REPORT

Blast Impact Assessment

Proposed Caledon Pit / Quarry

Submitted to:

CBM Aggregates, a division of St. Marys Cement Inc. (Canada)
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Toronto ON M4G 3W9

Submitted by:

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19129150

December 2022 (Revised July 2023)

Distribution List

1 e-copy: CBM Aggregates, a division of St. Marys Cement Inc. (Canada)

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Table of Contents

TABLES

FIGURES

APPENDICES

APPENDIX A
Terms of Reference

APPENDIX B
Definition of Blasting Terms and Glossary of Blasting Terms

APPENDIX C
Publication NPC-119, Model Municipal Noise Control By-Law, Final Report, 1978

APPENDIX D
Nearest Receptors to the Proposed Caledon Pit / Quarry

APPENDIX E
Enbridge Third-Party Requirements in the Vicinity of Natural Gas Facilities Standard

APPENDIX F
Curriculum Vitae

1.0 INTRODUCTION

1.1 General

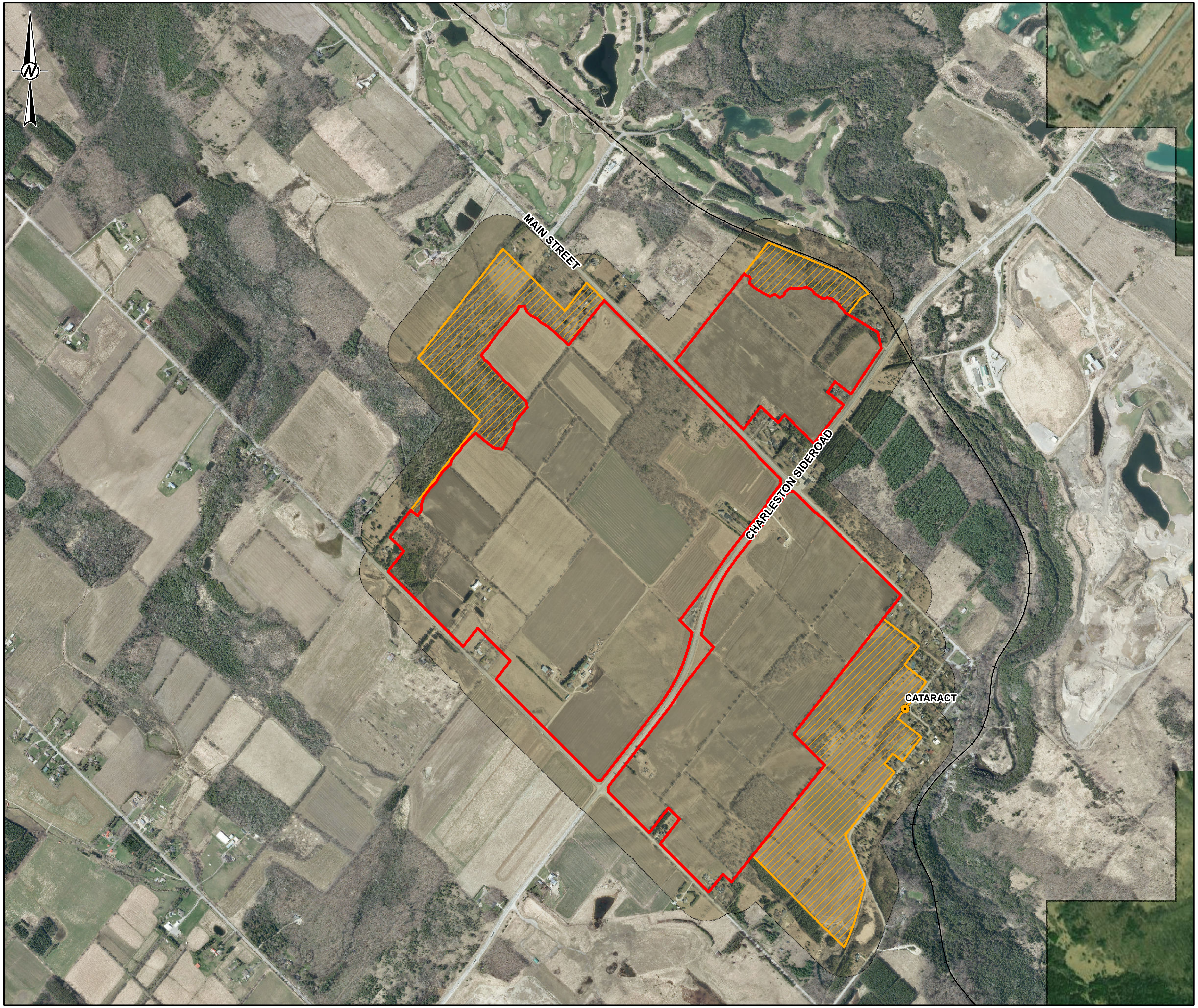
CBM Aggregates (CBM), a division of St. Marys Cement Inc. (Canada) is applying to the Ministry of Natural Resources and Forestry (MNRF) for a Class A Licence (Pit and Quarry Below Water) and to the Town of Caledon for an Official Plan Amendment and Zoning By-law Amendment to permit a mineral aggregate operation (Figure 1). Golder Associates Ltd. (Golder) has been retained by CBM to complete a Blast Impact Assessment for the proposed CBM Caledon Pit / Quarry in accordance with the Terms of Reference developed in consultation with the Development Application Review Team (DART) (Appendix A). and the MNRF, Aggregate Resources Act Ontario Regulation 244/97. A Blast Impact Assessment (BIA) is required if a sensitive receptor is within 500 metres of the limit of excavation to demonstrate that provincial guidelines for blast overpressure and ground vibration can be satisfied.

CBM owns / controls approximately 323 hectares of land located at the northwest, northeast and southwest intersection of Regional Road 24 (Charleston Sideroad) and Regional Road 