; non-combustion uses of fossil fuels; industrial processes; agricultural soils; livestock manure and enteric fermentation.

Energy intensity: a measure of the energy inefficiency of an economy. It is calculated as units of energy per unit of GDP. High energy intensities indicate a high price or cost of converting energy into GDP. Low energy intensity indicates a lower price or cost of converting energy into GDP.

Evapotranspiration: the sum of evaporation from the land surface plus transpiration from plants.

Freight on board (FOB): pricing a commodity to include the cost of loading onto freight vehicles at the point of sale but excluding the cost of transporting the goods from the point of sale to the buyer.

Greater Toronto Area (GTA): the most populous metropolitan area in Canada located in the province of Ontario. It includes the City of Toronto and the regional municipalities of Durham, Halton, Peel, and York. In total, the region contains 25 urban, suburban, and rural municipalities.

Greater Toronto and Hamilton Area (GTHA): a geographic region within Ontario that encompasses the GTA and Hamilton area.

Greenhouse gas (GHG) emissions: gases emitted into the Earth's atmosphere that trap heat from leaving the atmosphere. The main greenhouse gases are water vapor, carbon dioxide (CO2), methane, ozone, nitrous oxide, and chlorofluorocarbons.

Gross domestic product (GDP): the value of all currently produced final goods and services created in a particular period. GDP can be calculated for an entire economy, or by industry.

Gross output: the total value of sales related to a good or service, including the value of intermediary goods or services used in their production.

Haul distance: the distance required to transport aggregate materials to market for consumption.

Indirect effects: subsequent changes in employment, income, and output in all economic sectors that support sectors that are directly affected by production spending.

Induced effects: subsequent changes in employment, income, and output in all economic sectors as a result of income spending by employees in the direct and indirect sectors.

Input-output (IO) model: a quantitative economic model that portrays the economy of a geographic area for a fixed period. The model divides all economic activity into sectors. It initially calculates the effect of spending to produce one dollar's worth of output in a subject economic sector. Subsequently, it calculates the "ripple" effects of this first expenditure on all other sectors of the economy that support the subject sector.

Labour income: the sum of wages and salaries plus supplementary income.

Linear regression: in statistics, linear regression is a linear approach for modelling the relationship between a scalar response and one or more explanatory variables.

Multipliers: factors of proportionality that measure the effect of one variable on another. For example, if $1 million in gross output results in $1.3 million in GDP, the gross-output-to-GDP multiplier is 1.3.

North American Industry Classification System (NAICS): standard classification system used by national statistical agencies to collect, analyze, code, and report upon industry-related activity.

Pit: land or land under water from which unconsolidated aggregate (usually sand and gravel) is excavated.

Purchasers' price: the amount paid by a purchaser, excluding any deductible tax, to take delivery of a unit of a good or service at the time and place required by the purchaser. The purchaser's price of a good includes any transport charges paid separately by the purchaser to take delivery at the required time and place.

Quarry: land or land under water from which consolidated rock (bedrock) is excavated via blasting.

Recycled aggregates: crushed cement concrete or asphalt pavement from construction debris that is reused in other building projects.

Rehabilitation: the process and efforts required to rehabilitate a pit or quarry once aggregates have been extracted into productive wildlife habitats, wetlands, golf courses, recreational parks, urban uses, conservation lands, forestry, or agricultural lands.

Shock: the direct and indirect economic impact of a specified, exogenous output value across all industries and commodity groups measured using Statistics Canada's input-output model.

Supply and use tables: measures of the productive structure of the economy. They trace production of products by domestic industries, combined with imports, through their use as intermediate inputs or as final consumption, investment, or exports.

Upstream effects: effects in sectors that supply goods and services to a subject sector where initial production spending took place.

Introduction

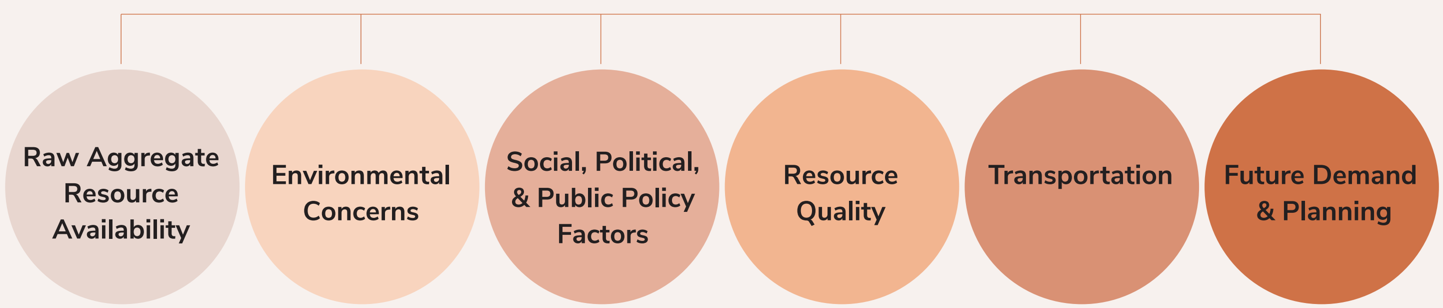
Mineral aggregate resources are a critical component of Ontario's economy. Sand, stone, gravel, clay, and other aggregate materials are essential for both the construction of new and maintenance of existing infrastructure. **From highways and transit lines, to hospitals, airports, and manufacturing processes, aggregates underpin infrastructure, economic activity, and social well-being in communities across Ontario.**

On average, the Greater Toronto and Hamilton Area (GTHA) consumes approximately 73 million tonnes of aggregates each year, while only producing 25 million tonnes, making it a net importer of aggregates. The region is projected to consume another 1.5 billion tonnes of aggregates by 2041.[2] The Greater Toronto Area (GTA) alone consumes 89 percent of all GTHA consumption at 65 million tonnes annually.[i]

Against a backdrop of declining close-to-market aggregate production, it will become especially important that a reliable and affordable supply of aggregates be available for the GTHA, where the population is projected to surpass 10 million over the next two decades,[ii,iii] and where governments have committed to tackling the growing infrastructure deficit.

The accessibility and availability of aggregates are contingent on several factors (see Figure 1). This report will specifically focus on the direct transportation and environmental concerns associated with far-from-market aggregate production.

Figure 1: Considerations for Aggregate Extraction[iv]



2 Hamilton consumption of aggregates estimate provided by MacNaughton Hermsen Britton Clarkson Planning Limited (MHBC).

Restricted close-to-market supply within the GTHA puts the next generation of pits and quarries at an average 75 kilometres farther away from market relative to the current close-to-market haul distance average of 35 kilometres.[3]

Our analysis quantitatively and qualitatively investigates the economic and environmental implications associated with longer haul distances under a far-from-market scenario where aggregates are transported an average of 110 kilometres from production site to market.

The report is divided into four parts:

- **Part One analyzes the economic value of Ontario's aggregates industry. It estimates the upstream and downstream portions of the industry's supply chain and the economic outputs generated from the production and consumption of aggregate resources, namely, gross output (as a proxy for sales), GDP, labour income, employment, and taxes.**
- **Part Two models the relationship between total transportation costs and distance. The analysis uses roadways, hospitals, and subway line extension projects as examples to illustrate how a change in transportation costs affects the cost of infrastructure.**
- **Part Three looks at environmental impacts with a literature review and a quantitative analysis to show the impacts of longer haul distances on total fuel consumption and greenhouse gas emissions.**
- **Part Four presents a case study to illustrate the regional and local economic and environmental implications of closing the Nelson Aggregate Co. quarry in Burlington, Ontario.**

3 Based on the geographical analysis conducted by MacNaughton Hermsen Britton Clarkson Planning Limited (MHBC). See Figure 12 in Part Two for more details.

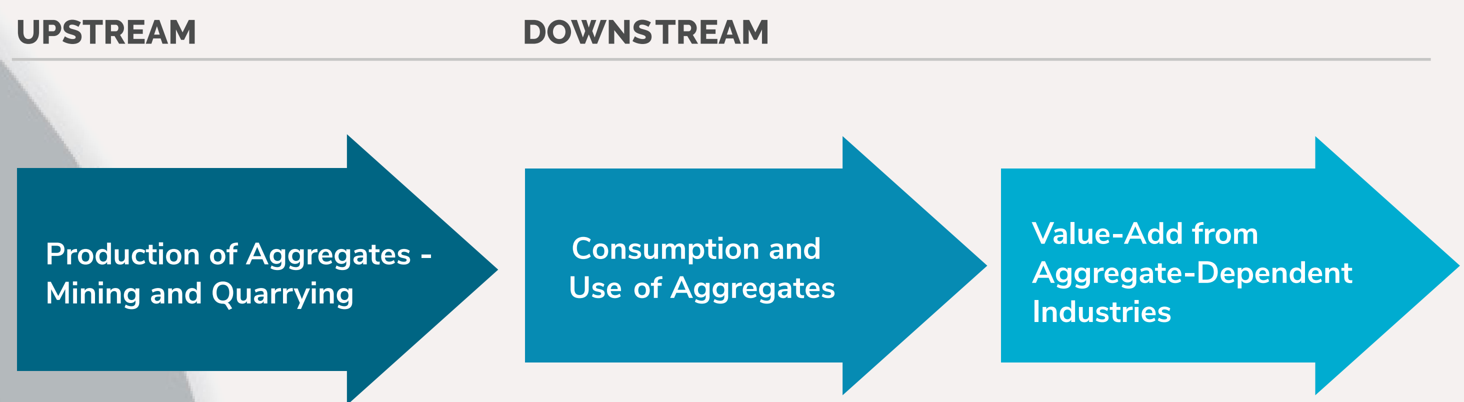
Part One:

The Value of Ontario Aggregates

The aggregates industry is made up of a complex and highly integrated network of industries that include mining and quarrying, construction, transportation, and manufacturing. The supply chain can be broken down into upstream and downstream industries, where upstream involves all the industries producing and supplying the aggregates that are then distributed to downstream industries, where they are used in construction and manufacturing (Figure 2).

Much of the existing literature on the value of Ontario's aggregate industry is outdated. To provide more recent estimates, we used Statistics Canada's 2017 interprovincial input-output (IO) model[4] to quantify the industry's impacts on: total gross output as a proxy for sales, nominal GDP contributions, labour income, total number of jobs, as well as taxes collected by federal, provincial, municipal, and Indigenous governments.[5] Our analysis uses data from 2019 to avoid any disruptions caused by the COVID-19 pandemic. For the purposes of this report, the upstream and downstream economic analyses are exclusive to within Ontario and do not include the economic effects generated for other provinces or territories. They also exclude impacts further downstream from aggregate-dependent industries.

Figure 2: Flow of Aggregates



4 The upstream and downstream analyses build on some of the methodology used in AECOM 2009. Statistics Canada's IO model has since been updated to include direct, indirect, and induced effects using a single model simulation.

5 Personal income tax and corporate taxes not included.

Figure 3: Aggregate Supply Chain

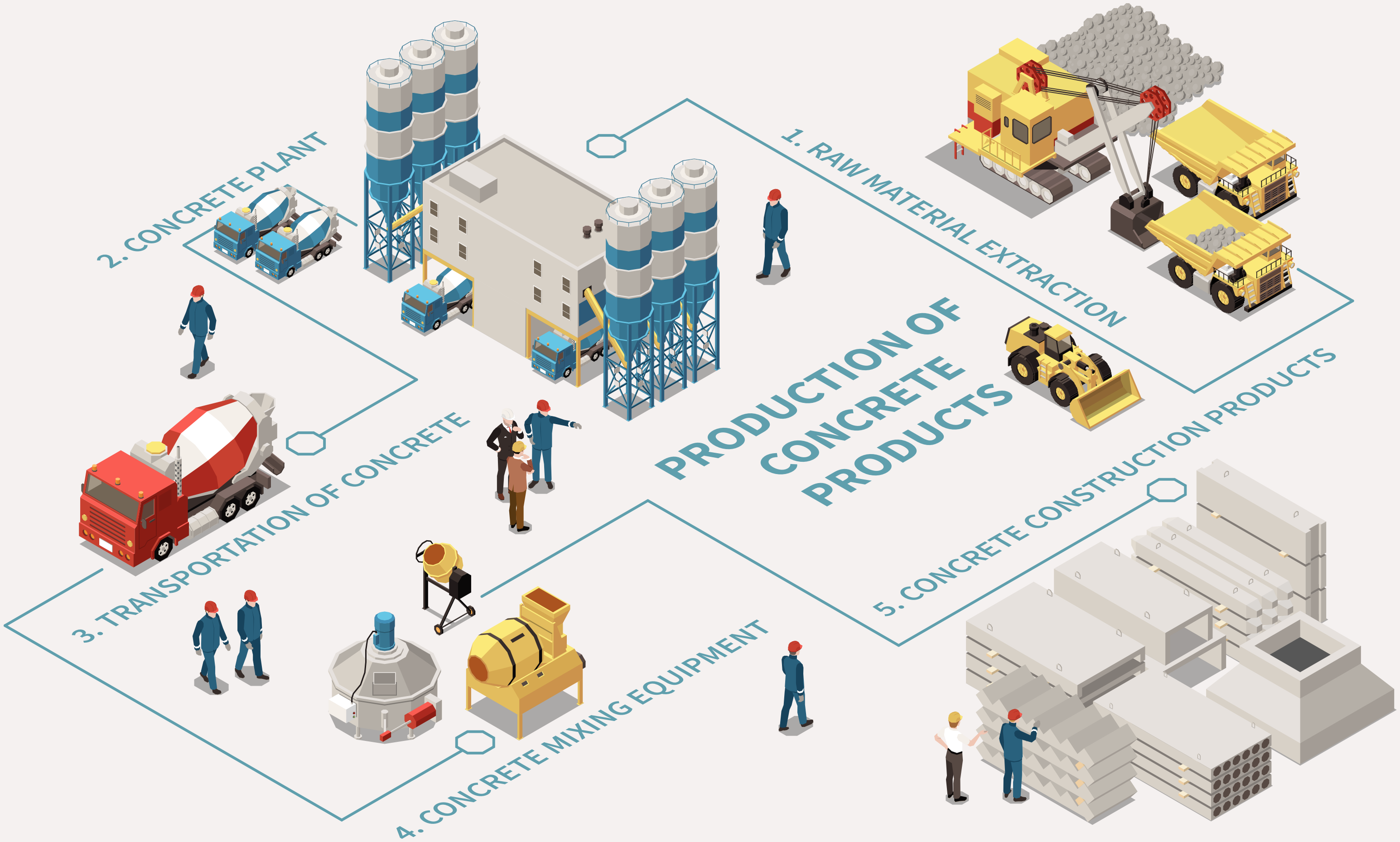
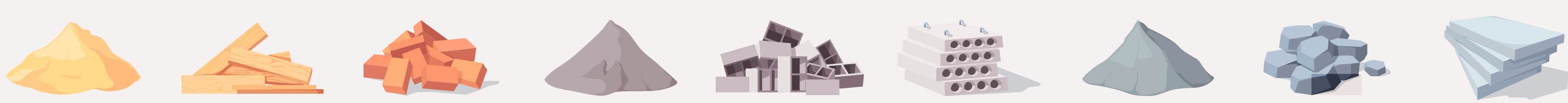


Figure 3 illustrates how aggregates move through the supply chain, using concrete production as an example. The process begins with the extraction of aggregates and ends with the use of concrete products in construction projects, such as **hospitals, schools, roads, sidewalks, and apartment buildings**. At each stage, economic activity is generated and captured as gross output, GDP, labour income, jobs, and taxation.

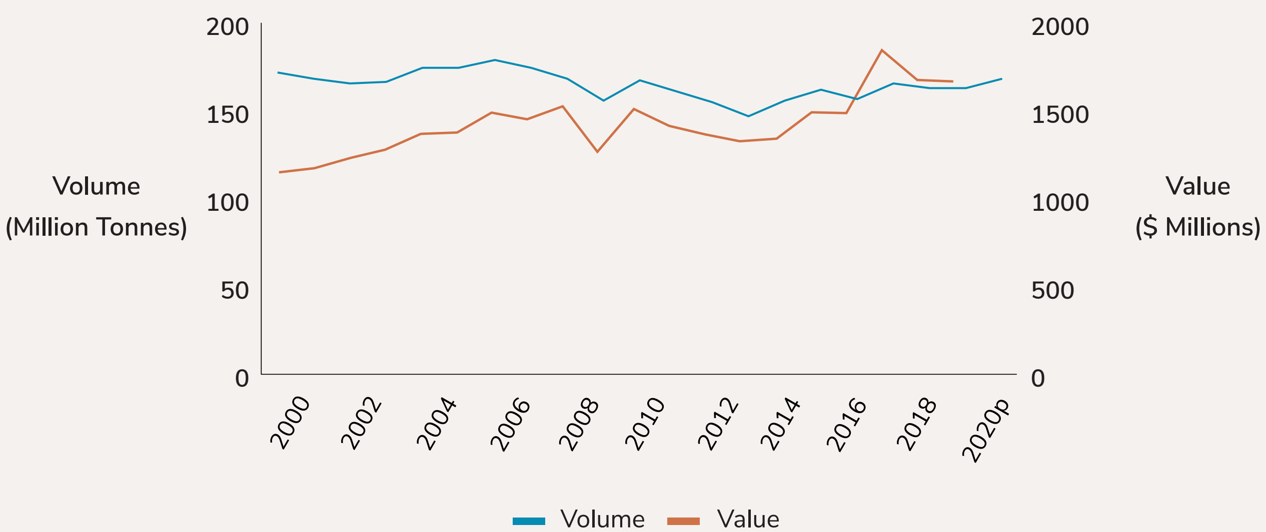


Upstream Value

We begin our upstream economic analysis by determining the dollar value of total new aggregate production for the following commodity categories: stone, sand and gravel, clay, and other aggregates (lime, quartz, and gypsum).[6] Production data were compiled from a combination of sources, including annual production statistics reports from The Ontario Aggregate Resources Corporation (TOARC)[v], Natural Resources Canada (NRCan)[vi], and the most recent Annual Statistics Report (2016) by Ontario's Ministry of Energy, Northern Development and Mines (ENDM).[vii]

According to annual production statistics made available by TOARC, Ontario produced 161 million tonnes of stone, sand and gravel, clay/shale, and other stone aggregates in 2019 – about 11 tonnes per capita – or an average of 163 million tonnes per year over the past two decades (Figure 4).[7]

Figure 4: Annual Aggregate Production in Ontario (2000 to 2020)[viii]



6 While the supply of aggregate resources includes imports from other countries and provinces as well as recycled aggregates, the focus of the economic analysis, both upstream and downstream, are on new production only.

7 Inclusive of aggregate production by licenses, wayside permits, aggregate permits, forestry aggregate pits, and private land non-designated (estimated).

Given the lack of available data for select years and commodities, we applied conservative linear forecast models and classical multiplicative time series models to project estimates for missing values. Moving averages were used to manually control for seasonality followed by regression models to account for trends occurring in the existing data. Tabulating the final estimates, we produced a set of annual production values for each of the highlighted commodity categories from 2000 to 2019 (see Appendices A to C).

In 2019, sand and gravel represented the largest share of total new production (50 percent), followed closely by stone (49 percent), with other aggregates representing approximately one percent, and clay 0.4 percent, of total production (Appendix A).

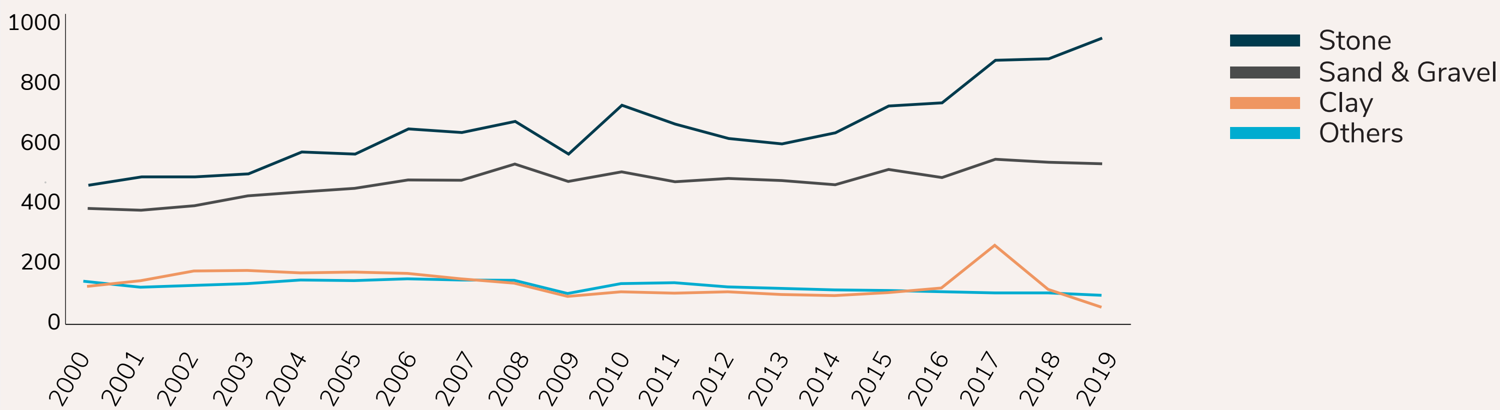
$12.72

$6.97

$101.09

The **value of total new production across all commodities amounted to approximately $1.7 billion** before delivery in 2019, reflecting freight on board (FOB) prices (see Appendix B) – a modest increase from the $1.4 billion average seen in the previous two decades as shown in Figure 5. On a per-tonne basis, we estimate that the 2019 production value for **stone was $12.72, $6.97 for sand and gravel, and $101.09 for clay** (Appendix C).

Figure 5: Historical Commodity Values ($ millions)[8]



Sources: TOARC, Natural Resources Canada (NRCan), Ministry of Energy, Northern Development and Mines (ENDM), and the Ontario Chamber of Commerce

8 Actual and projected values included.

Upstream Economic Analysis

The following three North American Industry Classification System (NAICS) codes were included in Statistics Canada's IO model and were assumed to fully capture the economic activity generated from the production of stone, sand and gravel, clay, and other aggregates:

BS212310	Stone mining and quarrying
BS212320	Sand, gravel, clay, and ceramic and refractory minerals mining and quarrying
BS21239A	Other non-metallic mineral mining and quarrying (except diamond and potash)

To assess the upstream value of the aggregates industry, a $1-billion industry-level output shock was applied to each of the three NAICS industries to produce a set of multipliers that reflect how a given quantity of output impacts Ontario's economy directly and indirectly across sectors and commodity groups. The resulting set of multipliers were then multiplied with the total commodity production values (listed in Appendix B) to estimate the direct, indirect, and induced effects of aggregate production on the provincial economy. Appendix D summarizes the direct, indirect, and induced economic outputs of new production with respect to gross output, nominal GDP at basic prices, labour income, jobs, and taxation.[9]

In 2019, the $1.7 billion of new production generated by the aggregates industry translated into an estimated $2.9 billion in total gross output, $1.6 billion in GDP ($107 per capita), $806 million in labour income, and 13,400 jobs in Ontario. Total federal, provincial, municipal, and Indigenous government tax revenues amounted to approximately $150 million, 84 percent of which resulted from provincial and municipal taxation (see Appendix E for the full tax revenue table).[10]

9 Unless noted otherwise, all economic outputs are listed in 2019 dollars.

10 Totals presented throughout the report may differ due to rounding.

Table 1: Total Upstream Economic Outputs (2019)[11]

Upstream Economic Outputs (2019)	Stone	Sand & Gravel	Clay	Other	Grand Total
Gross Output	$1,617,376,679	$1,006,168,759	$104,728,848	$153,204,838	$2,881,479,123
GDP at Basic Prices	$850,184,280	$561,164,039	$58,409,748	$92,039,408	$1,561,797,476
Labour Income	$345,477,835	$382,834,942	$39,848,049	$38,252,665	$806,413,492
Jobs	4,248	5,722	2,927	490	13,388
Taxes	$86,485,053	$48,874,052	$5,087,142	$8,701,004	$149,147,251

Of the $1.6 billion GDP value, approximately 54 percent came from the production of stone, 36 percent from sand and gravel, and 10 percent from clay and other aggregates. Relative to the other commodities, sand and gravel produced the most jobs (43 percent of all jobs generated by mining and quarrying) and labour income (47 percent), followed by stone (32 percent of all jobs and 43 percent of all labour income).

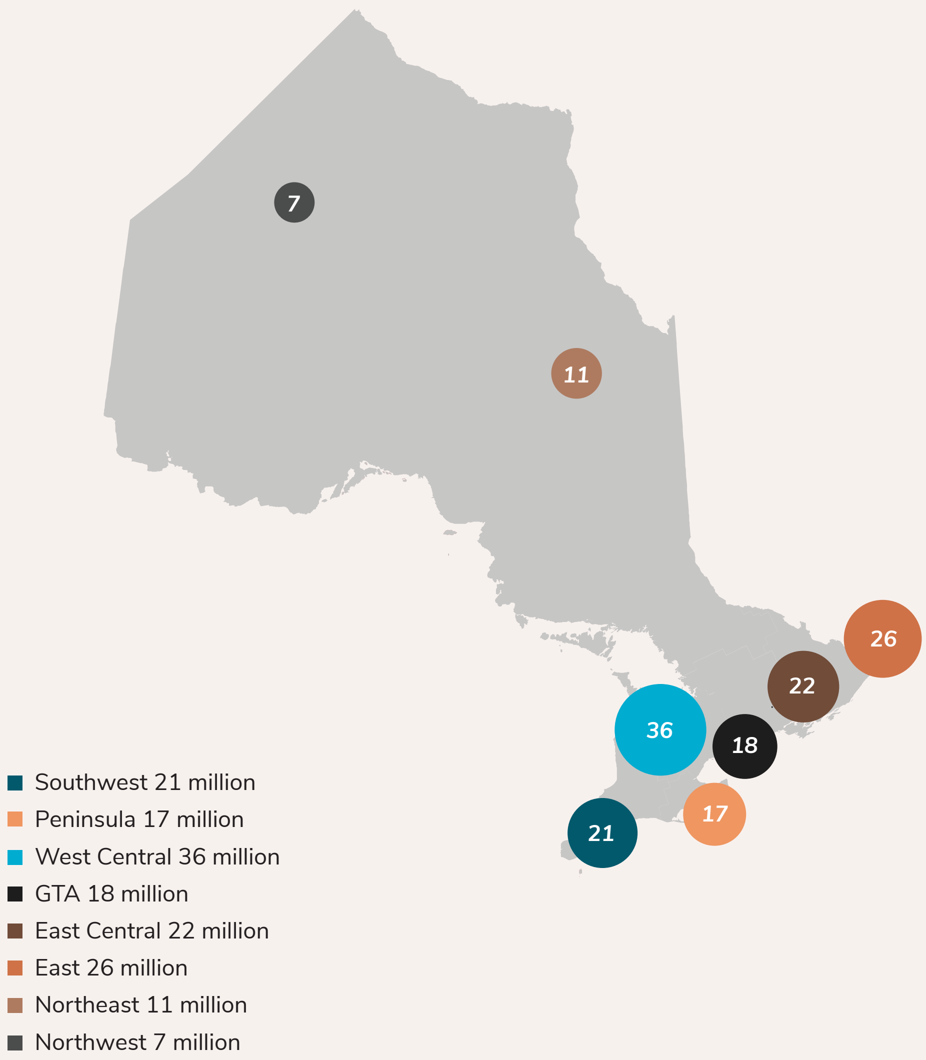
On a per-tonne basis, the production of clay contributed the most to upstream GDP at $104 per tonne, followed by other aggregates (lime, quartz, and gypsum) at approximately $80 per tonne. Most notably, mining and quarrying for clay has the greatest impact on jobs compared to that of all other aggregates. Moreover, for every tonne of aggregate produced, approximately $0.80 is distributed to provincial ($0.40) and municipal ($0.41) governments through product and production taxation. See Appendix F for per-tonne output tables.

11 Jobs deflated to 2017 production values for consistency with 2017 Supply and Use Tables. Unlike other economic output variables, jobs are more sensitive to variability.

Upstream Analysis by Region

To provide a regional breakdown of the upstream economic outputs, we first identified relative aggregate production volumes by region (Figure 6) and then applied the same apportionment to the corresponding economic outputs.[12]

Figure 6: Aggregate Production in Tonnes by Region (2019)[13, ix]



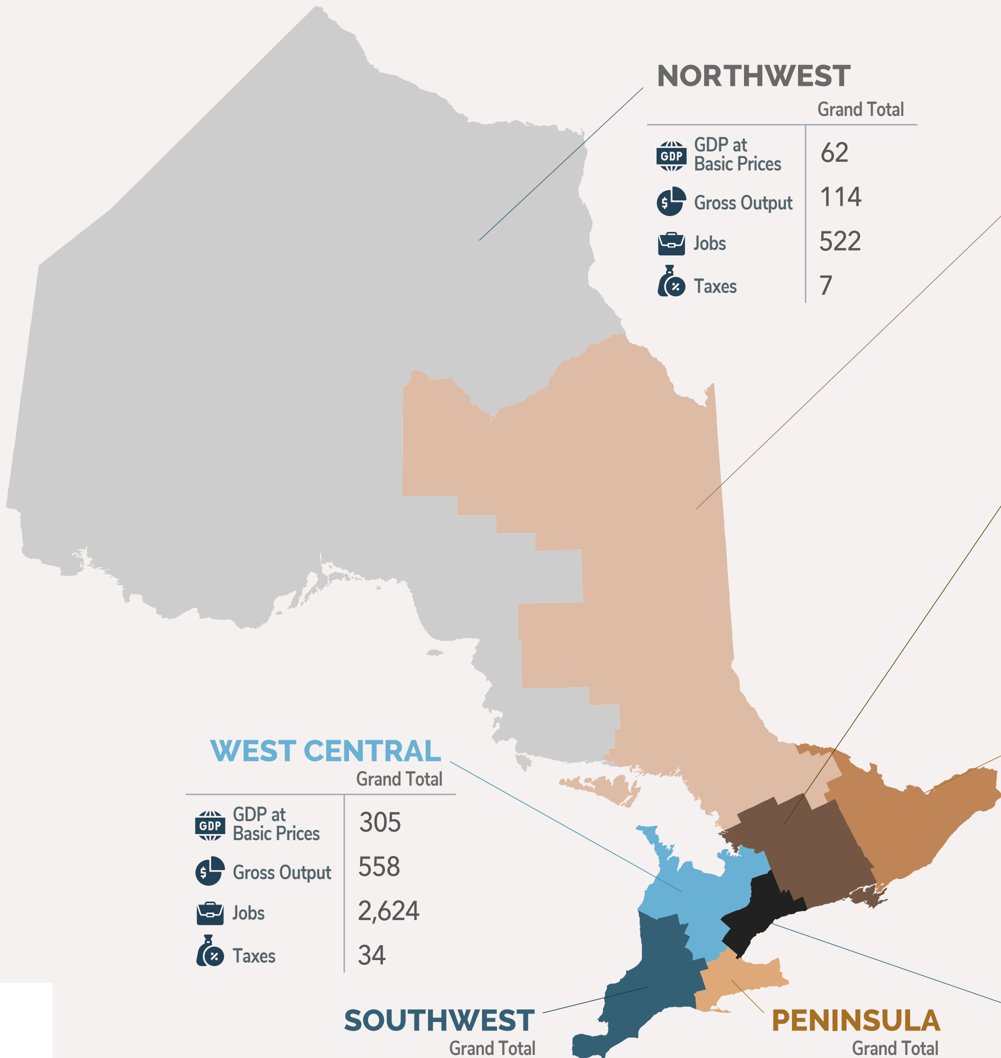
In 2019, West Central Ontario produced the greatest total volume of aggregates at approximately 36 million tonnes (23 percent of overall production), with Ontario's Northwest region producing the least amount of aggregates at approximately 7 million tonnes (four percent). By aggregate type, Ontario's East region produced the largest amount of stone and other aggregates in 2019 (19 million tonnes and 1 million tonnes, respectively), West Central produced the greatest amount of sand and gravel (26 million tonnes), while the GTA specialized in the production of clay (0.4 million tonnes).

Figure 7 summarizes the total direct, indirect, and induced upstream economic outputs by region. Upstream GDP was highest in East Ontario at $312 million, followed by $305 million in West Ontario, and lowest for both the Northwest and Northeast regions at $62 million and $100 million, respectively. The largest number of jobs created was in the GTA (3,200 jobs). The Northeast and Northwest regions generated the least number of jobs (1,240 jobs combined). Labour income was highest for West Central Ontario ($176 million), followed by the East region of Ontario ($138 million). Similarly, West Central and East Ontario were responsible for contributing the largest share of taxes at $34 million and $25 million, respectively.

12 For a breakdown of regional classifications used in this section, see Appendix G.

13 Aggregate production by permit and license only as they make up the majority of overall production.

Figure 7: Map of Upstream Economic Outputs by Region (2019)[14]



NORTHWEST

	Grand Total
GDP at Basic Prices	62
Gross Output	114
Jobs	522
Taxes	7

NORTHEAST

	Grand Total
GDP at Basic Prices	100
Gross Output	186
Jobs	717
Taxes	10

EAST CENTRAL

	Grand Total
GDP at Basic Prices	222
Gross Output	411
Jobs	1,509
Taxes	21

WEST CENTRAL

	Grand Total
GDP at Basic Prices	305
Gross Output	558
Jobs	2,624
Taxes	34

EAST

	Grand Total
GDP at Basic Prices	313
Gross Output	576
Jobs	1,792
Taxes	25

SOUTHWEST

	Grand Total
GDP at Basic Prices	184
Gross Output	337
Jobs	1,822
Taxes	20

PENINSULA

	Grand Total
GDP at Basic Prices	176
Gross Output	331
Jobs	1,197
Taxes	16

GTA

	Grand Total
GDP at Basic Prices	200
Gross Output	368
Jobs	3,206
Taxes	17

GDP at Basic Prices ($ Millions)
Gross Output ($ Millions)
Jobs
Taxes ($ Millions)

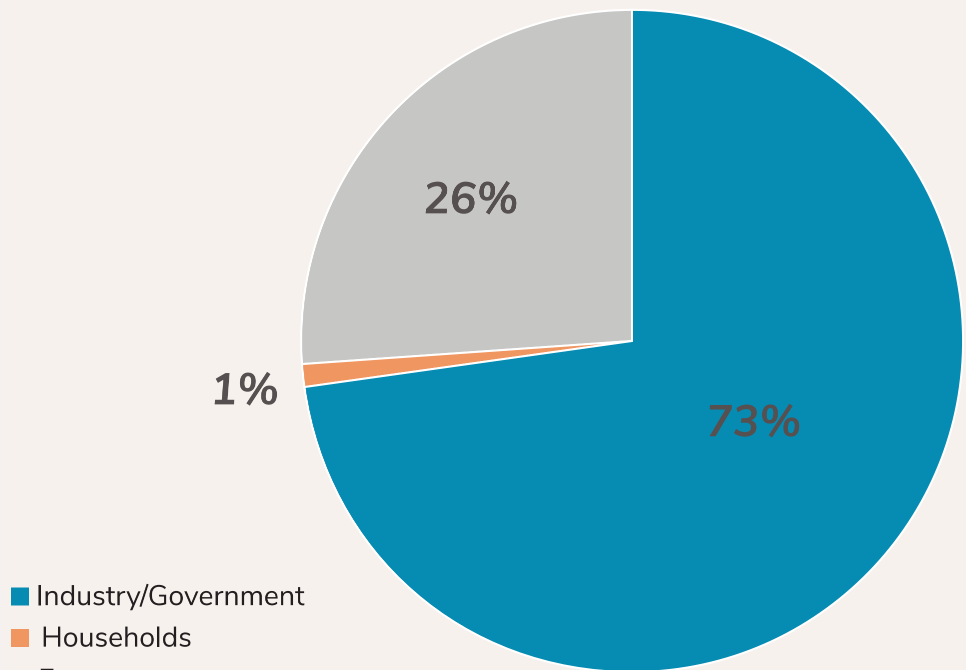
All figures expressed in millions of dollars except for jobs.

14 See Appendix G for a full breakdown of regional data.

Downstream Value

The goal of the downstream economic analysis is to track how a given production amount “flows” through the economy into downstream use and final consumption. We first identified aggregate consumption by consumer type and industry (Figure 8).

Figure 8: Final Demand for Aggregates by Industry and Non-Industry Consumers in Ontario[15, x]



Source: Statistics Canada

15 Exports include interprovincial and international exports.

Figure 9: Downstream Industries and their Proportion of Total Demand in Ontario

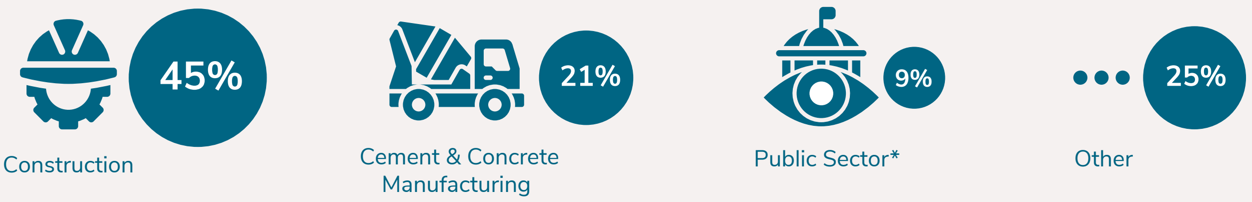
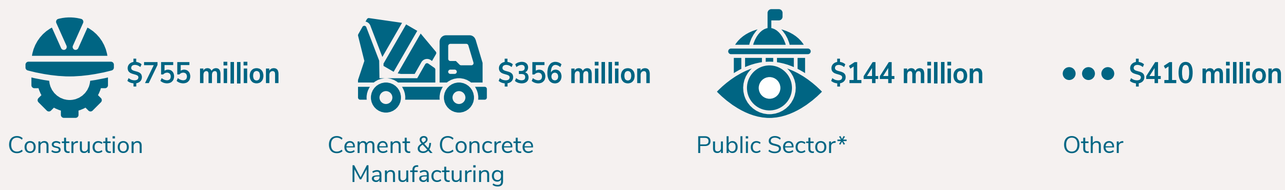


Figure 10: Distribution of Upstream Production Value by Industry Demand (2019)[16]



* Note that the public sector's consumption of aggregates does not account for contracted services, which would be captured by other industry categories such as construction.

Source: Statistics Canada

Figure 9 outlines four major industry categories of aggregate consumers along with their corresponding proportion of total demand (for a full breakdown, see Appendix H).[17] Importantly, the public sector's consumption of aggregates here does not account for contracted services, which would be captured by other industry categories such as construction. Although other industries also consume the highlighted aggregates, they are not included in our modelling analysis as their total consumption was below one percent of overall industry-level consumption.[18]

At 45 percent of overall consumption, the construction sector consumes the most aggregates, largely resulting from residential and non-residential building construction industries.

To calculate the relative share of upstream production value consumed by each downstream industry, we multiplied the proportions identified in Figure 9 with the total upstream production value of $1.7 billion. Results indicate that the value of total aggregates demanded by the construction industry amount to $755 million, followed by the cement and concrete manufacturing industry at $356 million, and the public sector at $144 million (for a full breakdown, see Appendix I).

16 Industry consumption at basic prices.

17 We use Statistics Canada's NAICS commodity grouping "Other Non-Metallic Minerals (except diamond and potash)" to define the 'Other aggregates' category for our downstream analysis. It includes salt, asbestos, gypsum, peat, and all other non-metallic minerals.

18 For the purposes of this report, downstream analysis will also exclude household consumption of aggregates and exports.

Downstream Economic Analysis

Once again, to conduct our economic analysis, we use Statistics Canada's IO model to estimate the economic impacts of industry-level shocks across all relevant aggregate commodities purchased and demanded by each of the 15 downstream industries. A combination of Statistics Canada's online multipliers was used alongside a customized set of multipliers produced from the IO model simulation to evaluate the direct, indirect, and induced effects of purchasing $1.7 billion worth of aggregates on gross output, nominal GDP at purchasers' prices, labour income, jobs, and taxation.[xi,19]

Applying the corresponding multipliers with the values outlined in Figure 10 produces the economic outputs listed in Table 2 below.

Table 2: Total Economic Outputs of Downstream Industry Aggregate Consumption[20]

Downstream Economic Outputs (2019)	Construction	Cement & Concrete	Public Sector	Other	Downstream Industries Total
Gross Output	$1,670,179,506	$787,048,061	$318,371,078	$907,624,965	$3,683,223,610
GDP	$847,045,150	$370,146,365	$167,877,093	$414,491,788	$1,799,560,397
Labour Income	$505,760,459	$199,940,461	$99,228,707	$204,603,709	$1,009,533,336
Jobs	7,196	2,656	1,304	2,782	13,939

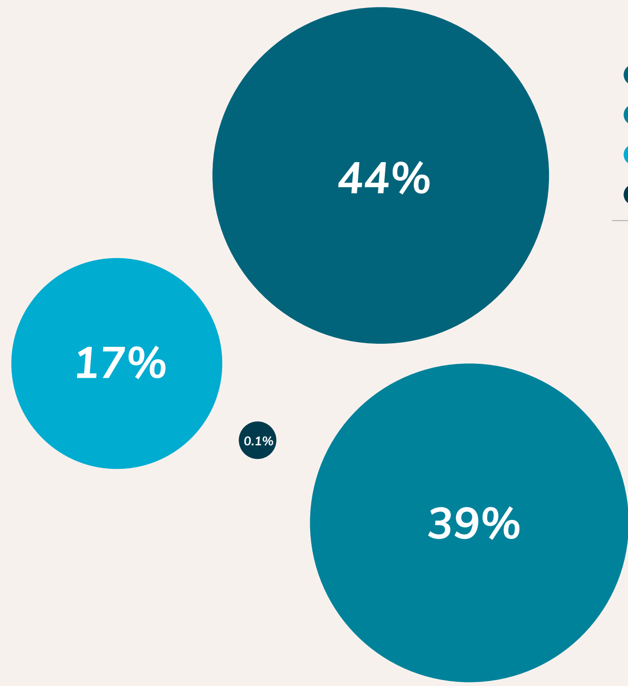
19 An underlying assumption is made here that downstream industries consume the total value of production as specified in the upstream portion of the supply chain, and that all value-add occurring between production and consumption is captured by the difference between basic prices (used in upstream) and market/purchasers' prices (used in downstream).

20 Values expressed in basic (direct effects) and purchasers' prices (indirect and induced). Jobs deflated to 2017 production values, all else is 2019 dollars.

Appendix J further summarizes the direct, indirect, and induced economic outputs generated by the consumption of aggregates with respect to gross output, nominal GDP at basic prices, labour income, jobs, and taxation. **In 2019, the consumption of $1.7 billion worth of aggregates in Ontario resulted in an estimated $3.7 billion in gross output, $1.8 billion in GDP ($124 per capita), $1 billion in labour income, and 14,000 jobs. Total revenue generated from taxes on production and products was approximately $103 million** (Figure 11).[21]

Figure 11: Taxes Generated by Downstream Aggregate Consumption[22]

DOWNSTREAM TAXES BY JURISDICTION (2019)



Provincial	$44,851,993
Municipal	$40,221,838
Federal	$17,613,805
Indigenous	$104,332
Total	**$102,791,968**

21 See also Appendix K.

22 Includes all downstream industries that consume stone, sand, gravel, clay, and other refractory minerals, other non-metallic mineral (except diamond and potash).

Other Aggregate-Dependent Economic Activities

In addition to the upstream and downstream economic outputs outlined above, the aggregates industry is essential for many other industries further downstream and therefore contributes to their economic outputs as well. Aggregate-dependent industries like residential and non-residential construction heavily rely on aggregate resources as critical inputs to their operations. When industries like these use aggregates to build homes, office buildings, and infrastructure like railway lines, bridges, and roadways, those aggregates transform into additional economic activity, adding to Ontario's gross output, GDP, labour income, employment, and tax revenue contributions. Ontario's construction industry alone employed 540,000 people in 2019, generating $51 billion in GDP (chained 2012 dollars), a significant portion of which are directly dependent on the aggregate industry's production of commodities like sand, stone, and gravel.[xii, xiii]

Moreover, Ontario's aggregates industry is directly responsible for contributing more than $35 million annually in revenue to municipal and provincial coffers through production fees – a fee collected and disbursed by TOARC and required by aggregate producers in Ontario to operate a pit or quarry.[xiv]

Summary: The Economic Impacts of Ontario's Aggregates Industry

In 2019, $1.7 billion worth of total new aggregates production in Ontario contributed the following estimated upstream economic outputs through direct, indirect, and induced effects:

- $2.9 billion in gross output ($196 per capita)
- $1.6 billion in GDP ($107 per capita)
- $806 million in labour income ($54 per capita)
- $150 million in tax revenue ($10 per capita)
- Approximately 13,400 jobs

In 2019, industry-level consumption of $1.7 billion worth of aggregates in Ontario resulted in the following estimated downstream economic outputs through direct, indirect, and induced effects:

- $3.7 billion in gross output ($250 per capita)
- $1.8 billion in GDP ($124 per capita)
- $1 billion in labour income ($67 per capita)
- $103 million in tax revenue ($7 per capita)
- Approximately 14,000 jobs

Many industries within the construction and manufacturing sectors rely on aggregates as a factor of production. Collectively, these industries generate billions of dollars annually in GDP and support thousands of jobs. **We can therefore derive that a shock to aggregate input costs would have widespread micro- and macroeconomic implications.** With that in mind, Part Two will investigate how a change in transportation distance affects the per-tonne cost of aggregates and the economic impacts this has on infrastructure projects.

Part Two:

Economic Implications of Far-From-Market Aggregates

The Greater Toronto Hamilton Area (GTHA) consumes one of the largest shares of aggregates in Ontario, averaging 73 million tonnes per year. For the past several decades, the GTHA has consistently seen a decline in the number of close-to-market licensed reserves and local production volume coupled with an increase in the volume of imported aggregates from surrounding far-from-market sites. Without the continued replacement of licensed reserves in the area, and as existing resources are depleted, the GTHA has increasingly relied on pits and quarries located farther away from market to meet local consumption demand and can expect to exhaust all close-to-market aggregate production supply within the next 10 to 15 years.[xv]

In 2019, close-to-market production within the GTHA amounted to a mere 25 million tonnes; thus, 66 percent (48 million tonnes) of all aggregates consumed in the area needed to be imported from surrounding regions to satisfy annual demand.[xvi] The GTHA's demand for aggregates will continue to increase along with population and economic growth.

In this section, we investigate the economic implications of longer truck transport haul routes associated with far-from-market aggregate production. While alternative transportation modes exist for far-from-market aggregates, such as rail transport and marine transport, several studies have found that the current state of infrastructure in the province is inadequate and would require significant, long-term investments in the construction of ports, stations, and redistribution terminals. Moreover, these alternate modes of transport would not eliminate the volume of trucks needed for last-mile delivery to redistribution terminals and job sites.[xvii] The *State of the Aggregate Resource in Ontario Study* by the Ministry of Natural Resources further highlights the considerate economic, environmental, and social implications associated with marine and long-haul rail transport.[xviii] In light of inadequate infrastructure and the years it would take to build such infrastructure, our analysis focuses only on truck transport scenarios.

We begin our analysis by determining the relationship between longer haul distances and the cost to transport aggregates by heavy duty trucks. We then assess the impact of longer distances on select infrastructure projects in the public sector, which purchases approximately 60 percent[23] of all aggregates.[xix] Based on GTHA aggregate import trends and for the purposes of this report, we assume all 25 million tonnes of aggregates are no longer produced within the GTHA annually under a close-to-market scenario and are instead imported from pit and quarry sites located far-from-market.

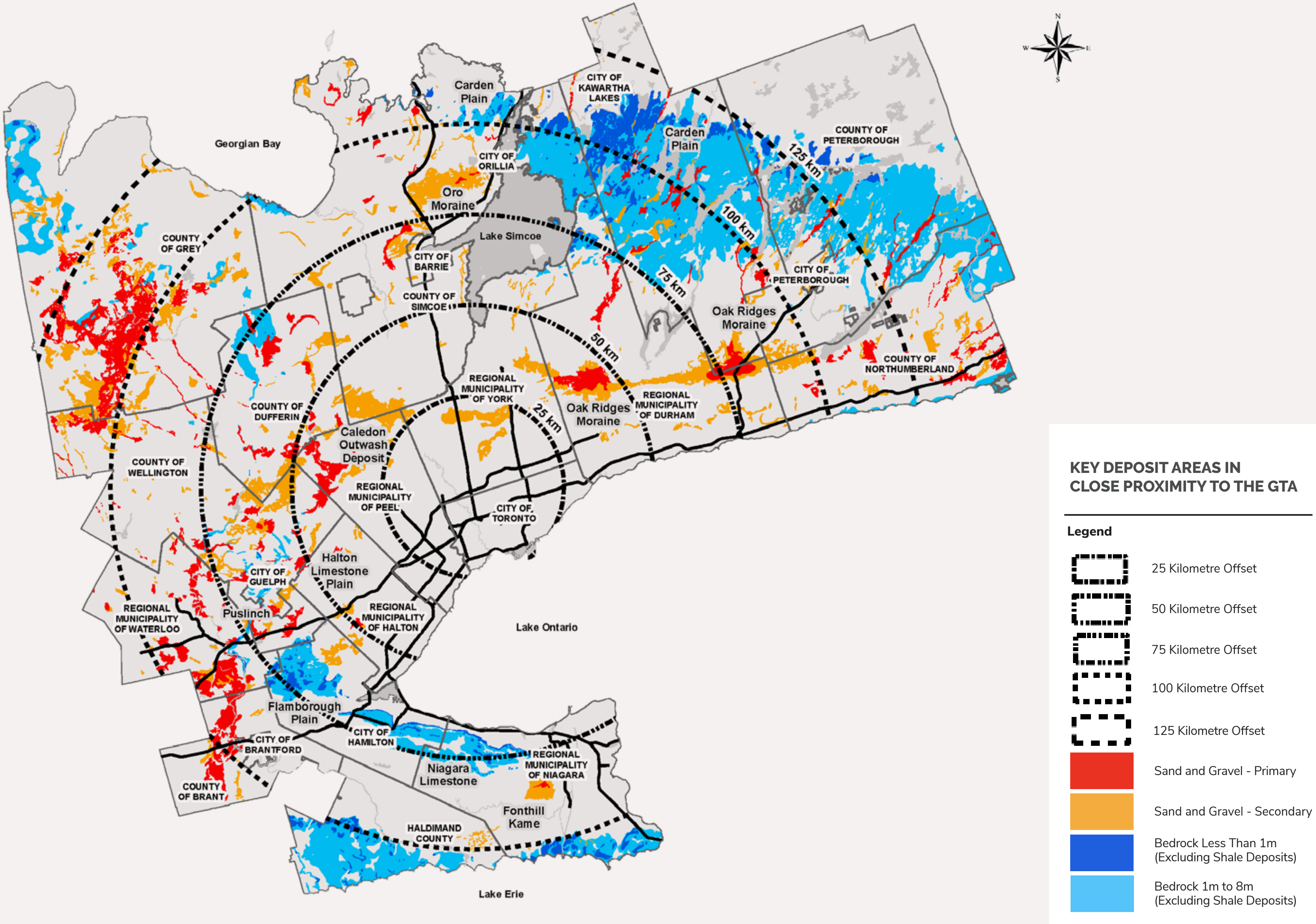
23 Not inclusive of the transportation of recycled aggregates or aggregates imported from other provinces, territories, or countries.

Transportation Costs

Aggregates are a low-priced, but volume-intensive commodity used in various industries, including construction, repair, and maintenance of infrastructure.

The current average haul route for close-to-market production in the GTHA is 35 kilometres and the next generation of available pits and quarries is an additional 75 kilometres farther away, on average, for a new total, one-way haul route of 110 kilometres from production site to market (see Figure 12 and explanation below). Although several aggregate deposits are located between these two bounds, current provincial land use plans constrain where aggregate operations may occur in Ontario, limiting accessibility and availability (see Appendix L).[xx]

Figure 12: Key Deposit Areas in Close Proximity to the GTA



Source: MHBC Planning, Urban Design & Landscape Architecture

The map in Figure 12 illustrates key deposit areas in and around the GTA before taking into account constraints. It is worth noting that moving material east-to-west and vice versa across Toronto is difficult due to transportation and congestion barriers. Therefore, supply areas for the GTA are separated into the east and west sides.[xxi]

Quality constraints on available aggregate deposits also pose a challenge when siting pits and quarries. High-quality aggregates are required to meet asphalt and concrete project specifications for high-quality work, including bridges and other major types of infrastructure. The highest quality reserves are within a 25- to 50-kilometre radius of the GTHA, supporting the argument for close-to-market aggregates.

For example, for sand and gravel, the closest-to-market (CMT) source for the GTA west region is Caledon Guelph outwash at 25 to 50 kilometres from market. The nearby alternative, Puslinch, is currently nearly depleted. Thus, the logical replacement would be Brant and Waterloo at 75 to over 100 kilometres away from market, requiring an additional 50 kilometres or more in haul distance. Grey County has been suggested as the alternative source in other studies, resulting in a total haul distance of 125+ kilometres, or an additional 75+ kilometres farther away from market. For bedrock (crushed stone) west of the GTA, the CTM source is Halton/Flamborough at 25 to 50 kilometres from market. The alternative is Singhampton/Duntroon at 100 kilometres, resulting in a 75-kilometres increase in the haul distance.

Therefore, if all 25 million tonnes of aggregates produced annually in the GTHA were to be imported from alternative sites in surrounding regions, this would result in extraction sites being located an average 75 kilometres farther away from market. Since the average close-to-market haul distance is 35 kilometres, the total haul distance under a far-from-market scenario would be 110 kilometres. For a more detailed version of the map in Figure 12, see Appendix M.

To estimate average transportation costs on a per-tonne, per-kilometre basis, we relied on data provided by various producers throughout Ontario. The final dataset included 147 observations, consisting of the total amount paid in transportation costs per heavy-duty truckload, city of pit/quarry, city of project site, total distance to project site (measured in kilometres), and total tonnage per load (averaging 32 tonnes per load).[24] The total transportation costs included in our data are from producers that contract out their transportation to external providers. Thus, the reported transportation costs already take into account an estimate of input expense factors such as driver's time, vehicle depreciation, fuel costs, and mileage. With this in mind, we specify the following model in linear functional form to estimate transportation costs per tonne, per kilometre:

Total Transportation Costs Per Tonne = $\alpha + \beta$ x (Total Kilometres Travelled)

– where α denotes the intercept as an estimate for other transportation-related costs not influenced by a change in distance travelled. In other words, it represents base transportation costs that exist irrespective of kilometres travelled. β denotes the coefficient value estimating the change in total transportation costs per tonne for every additional kilometre travelled.

To estimate the model values for **α** and **β**, we run a simple linear regression[25] and find that for every additional kilometre travelled, per-tonne transportation costs increase by $0.09. This gives us the following:

Total Transportation Costs Per Tonne = $2.77 + $0.09 x (Total Kilometres Travelled)[26]

Although we find no statistically significant relationship between transportation costs and highly congested cities or distance level (short- versus long-haul) in the dataset, it is reasonable to expect that the number of trips required per truck per day, congestion, and longer distances do incur some additional costs in the long-run (due to vehicle wear and tear, increased exposure to fuel price variability and service disruptions resulting from severe weather conditions, idling time, etc.), that are not factored into our model. Another limitation is that our model does not differentiate between the costs of transporting different types of aggregate, which may vary given differences in density, demand, and supply.

24 2019 data.

25 As opposed to taking averages of select variables in our dataset, regression analysis produces more statistically accurate results in that it aims to find a line of best fit for the data, focusing on the average trend and less on the random outliers. It minimizes the unexplained portion whereas taking a simple average would give equal importance to outliers and would produce biased and inefficient results. The modelling output also allows for running statistical significance tests to verify the legitimacy of the results.

26 The R-Squared value (0.9) indicates a strong goodness-of-fit measure of the model with our dependent variable. P-values for the intercept and coefficient estimates were less than 0.01, demonstrating statistical significance at the one percent level. We conclude our model strongly predicts the relationship between total per-tonne transportation costs and distance travelled.

Lastly, it is also worth noting that longer haul distances would require more trucks, and therefore more drivers, to ensure the necessary volume of aggregates reaches job sites according to project timelines. The above analysis does not consider the costs for securing a larger fleet and the labour cost pressures associated with hiring truck drivers, particularly in the face of pervasive labour shortages within the industry.

Cost Assessment

Table 3 below summarizes total transportation costs for close-to-market and far-from-market aggregate production on a per-tonne basis as well as on a total-cost basis for all 25 million tonnes of aggregates produced in the GTHA.[27]

Table 3: Total Transportation Costs by Average Haul Distance

Total Transportation Costs by Average Haul Distance (2019)	One-Way Trip		
	35 km (Current)	Additional 75 km (Anticipated)	110 km (Total)
Per Tonne	$ 5.92	$ 6.75	$ 12.67
25 Million Tonnes	$ 148,000,000	$ 168,750,000	$ 316,750,000

At the current 35-kilometre haul distance, the average transportation cost is $5.92 per tonne (representing 32 percent of total costs per tonne of stone and 46 percent per tonne of sand and gravel). Assuming no change in non-transportation related costs, an additional 75-kilometre distance would add $6.75 to the per-tonne transportation cost, bringing the total transportation cost to $12.67 per tonne of aggregate. **Under a far-from-market scenario, transportation would represent 50 percent of the total cost per tonne of stone and 65 percent of the total cost per tonne of sand and gravel.[28] A new average haul distance of 110 kilometres would more than double the current transportation costs (a 114 percent increase).**

27 Based on GTHA aggregate import trends, we assume all 25 million tonnes of aggregates are no longer produced within the GTHA annually under a close-to-market scenario and are instead imported from pit and quarry sites located far-from-market.

28 Using FOB prices determined in the upstream analysis found in Part One (see also Appendix C), we measure total costs here as the addition of per-tonne raw material FOB prices and transportation costs for a given aggregate type and haul distance.

Moreover, the total transportation costs for transporting 25 million tonnes annually from extraction sites located farther away to meet demand and replace local production in the GTHA would increase from $148 million to nearly $317 million.

Relocating a single site producing an average of 89,000 tonnes[29] farther away from market would result in approximately $601,000 in additional annual transportation costs.

It is worth noting these estimates are conservative. **First, we only factored in one-way trips, ignoring the fact that additional costs would be incurred by the empty trucks on their return trips.** Further, the population in the GTHA is projected to reach well over 10 million in the next two decades, and the region is expected to consume another 1.5 billion tonnes of aggregates by 2041.[xxii, xxiii] Combined with inflationary pressures, we can infer that transporting aggregates from farther away will have a sizeable impact on the total costs of aggregates for the GTHA.

29 The actual number of tonnes produced per site varies significantly. This estimate reflects an average volume of aggregates produced per site using sample data from the 2019 TOARC Production Statistics report.

Implications for the Cost of Infrastructure

Our modelling and analysis reveal that transportation costs make up a significant portion of the final cost incurred by end-users of aggregate material. Considering the large volume of aggregates required to construct various types of infrastructure, we use three different types of infrastructure to exemplify the implications for building roadways, hospitals, and subway lines. Each exhibit will outline the typical volume of aggregates required and compare associated transportation costs under close-to-market and far-from-market scenarios. We then contextualize the implications of far-from-market aggregates using total annual public sector spending on aggregate-dependant infrastructure.

The subsequent infrastructure projects were selected based on their aggregate intensity, relevance to the GTHA, and significance for municipal and provincial budgets. Table 4[xxiv] below summarizes a selection of infrastructure important to Ontario's economy and public sector budgets.

Table 4: Infrastructure Aggregate Requirements and Associated Transportation Costs[30]

	Infrastructure Type	Tonnes Required	Close-to-Market Cost (35km)	Additional Far-from-Market Cost (75km)	Total Far-from-Market Distance Cost (110km)
Exhibit A: Roadways (per km)	2 lane highway	18,000	$106,505	$121,500	$228,005
	4 lane highway	30,000	$177,509	$202,500	$380,009
	4 lane freeway	44,000	$260,346	$297,000	$557,346
	Major arterial road (Southern Ontario)	18,000	$106,505	$121,500	$228,005
	Local (Southern Ontario)	6,500	$38,460	$43,875	$82,335
Exhibit B: Hospitals	Office, school, hospital space (1000m2)	730	$4,319	$4,928	$9,247
	Medium-sized hospital (56,000m2)	75,600	$447,322	$510,300	$957,622
Exhibit C: Subway Lines	Subway Line (per km)	114,000	$674,534	$769,500	$1,444,034
	Average Subway Line Extension (8 km)	912,000	$5,396,271	$6,156,000	$11,552,271

30 In 2019 dollars. 35 km and 110 km costs were calculated using transportation cost estimates from previous regression analysis results. The 75 km portion of the new distance calculated as the difference between the two.

Exhibit A: Roadways

Table 4 highlights the number of aggregate tonnes required for various roadway applications. Approximately 44 thousand tonnes are required to build one kilometre of a four-lane freeway. The total transportation costs associated with sourcing these aggregates farther away from market amount to nearly $300,000.

An average widening or reconstruction project of freeways in Ontario can include the addition of two lanes approximately 18 kilometres in length, therefore requiring a total of 396,000 tonnes of aggregate.[31] Close-to-market production based on a 35-kilometre haul distance would amount to $2.3 million in transportation costs, while a far-from-market haul average of 75 kilometres would result in an additional $2.7 million, resulting in a total of $5 million in transportation costs.

To put this into context, the City of Toronto alone has over 13,500 single-lane kilometres of roadways that require ongoing maintenance and repairs, needing approximately 600 tonnes of aggregate per single-lane kilometre that are necessary for asphalt overlays.[xxv] Far-from-market extraction sites would mean an estimated total increase of $55 million, or 1.4 percent of the City of Toronto's annual spending on infrastructure.[32]

Exhibit B: Hospitals

For every 1,000 square metres of office, school, or hospital space, 730 tonnes of aggregates are required, costing just over $4,000 to transport the given amount from close-to-market pits and quarry sites, and almost $5,000 in additional transportation costs from sites located farther away.

For context, an average medium-sized hospital in Ontario (56,000 square metres) requires approximately 75,600 tonnes of aggregates.[33] This translates to approximately $448,000 in transportation costs for close-to-market sites and an additional $510,000 for far-from-market sites (for a total of $958,000 in transportation costs).

Exhibit C: Subway Lines

Subway lines are one of the most aggregate-intensive infrastructure projects. An average subway extension project is 8 kilometres in length,[34] requiring a total of 912,000 tonnes of aggregate. Under the close-to-market scenario, total transportation costs are $5.4 million; if aggregates were to come from extraction sites 75 kilometres farther away, it would cost an additional $6.2 million (for a total of $11.6 million in transportation costs).

31 Calculated using an average of a sample of completed and announced roadway projects.

32 From the City of Toronto's 2019 Financial Information Returns (FIR), using additions and betterments of tangible capital assets (Schedule 51A) and expenditures on the active construction of tangible capital assets (Schedule 51C).

33 Averaged across hospital size.

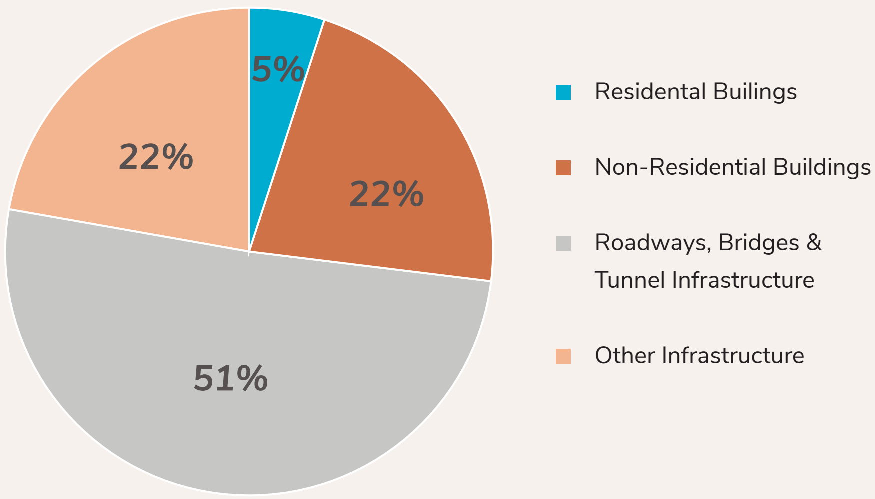
34 Averaged using a sample of subway line extension projects in the GTA.

Budgetary Impacts

In Ontario, the construction of new infrastructure, as well as their repair and maintenance, are primarily funded by the municipal, provincial, and federal governments. The majority of all spending on aggregate-dependent infrastructure in Ontario originates from municipalities (68 percent), with the remaining amount originating from the provincial (26 percent) and federal (seven percent) levels.[xxvi]

Figure 13 provides a breakdown of public sector spending on infrastructure and building construction, with roadways making up the largest share of all municipal, provincial, and federal investments on infrastructure requiring aggregates.

Figure 13: Public Sector Construction End-Uses of Aggregates Produced in Ontario



Source: Statistics Canada

The public sector purchases approximately 60 percent of the aggregates produced in the GTHA, or 15 million tonnes. **If the GTHA were to import its annual production of aggregates from sites located far-from-market each year, the public sector would incur an additional $101.3 million in transportation costs.** Under this scenario, close-to-market transportation costs would be approximately $88.8 million, suggesting that the public sector would incur a total of $190.1 million for the full 110-kilometre one-way route.

For context, the average amount spent by municipalities in the GTHA on tangible infrastructure and transportation capital assets[35] was over $361 million in 2019 (ranging from $3 million in the Township of Hamilton to $4 billion in the City of Toronto).[xxvii, xxviii]

The majority of the added transportation costs would be borne by municipalities ($69 million), followed by the provincial government ($26 million) and federal government ($7 million). It is also important to note that the roads and highways themselves are subject to greater wear and tear across a longer distance, which would further impact the cost of maintaining public infrastructure.

35 From the 2019 Financial Information Returns (FIR) of all municipalities located in the GTA and Hamilton area, we looked at the average total amount spent on the additions and betterments of tangible capital assets (Schedule 51A) as well as expenditures on the active construction of tangible capital assets (Schedule 51C).

Part Three:

Environmental Implications

When comparing close-to-market versus far-from-market aggregate production, it is important to consider the environmental implications in addition to the economic impacts. This section presents a high-level literature review of environmental considerations and externalities associated with the siting of pits and quarries. We then quantify greenhouse gas emissions (GHGs) and the economic costs of GHGs associated with longer haul distances.

Literature Review

Although aggregate resources are essential to infrastructure development, research suggests their extraction can have localized impacts that disproportionately distribute the costs and benefits associated with production at a regional level.[xxix]

On the one hand, Torres et al. (2017) discuss how urbanization, population growth, and aging infrastructure present challenges for the sustainable management of non-renewable aggregate resources and ultimately result in social and environmental concerns.[xxx] According to Philpot et al. (2020), the scarcity of aggregate resources often means mining and quarrying operations are occurring in areas that are ecologically sensitive and near population centres.[xxxi]

Although most of the environmental impacts noted in the literature are not limited to close-to-market aggregate production, the proximity of extraction sites to densely populated communities amplifies concerns about their localized impacts. These concerns include the potential for groundwater contamination; disruption to local watersheds, ecosystems, and habitats; noise pollution, dust, and poor air quality resulting from blasting and trucking; the sheer size of aggregate pits and quarries; land use opportunity costs; and the longer timeline required to see the rehabilitation of a pit or quarry site realized.

Campbell (2014) identifies numerous concerns regarding dust, water and soil contamination, noise pollution, negative visual aesthetics, traffic, and adverse effects on road conditions often associated with the development of aggregate sites. The results from a case study analysis on

Carburn Park, Alberta, provide evidence of significant environmental externalities generated by the gravel mine and have a downward effect on nearby property values.[xxxii] However, it should be noted that this site falls outside the jurisdiction of Ontario and would have followed operational policies and requirements specific to Alberta.

Winfield and Taylor (2005) similarly call attention to the significant amounts of dust that aggregate resource extraction and processing activities are known for, with the operation of machinery and equipment acting as a precursor to smog and adding to the emissions generated from transporting the aggregates to market.

Additionally, the Environmental Commissioner of Ontario (2003) demonstrates how the expansion of quarry operations results in the removal of vegetation and topsoil, which permanently changes the natural environment and affects water drainage by disrupting pre-existing streamflows.[xxxiii]

In another report used to legally challenge the expansion of an existing Niagara Escarpment quarry, Castrilli (2005) outlines several potential environmental impacts, including damage to the site's water quality and aquifer, impairment of the water quality in residential wells, declining water levels in nearby lakes, increasing lake temperatures posing risks to cold-water fish and surrounding wetlands, loss of habitat, and fragmentation of continuous natural environment.[xxxiv]

At the Papin Creek Watershed in British Columbia, Wang et al. (2017) estimate that 25 percent of the surface area of the Canadian portion of the watershed has been affected by aggregate mining with an estimated loss of water storage of 10 percent. Evapotranspiration decreased as a result of the removal of the vegetative cover. Precipitation had remained relatively constant over the study period, but the annual discharge measured at Pepin Creek decreased.[xxxv] Importantly, similar to the Carburn Park study, this example falls outside Ontario's jurisdiction and would be subject to different operational requirements.

The literature also indicates that aggregates are being extracted at a faster rate than pit and quarry sites can be rehabilitated, such that the net impact continues to grow, especially where rehabilitation is not being adequately enforced by governments. In an Ontario-specific report, Winfield and Taylor (2005) examine the environmental risks and policies in the province with respect to mineral aggregates over the previous 35 years. The study finds that during this study period, provincial policies relating to the sector have increasingly emphasized access to aggregate resources as a priority over other competing potential land uses. Each of the ten districts included in the analysis found that less than five percent of the pit/quarry sites had been fully rehabilitated.[xxxvi]

On the other hand, a 2009 report by the Ontario Ministry of Natural Resources (MNR) and AECOM Canada Ltd. analyzed 31 of the most recently approved licensed sites and found that most of them had almost fully preserved the environmental and agricultural features. Quarrying had affected a small amount of good quality habitat, though, on balance, the affected habitat was restored through rehabilitation. The study also concluded that the highly regulated nature of the aggregates industry has resulted in quarrying eco-services that help regulate and maintain ecosystems through landscape rehabilitation, maintenance of biodiversity, landfills, waste disposals, uses in mines, removal of anthropogenic pollutants practices, and water quality treatment procedures and practices.[xxxvii]

SENES Consultants (2013) further examines the relationship between aggregate extraction and water supplies using five Ontario case histories where aggregate operations occurred near municipal water wells. While potential threats do exist from certain ancillary land-use activities for pits and quarries, the research found that the extraction and processing of sand, gravel, and stone did not have any adverse impact on the quality of municipal water wells.[xxxviii]

Moreover, according to the Ontario Stone, Sand & Gravel Association (OSSGA, 2018), only 0.7 percent of all 12.1 million acres of prime agricultural land found in Southern Ontario has a licensed aggregate operation, with many of these sites being rehabilitated back to agriculture.[xxxix]

OSSGA (2015) highlights additional measures producers take that go beyond legal requirements to ensure the protection of wildlife. Examples include working alongside local conservation authorities on environmental management projects, sponsoring protection efforts and environmental research, as well as introducing buffer zones around sensitive natural resource areas.[xl]

The study also points out that aggregate operators primarily act as water managers as opposed to water consumers. The water used to wash fine particles from stone or gravel is recycled and any water that is pumped out of a quarry for extracting aggregates below the water table is regularly recharged into the groundwater system and/or released into surrounding streams. Producers will also use some of the water to spray on roadways to help minimize dust. Moreover, the authors note that chemicals are not involved in neither the extraction nor processing of aggregates. All topsoil and organic materials removed prior to mining are kept on-site to be used later for pit or quarry site rehabilitation.[xli]

To identify the total volume of water handled and consumed in aggregate operations, Golder Associates (2006) examine four types of above- or below-water table pits and quarries. Their findings indicate that depending on the site studied, consumed water (water not returned to the groundwater system and/or local surface water) is only two to eight percent of the total handled water and the actual water taking amount is only one to 37 percent of the maximum permitted by the Permit to Take Water (PTTW). Thus, the report concludes that the four study sites are primarily water handlers, and the majority of all handled water is either repeatedly recycled or returned to the local hydraulic system.[xlii]

Additionally, the practice of producing and using recycled aggregates is becoming increasingly recognized as a circular development solution for minimizing the environmental cost associated with aggregate mining and quarrying. OSSGA (2015) discusses how the aggregates industry is promoting the use of recycled aggregates for new construction, such as asphalt and concrete from torn up roadways and demolished buildings, as a means of protecting the environment.[xliii] A 2018 report commissioned by the Toronto and Area Road Builders Association (TARBA), *Aggregate Recycling by Ontario Municipalities*, makes the case for using recycled aggregates and identifies which Ontario municipalities are leading and falling behind in the practice.[xliv]

While outside the scope of this review, it is worth noting that industry is required to produce technical reports as part of the aggregates licensing process. These reports are peer reviewed, submitted to government, and produced in accordance with the Aggregate Resources of Ontario: Technical Reports and Information Standards. Together with permitting and environmental approvals, these reports are designed to address any concerns there may be regarding impacts on groundwater, the local watershed, air quality, ecosystems etc.

Finally, we note there is limited information comparing the GHG emissions that result from far-from-market versus close-to-market production.[36] To address this gap, we quantify GHG emissions in the following section.

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36 SAROS 2 (2009) provides a more in-depth analysis of GHG emissions in a long-haul trucking scenario from North Bay to the GTA. Source: https://files.ontario.ca/saros-paper-2-future-aggregate-availability-alternatives-analysis-en.pdf.

Greenhouse Gas Emissions

As noted in the preceding section, many of the environmental considerations outlined in the literature are not specific to close-to-market aggregate production. Since demand for aggregates will remain high in Ontario for the foreseeable future, it is important to understand how the location of extraction sites affects the environmental footprint of aggregate suppliers and consumers.

The remainder of this section will quantify the environmental implications directly associated with far-from-market aggregate production, namely the increase in GHG emissions as well as the economic cost associated with these emissions.

Fuel Consumption and Emissions

In 2019, 73 million tonnes of aggregate were consumed in the GTHA, with 25 million tonnes originating from GTHA close-to-market production. Based on the sample data used in Part Two, the average load size per haul is 32 tonnes. These 25 million tonnes would equate to over 781,000 truckloads per year. A single truck typically carries five loads per day, which amounts to approximately 156,000 trucks on the road per year, or an estimated 710 trucks on any given workday.[37] To calculate the added haul distance, we apply the same estimates used above – where average close-to-market haul distance is 35 kilometres, and the average far-from-market haul distance is an additional 75 kilometres from market (for a total of 110 kilometres). Table 5 below summarizes fuel consumption and GHG emissions by distance on an annual and daily basis for supplying 25 million tonnes of aggregates for the GTHA.

37 Daily figures estimated using 220 working days per year as reported by producers.

32.8 million litres of fuel

88,594 mt

Equivalent to:

19,000 cars

354 million kms driven

To offset, requires:

1.5 million tree seedlings

105,000 acres of forests

Table 5: Daily and Annual Fuel Consumption and GHG Emissions by Distance*

	Distance	Per Year (All Truckloads)	Per Day (All Truckloads)
Fuel Consumption (Litres of Diesel Fuel)	Per Kilometre	437,500	1,989
	35 Kilometres	15,312,500	69,602
	75 Kilometres	**32,812,500**	149,148
	110 Kilometres	48,125,000	218,750
	Distance	Per Year (All Truckloads)	Per Day (All Truckloads)
Greenhouse Gas Emissions (Metric Tonnes of CO2)	Per Kilometre	1,189	5
	35 Kilometres	41,344	188
	75 Kilometres	**88,594**	403
	110 Kilometres	129,938	591

*Based on 25 million tonnes

Longer haul routes require more fuel consumption and therefore result in more GHG emissions, especially when considering the emissions-intensive nature of the heavy-duty trucks used to transport high density and weight materials like sand, stone, and gravel. **If aggregates were to be imported from extraction sites located farther from market, their transportation would require an additional 32.8 million litres of fuel, generating another 88,594 metric tonnes of carbon dioxide (CO2) emissions annually.**[38]

For reference, the additional GHG emissions generated would be equivalent to the amount generated by 19,000 passenger cars in a given year, or a total of 354 million kilometres driven. It would take approximately 1.5 million tree seedlings grown for 10 years or close to 105,000 acres of forests in a single year, to sequester this amount of carbon.[39] A total far-from-market haul distance of 110 kilometres would require 48 million litres of fuel consumption and result in 130,000 metric tonnes of CO2 emissions annually – more than triple the current amount.

If a single site producing 89,000 tonnes of aggregate were to move its operations 75 additional kilometres away from market, this would entail over 2,700 truckloads, 117,000 litres of fuel, and 315 metric tonnes of emissions annually.

38 Producers estimate 0.56 litres of diesel fuel are consumed per kilometre travelled. Using the available data, we find 0.001512 metric tonnes of GHGs are emitted per kilometre travelled (CO2 equivalent).

39 Calculated using EPA's Greenhouse Gas Equivalencies calculator.

Accounting for the Cost of Carbon

In this portion of our analysis, we look to price the environmental impact and quantify the dollar value of what it would take to help offset the emissions reported above. The primary way through which the cost for CO2 can be paid in Ontario is through the federal price on carbon, which is paid directly at the fuelling station.

Under the current carbon price of $50 per tonne[xlv], the added haul distance would cost $4.4 million each year (or $6.5 million for the total far-from-market haul route of 110 kilometres). By 2030, when the carbon price is projected to reach $170 per tonne, the added emissions would cost more than $15.1 million (for a total cost of approximately $22.1 million for the far-from-market route).[xlvi]

Although future carbon prices are not yet in place, the cost of emissions will likely continue to increase in the coming years.

Energy and Emissions Intensity Per Value of Production

The transportation of aggregates from extraction sites to market largely takes place within the 'truck transportation industry' as defined by Statistics Canada. As with every industry, the interconnected nature of supply chains means there are a host of other industries directly and indirectly supporting its operations (e.g., diesel fuel producers and service providers). The GHG emissions analysis presented above only quantifies the direct emissions generated from the movement of aggregate resources by trucks. From a macro level, it is worthwhile to consider the direct and indirect GHG emissions generated by supporting industries involved in ensuring that aggregates are hauled the extra distance under the far-from-market scenario.

To do this, we adopt an approach using data from Statistics Canada on energy intensity and GHG emissions intensity.[xlvii] Both measures (energy intensity and emissions intensity) can be used to better understand the interdependency of Ontario's transportation industry – which is the principal industry involved in hauling aggregates – with the rest of the economy, energy usage as an input, and the GHG emissions that result from that energy use.

First, we converted the total transportation costs identified in Table 3 into relevant units (thousands of current dollars). Then, we applied the multipliers provided by Statistics Canada to calculate total energy intensity and GHG emissions associated with each haul distance. This allows us to estimate the total direct and indirect amount of additional energy required as an input for transporting aggregates, and the subsequent emissions generated from this energy use, for every additional dollar spent on transportation costs. Table 6 summarizes these findings under the different haul distance scenarios.[40]

Table 6: Direct and Indirect Intensities Associated with Hauling 25 Million Tonnes of Aggregate from Pits and Quarries to Market[41]

	35 km (Current)	Additional 75 km (Anticipated)	110 km (Total)
Total Transportation Costs	$148,000,000	$168,750,000	$316,750,000
Energy Intensity (Gigajoules)	1,509,600	1,721,250	3,230,850
Greenhouse Gas Emissions Intensity (Tonnes)	108,040	123,188	231,228

Combining the direct and indirect intensities, we find that over 1.7 million extra gigajoules of energy are required to support an additional 75-kilometre haul, producing approximately 123,000 extra tonnes of GHG emissions. For the full 110-kilometre route, over 3.2 million gigajoules of energy are required, generating over 231,000 tonnes of GHG emissions.

These results should be interpreted independently from the direct fuel emissions summarized in Table 5 as an alternative approach that accounts for both direct and indirect impacts.

40 Intensities here provide a useful estimate of the economy-wide effect on energy consumption and GHG emissions brought about by an increase in the total haul distance travelled. These intensities include both direct and indirect effects. Direct effects measure the energy use required as an input or GHG emitted as waste for an extra dollar's worth of transportation services provided by the truck transportation industry. Indirect effects measure the upstream activity required by supporting industries to help ensure these transportation services are provided by the truck transportation industry – which then, in turn, require the production of various goods and services from other industries, yielding additional energy use and GHGs emitted.

41 Final values are estimates only as the intensity reported by Statistics Canada for the truck transportation industry includes all truck transportation types and does not provide exact multiplier figures for transportation by heavy duty trucks alone, which is the vehicle classification used for transporting aggregates.

Part Four:

Case Study

The Cost Implications of Closing the Nelson Aggregate Co. Burlington Quarry

Against a backdrop of declining close-to-market aggregate production, we present a case study on the implications of closing a single site within the GTHA. The analysis demonstrates how relocating aggregate production farther from market leads to a meaningful increase in transportation and environmental costs over 10 years.

The case study was developed using real data from the Nelson Aggregate Co. quarry in Burlington, Ontario, and sites in the surrounding region. Due to confidentiality, details about alternative sites are not disclosed; however, data from these sites were obtained directly from producers and used in our calculations and modelling.

Nelson Aggregate Co. quarry is home to a number of important aggregates. In particular, Nelson quarry produces dolostone – a high-quality limestone used to manufacture a variety of products, including crushed granular, asphalt and concrete products, and building stone. The dolostone from this geologic formation along the Niagara Escarpment is recognized as a significant aggregate resource for the province and is characterized by its high strength and weather-resistance. The dolostone from this quarry has been used for buildings such as the Rogers Centre, the CN Tower, and all the bridges on the western portion of highway 407, among others.

While the dolostone from this formation is relatively abundant from the Burlington area north to Manitoulin Island, the vast majority is unavailable for extraction due to social and environmental constraints, and land assembly.

This quarry site also proves to be a timely example given that it is currently awaiting approval for an expansion license to allow for continued extraction of aggregates. Without this expansion, the case study assumes Nelson quarry would no longer be able to continue producing its two million tonnes of aggregates each year and would require other sites in the surrounding region to make up the lost production, thereby increasing the transportation and environmental costs required to sustain existing demand.[42]

42 Nelson Aggregate Co. is applying for an expansion of its site in Burlington to allow for continued extraction of aggregates Without the approval, the site would operate at a significantly reduced capacity. However, for the purposes of this case study, we assume that without the license for expansion, Nelson quarry will close and no longer produce aggregates over the study period. This allows us to examine the impact of site closures or relocation farther from market. See also: https://ero.ontario.ca/notice/019-4921.

Approach

The purpose of this analysis is to quantify the additional transportation and environmental costs that would result from the closure of Nelson quarry as production moves farther away from market.

To inform the case study, 20 alternative quarry sites were identified in the region that would need to collectively make up for the loss of Nelson quarry. For each of the sites included in this study, the following variables are used in the analysis:[43]

- Location and distance from market
- Annual extraction volumes
- Annual extraction limits
- Estimated remaining licensed reserves (beginning 2021)

Nelson quarry is located 36.4 kilometres from market, with an annual extraction volume of 2 million tonnes and estimated remaining reserves of 30 million tonnes. Alternative sites are located throughout the region, with the farthest site being approximately 148 kilometres away from market, located north of Orillia.

Assumptions

1. If Nelson is successful in obtaining a license for expansion, it will continue to operate and produce its base annual extraction volume of 2 million tonnes of aggregates. If it is unsuccessful, it would close and no longer produce any aggregates.
2. Kilometre distances associated with each site remain constant throughout the study period and are based on their market centre of gravity, which refers to a specific location within a city or metro market area to where the largest concentration of aggregates from a given quarry is delivered annually.
3. Aggregate type and quality across quarry sites are perfect substitutes, such that if one site closes, the next closest site can make up the lost production volume using their reserves.[44]
4. All quarries are capable of producing aggregates for high quality applications (i.e., concrete, asphalt, roads).

43 Data provided by OSSGA and its members.

44 Reserve base is based on only high quality dolostone (quarried) stone (i.e., no sand and gravel deposits).

5. We assume no other changes are made to the existing list of 21 quarry sites used in this study (i.e., no new sites open and no existing sites close, expand, or see changes to their annual extraction limits within the study period).
6. All sites have the production capacity and resources available to take on the additional production required to maintain existing annual market demand.
7. The next closest remaining quarries pick up tonnage shortfall as closest to market quarries are depleted.
8. Annual demand (consumption) remains constant.

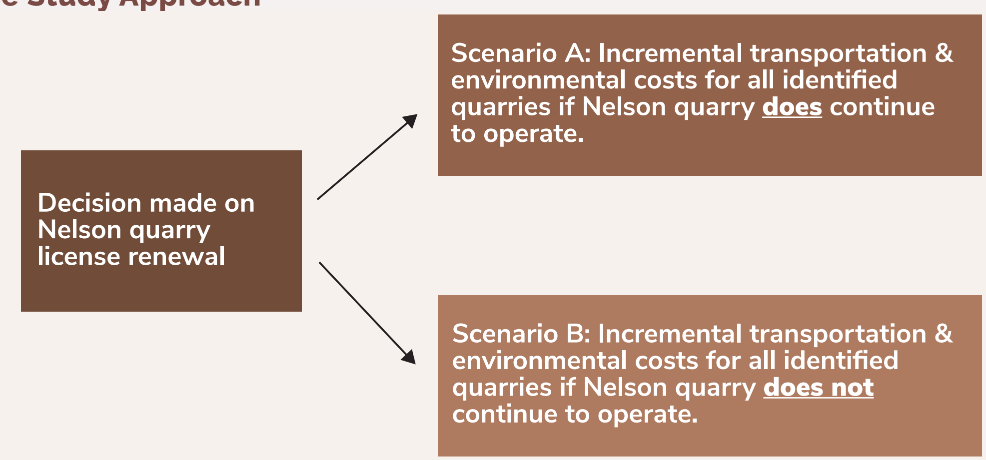
Methodology and Model

In Year 0, a decision is made on whether to approve the extraction license for Nelson quarry (Figure 14.1). This creates two potential scenarios:

- Scenario A represents the case in which Nelson quarry does continue producing its annual 2 million tonnes of aggregates until they deplete their estimated remaining reserves of 30 million tonnes.
- Scenario B represents the case in which Nelson quarry does not continue producing, thus requiring the next closest available sites to make up the 2 million tonnes of aggregates required annually.

The difference between the two scenarios represents the incremental transportation and environmental costs associated with the closure of Nelson quarry.

Figure 14.1: Case Study Approach



For both scenarios, we build the same year-by-year model that captures estimated aggregate extraction taking place at all 21 quarry sites in the region for a given year based on estimated remaining reserves and annual extraction limits. Because each site has finite reserves, the model also helps identify whether a given site can meet their annual demand requirements, and if not, which of the next closest sites would be capable of taking on the additional extraction volume to make up for annual supply shortfalls. Our model further takes into account the following rules:

- No site can extract more than their remaining reserves in a given year.
- No site can extract more than their annual extraction limit in a given year.
- The total annual demand is fixed and is defined as the total base annual extraction in Year 0 for all 21 sites.
- When a site cannot satisfy demand, it satisfies as much demand as is possible and then the next closest site picks up the excess demand.

For both scenarios, we calculate the incremental transportation and environmental costs associated with needing to source aggregates farther from market by inputting the incremental changes in distance (measured in kilometres) and the excess volume of aggregates or unsatisfied demand needing to come from farther away (measured in tonnes) into the following formulas as previously defined in this report:

- Transportation costs ($)[45] = (excess volume of aggregates)x($2.77 + $0.09x(change in kilometre distance))
- Diesel fuel consumption (litres)[46] = (excess volume of aggregates ÷ 32-tonne truckload)x(change in kilometre distance)x0.56
- GHG emissions (CO2 metric tonnes)[47] = (excess volume of aggregates ÷ 32-tonne truckload)x(change in kilometre distance)x0.001512

In some instances, because there are quarries that are extremely limited in the volume of aggregates they are allowed to extract annually, multiple sites farther away from market must work in tandem to ensure the necessary aggregate extraction takes place to meet demand should a quarry closer to market become unable to continue operating.

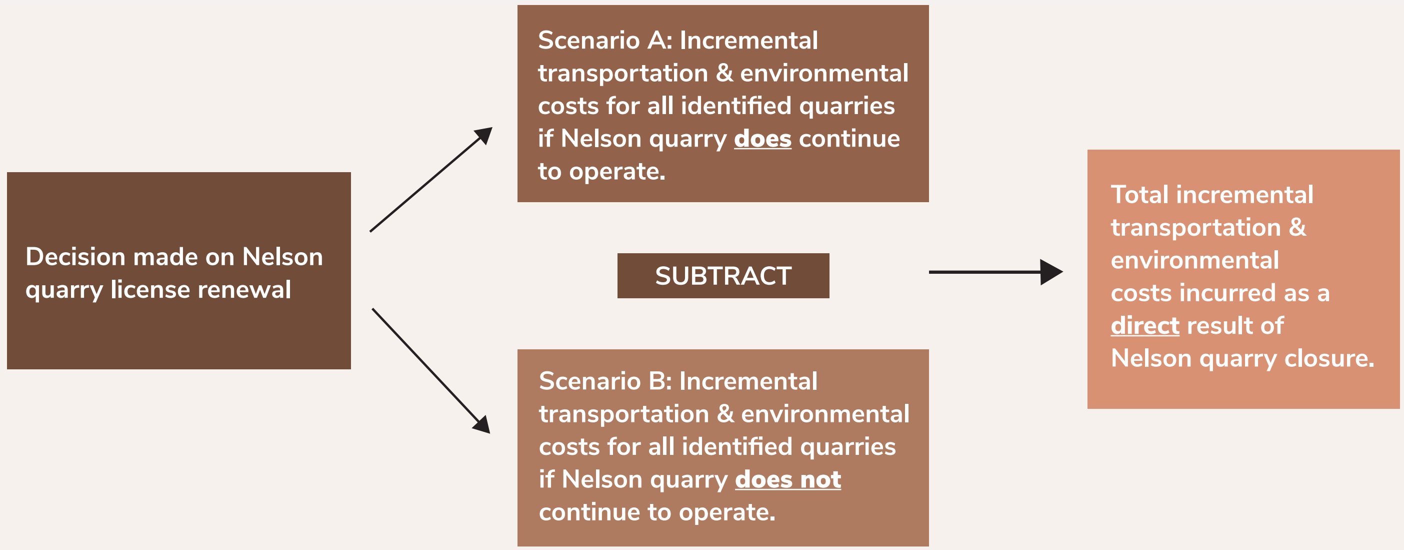
45 Using the cost equation estimated in Part Two of this report.

46 Producers estimate 0.56 litres of diesel fuel are consumed per kilometre travelled.

47 Using the available data, we find 0.0015122449 metric tonnes of GHGs are emitted per kilometre travelled (CO2 equivalent).

Finally, we calculate the difference between Scenarios A and B. This isolates the total incremental transportation and environmental costs incurred as a direct result of Nelson quarry's closure, and beyond the costs that would have naturally occurred due to reserves in the region depleting over time. In other words, in order to see the true additional costs incurred as a result of Nelson quarry closing, we subtract the total costs that would have been incurred in Scenario A from the total costs that are incurred in Scenario B (Figure 14.2).

Figure 14.2: Case Study Approach



Results

In Scenario A, we find that a number of sites eventually stop operating as a result of depleting their reserves. In Scenario B, we find that the closure of Nelson quarry significantly accelerates this depletion timeline and generates higher costs as sites located farther away from market increasingly take on more production volume to satisfy demand.

Figure 15 below illustrates the progression of sourcing aggregates farther away from market as sites become unable to produce the required volume for the region. Each point on the graph denotes the weighted average of distance to market associated with estimated annual extraction across all 21 sites (measured in millions of tonnes) in a given year.

Figure 15: Additional Transportation Distance to Market Associated with Estimated Annual Extraction in the Region

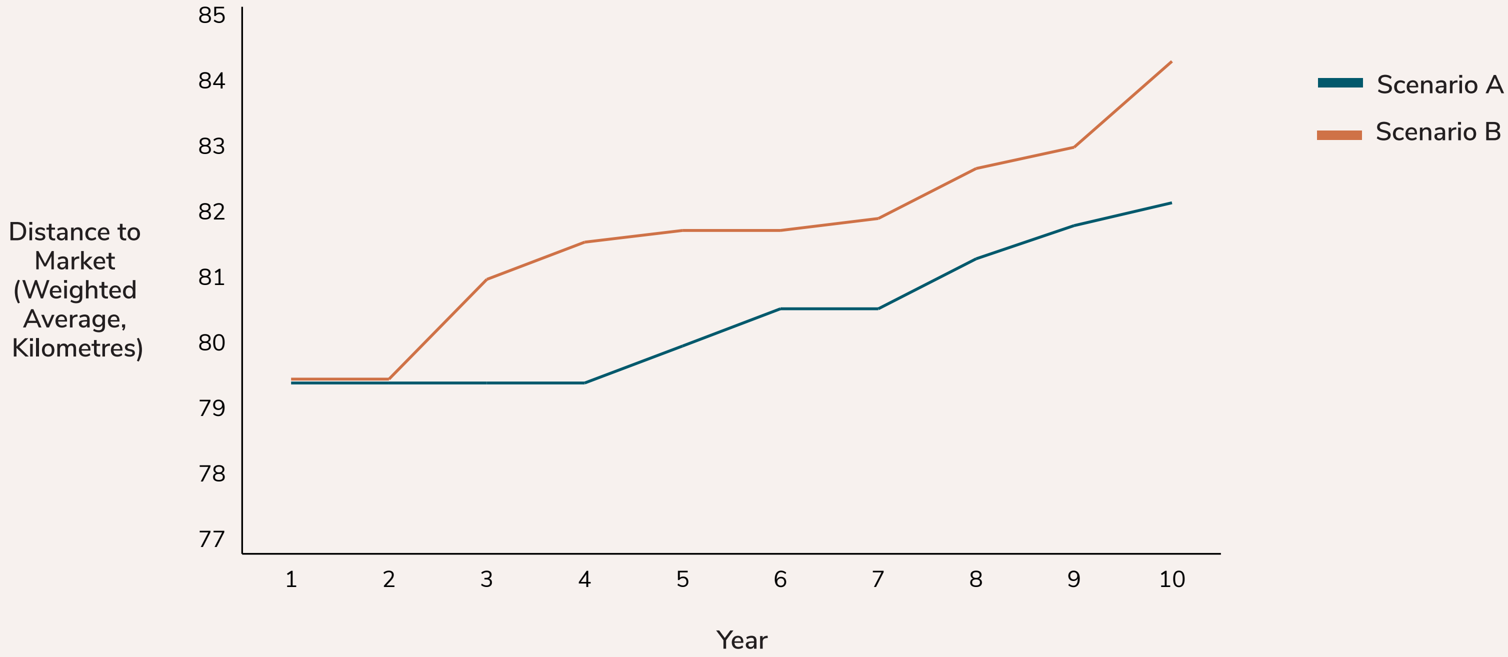


Figure 15 illustrates the average annual movement of aggregates by kilometre distance in both scenarios over the 10-year period used in this case study analysis.

Following Year 10, existing quarry sites within the region will no longer be able to sustain the total annual extraction volume needed to satisfy existing demand for aggregates and will begin to require supply from sites increasingly farther from market at well-over 148 kilometres away – an outcome that is realized at a much quicker pace given the Nelson quarry closure than what would have otherwise occurred.

Over the 10-year period, the total incremental transportation costs generated as a direct result of Nelson quarry's closure will amount to $206.3 million, or an average of $20.6 million per year. Additional diesel fuel consumption amounts to 5.8 million litres over 10 years (or an average of 580,000 litres per year), translating into nearly 16,000 metric tonnes of CO_2 emissions (or an average of 1,600 metric tonnes of CO_2 per year). Table 7 below summarizes these findings. For a more in-depth review of environmental externalities, see Part Three of this report.

Table 7: Summary of Results

	Ten-Year Incremental Totals	Annual Averages
Transportation Costs	$206,259,700	$20,625,970
Diesel Fuel Consumption (Litres)	5,796,525	579,653
GHG Emissions (Metric Tonnes of CO2)	15,759	1,576

Implications for the City of Burlington

Nelson quarry currently provides a number of economic benefits for the City of Burlington and greater Halton Region, particularly through local employment and revenue for the municipal and regional governments through taxes and levies. At present, 109 individuals are employed directly and indirectly as a result of Nelson quarry's operations in Burlington. This includes onsite jobs, such as employees responsible for crushing and processing the aggregates, quality control, supervising, administration, and maintenance, as well as staff employed offsite that are responsible for loading, hauling, shipping, and other support activities.[48]

From a revenue standpoint, a license approval for Nelson quarry is estimated to generate over $320,000 annually for the City of Burlington and over $125,000 for the greater Halton Region through property taxes and aggregate levies (Table 8). In addition to the transportation and environmental cost implications presented above, the discontinuation of Nelson quarry operations would have direct economic implications for the City of Burlington and Halton Region as a result of lost employment opportunities and annual revenues.

48 Figures provided by Nelson Quarry Co.

Table 8: Net Fiscal Impact - Nelson Quarry License Approval*[xlviii]

City of Burlington	
Property Taxes	$68,887
Aggregate Levy	$253,760
Total	$322,647
Halton Region	
Property Taxes	$63,064
Aggregate Levy	$62,400
Total	$125,464

*Based on 2 million tonnes of production per year
Source: Altus Group Economic Consulting

Evidently, a single site closure alone can generate significant cost implications for markets within and around the Greater Toronto Hamilton Area (GTHA).

This case study analysis illustrates a conservative picture of what would take place given the closure of Nelson Quarry Co. In reality, sites in different geographical locations do not contain the same type or quality of aggregates, making them less than perfect substitutes. Additionally, other constraints typically pose challenges for each site that would prevent them from taking on additional production; this includes labour shortages (which has been a long-standing issue within the aggregates and trucking industries) as well as other production capacity constraints such as insufficient or inadequate equipment. We also know that over the next decade, demand for aggregates will continue to grow, in contrast to the fixed demand we assumed for our model. As the population and infrastructure requirements increase in the GTHA, a growing volume of aggregates will need to be supplied from sites located increasingly farther away from market – a reality that does not come without a price tag.

Conclusion

This report demonstrates the importance of the aggregates industry for Ontario, the economic and environmental impacts of longer haul distances, as well as the many benefits associated with close-to-market aggregate production. Both the upstream and downstream portions of the industry's supply chain generate significant gross output, GDP, labour income, employment, and tax revenue. We find that an increase in the haul distance for transporting aggregates from pits and quarries to market can have sizeable economic and environmental implications through increased transportation costs and GHG emissions, especially for the GTHA.

By 2041, the GTHA is projected to consume another 1.5 billion tonnes of aggregates. Combined with inflationary pressures, rapid population growth, and economic growth, the increased transportation costs will have considerable budgetary impacts on all levels of government.

Furthermore, the aggregates industry will be front and centre to Ontario's economic recovery as governments across the country make historic investments in infrastructure over the next several years. Given the significant financial impact and pressures of COVID-19 on municipal budgets, Ontario's municipal infrastructure backlog amounted to $52 billion in 2020 – underscoring the importance of maximizing the value of every dollar spent to address the backlog.[xlix]

Lastly, for Ontario to meet its climate targets, it will need to significantly reduce GHG emissions from the transportation sector, which is the leading source of emissions in the province. At this time, close-to-market production can cost-effectively reduce emissions from aggregates. Going forward, further research should explore additional pathways to decarbonization, including zero-emission fleets, alternative modes of transportation, and the increased use of recycled aggregates.

Appendices

Appendix A: Total Production by Commodity Type (Metric Tonnes)[49]

Total Production by Commodity Type					
Year	**Stone**	**Sand & Gravel**	**Clay**	**Other**	**Total**
2000	58,704,000	99,848,000	1,771,259	2,634,000	162,957,259
2001	57,969,000	97,878,000	1,839,826	2,458,000	160,144,826
2002	55,945,000	95,464,000	1,773,697	2,480,000	155,662,697
2003	54,622,000	98,726,000	1,919,945	2,465,000	157,732,945
2004	59,584,000	99,581,000	1,606,147	2,137,000	162,908,147
2005	58,086,000	99,382,000	1,356,091	2,157,000	160,981,091
2006	65,860,000	99,671,000	1,356,091	2,325,000	169,212,091
2007	63,087,000	99,646,000	1,802,897	2,144,684	166,680,581
2008	64,754,000	90,158,000	1,288,765	2,124,485	158,325,250
2009	52,718,000	85,198,000	781,133	1,574,287	140,271,420
2010	71,543,000	83,327,000	1,215,105	1,671,088	157,756,193
2011	64,218,000	80,260,000	1,714,750	1,651,890	147,844,640
2012	58,461,000	81,226,000	918,644	1,565,250	142,170,894
2013	58,470,000	74,341,000	779,588	1,518,175	135,108,763
2014	61,106,000	77,288,000	801,789	1,486,100	140,681,889
2015	64,868,000	78,608,000	1,329,923	1,432,025	146,237,948
2016	66,191,000	74,297,000	936,568	1,388,950	142,813,518
2017	73,294,990	82,353,577	2,262,051	1,298,115	159,208,733
2018	73,174,335	79,560,452	1,075,556	1,224,930	155,035,273
2019	75,888,868	78,188,917	561,516	1,151,745	155,791,046

Sources: TOARC, Natural Resources Canada (NRCan), *Ministry of Energy, Northern Development and Mines* (ENDM), and the Ontario Chamber of Commerce

49 Shaded cells indicate projected values.

Appendix B: Total Aggregate Production Values (Current Dollars)[50]

Ontario Aggregate Production Value					
Year	Stone	Sand & Gravel	Clay	Other	Total
2000	$474,155,000	$395,832,000	$134,033,000	$143,811,000	$1,147,831,000
2001	$501,956,000	$390,272,000	$155,061,000	$123,910,000	$1,171,199,000
2002	$504,246,000	$405,317,000	$191,140,000	$130,378,000	$1,231,081,000
2003	$512,298,000	$437,893,000	$192,537,000	$136,361,000	$1,279,089,000
2004	$585,118,000	$451,134,000	$183,807,000	$147,457,000	$1,367,516,000
2005	$578,285,000	$463,376,000	$187,278,000	$146,123,000	$1,375,062,000
2006	$662,420,000	$491,109,000	$181,622,000	$151,608,000	$1,486,759,000
2007	$649,866,000	$490,428,000	$162,186,000	$147,920,437	$1,450,400,437
2008	$687,037,000	$544,406,000	$145,719,000	$146,469,892	$1,523,631,892
2009	$578,210,000	$486,136,000	$97,403,000	$103,451,923	$1,265,200,923
2010	$741,030,000	$517,824,000	$113,965,000	$135,503,866	$1,508,322,866
2011	$678,096,000	$485,091,000	$109,204,000	$138,672,241	$1,411,063,241
2012	$630,255,000	$496,303,000	$113,605,000	$125,004,159	$1,365,167,159
2013	$612,435,000	$488,572,000	$104,058,000	$119,835,864	$1,324,900,864
2014	$648,648,000	$475,223,000	$99,879,000	$115,246,295	$1,338,996,295
2015	$740,422,000	$526,006,000	$110,743,000	$113,185,679	$1,490,356,679
2016	$748,517,000	$498,856,000	$128,385,000	$109,475,540	$1,485,233,540
2017	$891,224,508	$559,917,861	$286,421,585	$105,089,879	$1,842,653,832
2018	$895,598,658	$550,498,632	$123,183,429	$103,757,771	$1,673,038,489
2019	$965,021,885	$545,348,921	$56,763,603	$97,087,983	$1,664,222,392

Sources: TOARC, Natural Resources Canada (NRCan), *Ministry of Energy, Northern Development and Mines* (ENDM), and the Ontario Chamber of Commerce

50 Actual and projected values included (reflective of FOB prices).

Appendix C: Per-Tonne Aggregate Production Values[51]

Aggregate Production Value per Tonne				
Year	Stone	Sand & Gravel	Clay	Other
2000	$8.08	$3.96	$75.67	$54.60
2001	$8.66	$3.99	$84.28	$50.41
2002	$9.01	$4.25	$107.76	$52.57
2003	$9.38	$4.44	$100.28	$55.32
2004	$9.82	$4.53	$114.44	$69.00
2005	$9.96	$4.66	$138.10	$67.74
2006	$10.06	$4.93	$133.93	$65.21
2007	$10.30	$4.92	$89.96	$68.97
2008	$10.61	$6.04	$113.07	$68.94
2009	$10.97	$5.71	$124.69	$65.71
2010	$10.36	$6.21	$93.79	$81.09
2011	$10.56	$6.04	$63.69	$83.95
2012	$10.78	$6.11	$123.67	$79.86
2013	$10.47	$6.57	$133.48	$78.93
2014	$10.62	$6.15	$124.57	$77.55
2015	$11.41	$6.69	$83.27	$79.04
2016	$11.31	$6.71	$137.08	$78.82
2017	$12.16	$6.80	126.62	$80.96
2018	$12.24	$6.92	$114.53	$84.71
2019	$12.72	$6.97	$101.09	$84.30

Sources: TOARC, Natural Resources Canada (NRCan), Ministry of Energy, Northern Development and Mines (ENDM), and the Ontario Chamber of Commerce.

51 Expressed in Current Dollars and representative of basic prices (reflective of FOB prices).

Appendix D: Total Upstream Economic Outputs (2019)[52]

Upstream Economic Outputs (2019)		Stone	Sand & Gravel	Clay	Other	Grand Total
Gross Output	Direct	$965,021,885	$545,348,921	$56,763,603	$97,087,983	$1,664,222,392
	Indirect	$454,525,308	$222,502,360	$23,159,550	$33,107,002	$733,294,220
	Induced	$197,829,486	$238,317,478	$24,805,695	$23,009,852	$483,962,511
	Total	$1,617,376,679	$1,006,168,759	$104,728,848	$153,204,838	$2,881,479,123
GDP at Basic Prices	Direct	$496,021,249	$306,486,093	$31,901,145	$60,194,550	$894,603,037
	Indirect	$238,360,406	$114,523,273	$11,920,357	$18,349,629	$383,153,664
	Induced	$115,802,626	$140,154,673	$14,588,246	$13,495,230	$284,040,774
	Total	$850,184,280	$561,164,039	$58,409,748	$92,039,408	$1,561,797,476
Labour Income	Direct	$151,508,436	$250,315,155	$26,054,494	$21,262,268	$449,140,353
	Indirect	$139,928,173	$67,623,266	$7,038,687	$10,679,678	$225,269,804
	Induced	$54,041,226	$64,896,522	$6,754,869	$6,310,719	$132,003,335
	Total	$345,477,835	$382,834,942	$39,848,049	$38,252,665	$806,413,492
Jobs	Direct	1,480	3,382	1,730	196	6,788
	Indirect	1,765	990	507	157	3,419
	Induced	1,004	1,350	691	137	3,182
	Total	4,248	5,722	2,927	490	13,388
Taxes	Federal	$13,850,008	$7,826,855	$814,672	$1,393,408	$23,884,943
	Provincial	$35,942,640	$20,311,746	$2,114,184	$3,616,082	$61,984,652
	Municipal	$36,604,268	$20,685,643	$2,153,102	$3,682,647	$63,125,659
	Indigenous	$88,137	$49,807	$5,184	$8,867	$151,996
	Total	$86,485,053	$48,874,052	$5,087,142	$8,701,004	$149,147,251

52 Jobs deflated to 2017 production values for consistency with 2017 Supply and Use Tables. Unlike other economic output variables, jobs are more sensitive to variability.

Appendix E: Upstream Tax Revenues by Jurisdiction and Type[53]

2019 Taxes by Type Total Impact, Closed Model		Stone	Sand & Gravel	Clay	Other	Total
Federal	Taxes on Products	$13,350,089	$7,544,344	$785,266	$1,343,113	$23,022,812
	Taxes on Production	$499,919	$282,512	$29,406	$50,295	$862,131
	Total	$13,850,008	$7,826,855	$814,672	$1,393,408	$23,884,943
Provincial	Taxes on Products	$24,017,308	$13,572,556	$1,412,723	$2,416,310	$41,418,897
	Taxes on Production	$11,925,331	$6,739,191	$701,461	$1,199,772	$20,565,755
	Total	$35,942,640	$20,311,746	$2,114,184	$3,616,082	$61,984,652
Municipal	Taxes on Products	-	-	-	-	-
	Taxes on Production	$36,604,268	$20,685,643	$2,153,102	$3,682,647	$63,125,659
	Total	$36,604,268	$20,685,643	$2,153,102	$3,682,647	$63,125,659
Indigenous	Taxes on Products	$88,137	$49,807	$5,184	$8,867	$151,996
	Taxes on Production	$-	$-	$-	$-	$-
	Total	$88,137	$49,807	$5,184	$8,867	$151,996
All Levels	Taxes on Products	$37,455,534	$21,166,707	$2,203,174	$3,768,290	$64,593,705
	Taxes on Production	$49,029,518	$27,707,346	$2,883,968	$4,932,714	$84,553,546
	Total	$86,485,053	$48,874,052	$5,087,142	$8,701,004	$149,147,251

53 The Total Impact, Closed Model includes direct, indirect, and induced effects.

Appendix F: Per-Tonne Upstream Economic Outputs (2019)

2019 Upstream Economic Outputs Per-Tonne	Stone	Sand & Gravel	Clay	Other	Total
Gross Output	$21.31	$12.87	$186.51	$133.02	$18.50
GDP at Basic Prices	$11.20	$7.18	$104.02	$79.91	$10.02
Labour Income	$4.55	$4.90	$70.97	$33.21	$5.18

Per-Tonne Upstream Taxation (2019)

2019 Per-Tonne Upstream Taxation	Stone	Sand & Gravel	Clay	Other	Total
Federal	$0.18	$0.10	$1.45	$1.21	$0.15
Provincial	$0.47	$0.26	$3.77	$3.14	$0.40
Municipal	$0.48	$0.26	$3.83	$3.20	$0.41

Appendix G

Regional breakdowns are identified by the Cement Association of Canada (CAC). The Southwest region (Area 1) includes Essex, Chatham-Kent, Lambton, Elgin, Middlesex, Huron, Perth, and Oxford; Peninsula region (Area 2) includes Niagara, Brant, Haldimand, Norfolk, and Hamilton; West Central region (Area 3) includes Bruce, Grey, Simcoe, Dufferin, Wellington, and Waterloo; GTA region (Area 4) includes Metro Toronto, Peel, York, Durham, and Halton; East Central region (Area 5) includes Kawartha Lakes, Peterborough, Haliburton, Northumberland, Hastings, Prince Edward, and Muskoka; East region (Area 6) includes Prescott & Russell, Leeds & Grenville, Stormont, Dundas, & Glengarry, Frontenac, Greater Ottawa, Lanark, Renfrew, and Lennox & Addington; Northeast region (Area 7) includes Nipissing, Parry Sound, Timiskaming, Cochrane, Sudbury District, Greater Sudbury, and Manitoulin; and the Northwest region (Area 8) includes Algoma, Thunder Bay, Kenora, and Rainy River.

Upstream Economic Outputs by Region (2019)

Production (2019)					
Region	Stone	Sand & Gravel	Clay	Other	Grand Total
Southwest (1)	5,565,280	15,784,465	66,124	46,753	21,462,622
Peninsula (2)	13,021,087	3,616,015	38,941	-	16,676,043
West Central (3)	9,644,583	25,848,233	27,993	215,773	35,736,582
GTA (4)	8,253,431	8,856,835	399,504	59,991	17,569,761
East Central (5)	12,229,332	9,361,935	9,559	416,937	22,017,763
East (6)	19,177,575	5,191,911	3,482	1,487,987	25,860,955
Northeast (7)	5,394,992	5,238,130	4,604	36,550	10,674,276
Northwest (8)	2,602,588	4,291,393	11,308	16,125	6,921,414
Total	75,888,868	78,188,917	561,516	2,280,115	156,919,416

GDP at Basic Prices					
Region	Stone	Sand & Gravel	Clay	Other	Grand Total
Southwest (1)	$62,347,927	$113,285,546	$6,878,319	$1,887,237	$184,399,029
Peninsula (2)	$145,875,459	$25,952,241	$4,050,702	$-	$175,878,402
West Central (3)	$108,048,428	$185,513,490	$2,911,874	$8,709,920	$305,183,712
GTA (4)	$92,463,328	$63,565,752	$41,557,013	$2,421,604	$200,007,697
East Central (5)	$137,005,415	$67,190,869	$994,342	$16,830,131	$222,020,756
East (6)	$214,846,699	$37,262,490	$362,203	$60,064,270	$312,535,662
Northeast (7)	$60,440,187	$37,594,205	$478,915	$1,475,382	$99,988,689
Northwest (8)	$29,156,838	$30,799,447	$1,176,275	$650,904	$61,783,464
Total	$850,184,280	$561,164,039	$58,409,748	$92,039,408	$1,561,797,476

Gross Output					
Region	**Stone**	**Sand & Gravel**	**Clay**	**Other**	**Grand Total**
Southwest (1)	$118,609,676	$203,121,314	$12,332,846	$3,141,414	$337,205,251
Peninsula (2)	$277,511,090	$46,532,443	$7,262,920	$-	$331,306,453
West Central (3)	$205,549,563	$332,626,228	$5,220,999	$14,498,158	$557,894,948
GTA (4)	$175,900,724	$113,973,579	$74,511,846	$4,030,898	$368,417,047
East Central (5)	$260,636,861	$120,473,424	$1,782,858	$28,014,712	$410,907,855
East (6)	$408,720,849	$66,811,753	$649,431	$99,980,399	$576,162,432
Northeast (7)	$114,980,424	$67,406,520	$858,696	$2,455,857	$185,701,497
Northwest (8)	$55,467,491	$55,223,499	$2,109,065	$1,083,466	$113,883,522
Total	$1,617,376,679	$1,006,168,759	$104,728,848	$153,204,838	$2,881,479,123

Labour Income					
Region	**Stone**	**Sand & Gravel**	**Clay**	**Other**	**Grand Total**
Southwest (1)	$25,335,480	$77,285,183	$4,692,497	$784,358	$108,097,518
Peninsula (2)	$59,277,428	$17,705,027	$2,763,453	$-	$79,745,908
West Central (3)	$43,906,171	$126,560,223	$1,986,527	$3,619,946	$176,072,867
GTA (4)	$37,573,066	$43,365,557	$28,350,849	$1,006,447	$110,295,919
East Central (5)	$55,673,029	$45,838,668	$678,356	$6,994,801	$109,184,854
East (6)	$87,304,334	$25,421,057	$247,101	$24,963,420	$137,935,912
Northeast (7)	$24,560,258	$25,647,359	$326,723	$613,186	$51,147,526
Northwest (8)	$11,848,068	$21,011,868	$802,474	$270,523	$33,932,933
Total	$345,477,835	$382,834,942	$39,848,049	$38,252,665	$806,413,492

Jobs					
Region	Stone	Sand & Gravel	Clay	Other	Grand Total
Southwest (1)	312	1,155	345	10	1,822
Peninsula (2)	729	265	203	-	1,197
West Central (3)	540	1,892	146	46	2,624
GTA (4)	462	648	2,083	13	3,206
East Central (5)	685	685	50	90	1,509
East (6)	1,074	380	18	320	1,792
Northeast (7)	302	383	24	8	717
Northwest (8)	146	314	59	3	522
Total	4,248	5,722	2,927	490	13,388

Sum of Taxes by Jurisdiction					
Region	Federal	Provincial	Municipal	Indigenous	Grand Total
Southwest (1)	$3,266,858	$8,477,938	$8,633,999	$20,789	$20,399,586
Peninsula (2)	$2,538,286	$6,587,195	$6,708,451	$16,153	$15,850,084
West Central (3)	$5,439,520	$14,116,288	$14,376,139	$34,615	$33,966,561
GTA (4)	$2,674,320	$6,940,222	$7,067,976	$17,018	$16,699,537
East Central (5)	$3,351,357	$8,697,224	$8,857,322	$21,327	$20,927,231
East (6)	$3,936,335	$10,215,322	$10,403,364	$25,050	$24,580,071
Northeast (7)	$1,624,748	$4,216,440	$4,294,056	$10,339	$10,145,583
Northwest (8)	$1,053,519	$2,734,024	$2,784,352	$6,704	$6,578,599
Total	$23,884,943	$61,984,652	$63,125,659	$151,996	$149,147,251

Appendix H: Ontario Industries Included in Downstream Modelling and Analysis

Industry Category	Industry	Proportion of Total Demand
Construction	Residential building construction	17%
	Non-residential building construction	3%
	Transportation engineering construction	17%
	Other engineering construction	2%
	Repair construction	6%
	Total - Construction	45%
Cement & Concrete Manufacturing	Cement and concrete product manufacturing	21%
	Total - Cement and concrete product manufacturing	21%
Public Sector*	Other federal government services (except defence)	1%
	Other provincial and territorial government services	4%
	Other municipal government services	4%
	Total - Public Sector	9%
Other	Copper, nickel, lead and zinc ore mining	1%
	Petroleum and coal product manufacturing (except petroleum refineries)	11%
	Paint, coating and adhesive manufacturing	1%
	Non-metallic mineral product manufacturing	9%
	Support activities for transportation	1%
	Electric power generation, transmission and distribution	1%
	Total - Other	25%
Grand Total		100.0%

Source: Statistics Canada
* Note that the public sector's consumption of aggregates does not account for contracted services, which would be captured by other industry categories such as construction.

Appendix I: Distribution of Upstream Production Value by Industry Demand (2019)[54]

Industry Category	Industry	Proportion of Total Demand
Construction	Residential building construction	$290,818,970
	Non-residential building construction	$46,982,465
	Transportation engineering construction	$290,678,223
	Other engineering construction	$28,801,268
	Repair construction	$97,370,551
	Total - Construction	$754,651,475
Cement & Concrete Manufacturing	Cement and concrete product manufacturing	$355,618,650
	Total - Cement and concrete product manufacturing	$355,618,650
Public Sector	Other federal government services (except defence)	$9,082,811
	Other provincial and territorial government services	$70,255,366
	Other municipal government services	$64,514,148
	Total - Public Sector	$143,852,324
Other	Copper, nickel, lead and zinc ore mining	$15,523,151
	Petroleum and coal product manufacturing (except petroleum refineries)	$184,789,003
	Paint, coating and adhesive manufacturing	$14,686,166
	Non-metallic mineral product manufacturing	$151,315,389
	Support activities for transportation	$20,975,952
	Electric power generation, transmission and distribution	$22,810,281
	Total - Other	$410,099,942
Grand Total		$1,664,222,392

Source: Statistics Canada

54 Industry consumption at basic prices.

Appendix J: Total Economic Outputs of Downstream Industry Aggregate Consumption[55]

Downstream Economic Outputs (2019)		Construction	Cement & Concrete	Public Sector	Other	Downstream Industries Total
Gross Output	Direct	$754,651,475	$355,618,650	$143,852,324	$410,099,942	$1,664,222,392
	Indirect	$768,453,862	$362,122,826	$146,483,347	$417,600,568	$1,694,660,603
	Induced	$147,074,168	$69,306,585	$28,035,407	$79,924,455	$324,340,615
	Total	$1,670,179,506	$787,048,061	$318,371,078	$907,624,965	$3,683,223,610
GDP	Direct	$349,086,903	$135,490,706	$72,955,857	$143,886,542	$701,420,008
	Indirect	$411,882,132	$194,093,529	$78,513,332	$223,828,938	$908,317,932
	Induced	$86,076,115	$40,562,130	$16,407,904	$46,776,308	$189,822,457
	Total	$847,045,150	$370,146,365	$167,877,093	$414,491,788	$1,799,560,397
Labour Income	Direct	$253,531,199	$81,081,052	$51,148,545	$67,534,866	$453,295,663
	Indirect	$212,110,641	$99,954,088	$40,432,716	$115,267,199	$467,764,644
	Induced	$40,118,618	$18,905,321	$7,647,446	$21,801,644	$88,473,029
	Total	$505,760,459	$199,940,461	$99,228,707	$204,603,709	$1,009,533,336
Jobs	Direct	3,488	909	597	767	5,760
	Indirect	2,900	1,367	553	1,576	6,395
	Induced	809	381	154	440	1,784
	Total	7,196	2,656	1,304	2,782	13,939

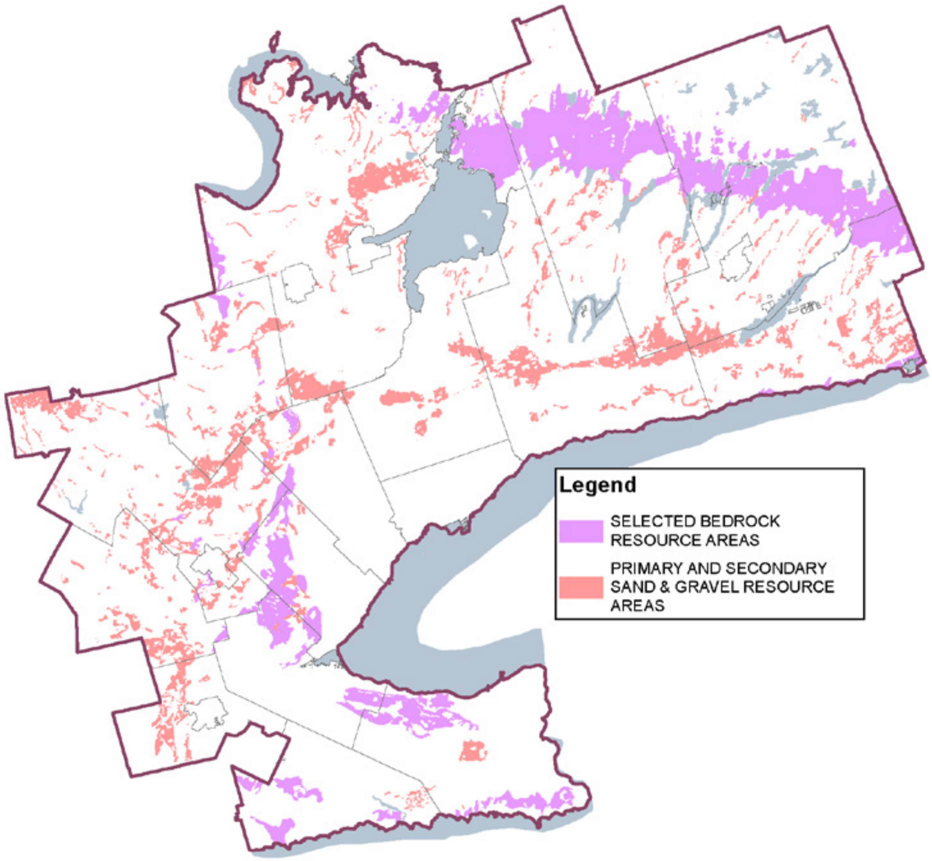
55 Values expressed in basic (direct effects) and purchasers' prices (indirect and induced). Jobs deflated to 2017 production values, all else is 2019 dollars.

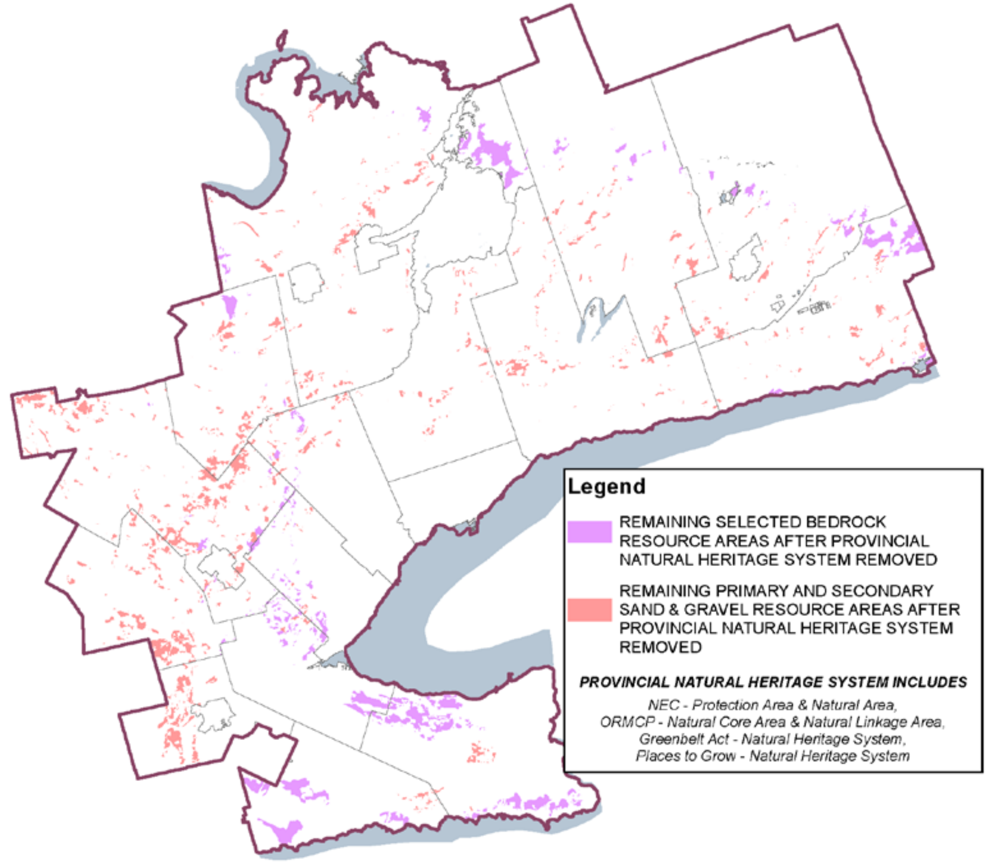
Appendix K: Taxes Generated by Downstream Aggregate Consumption[56]

Downstream Taxes by Jurisdiction (2019)		
Federal	Taxes on products	$17,064,480
	Taxes on production	$549,325
	Total	$17,613,805
Provincial	Taxes on products	$31,748,091
	Taxes on production	$13,103,902
	Total	$44,851,993
Municipal	Taxes on products	$-
	Taxes on production	$40,221,838
	Total	$40,221,838
Indigenous	Taxes on products	$104,332
	Taxes on production	$-
	Total	$104,332
Total		$102,791,968

56 Includes all downstream industries that consume stone, sand, gravel, clay, and other refractory minerals, other non-metallic mineral (except diamond and potash).

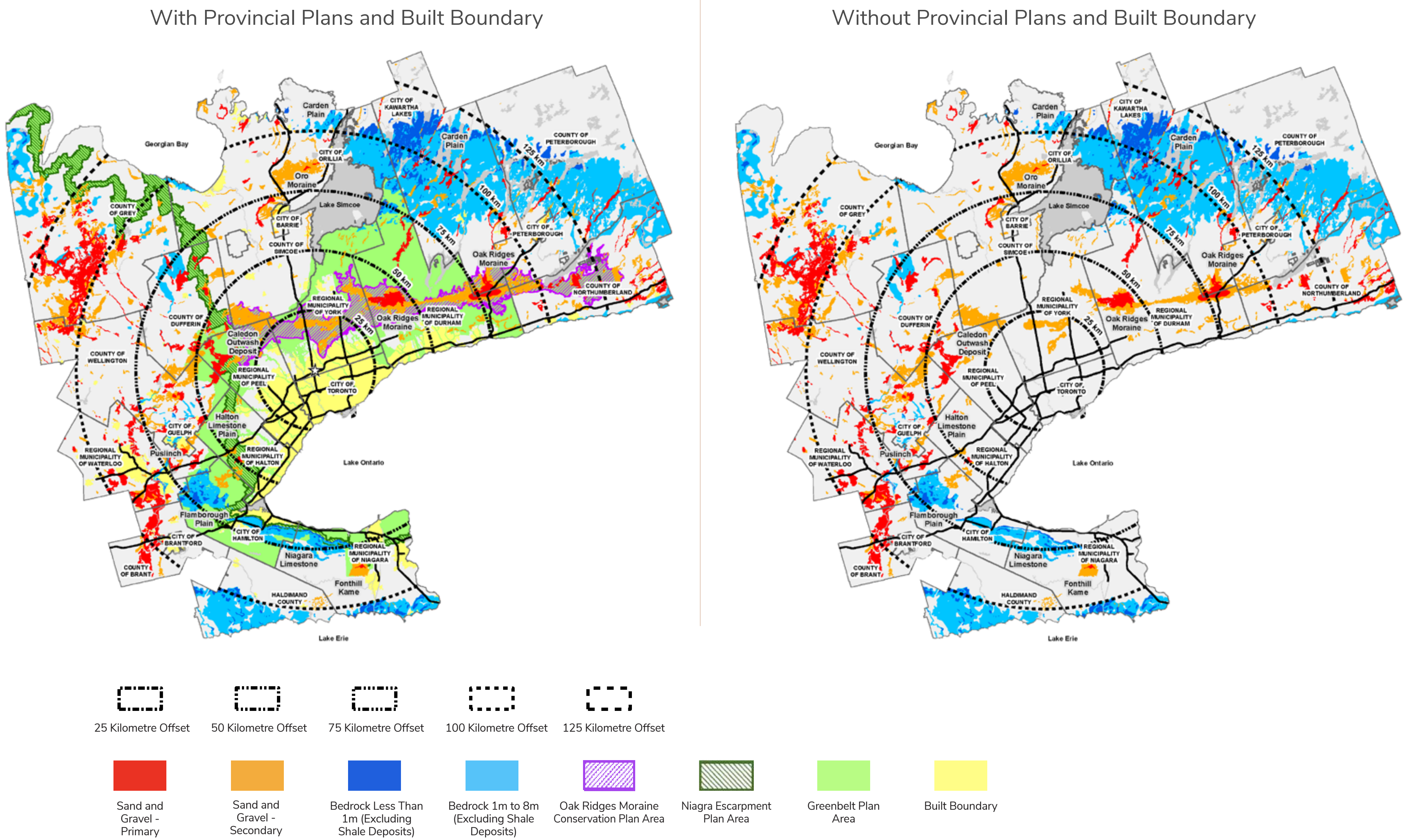
Appendix L: Areas within the GTHA Eligible for Extraction Before (Left) and After (Right) Natural Heritage System (NHS) Restrictions in Provincial Plan





Source: MHBC Planning

Appendix M: Key Deposit Areas in and Around the Greater Toronto Area (GTA): With and Without Provincial Plans and Built Boundary[57]



Source: MHBC Planning, Urban Design & Landscape Architecture

57 Built boundary refers to the limits of the developed urban area and consists of delineated and undelineated built-up areas.

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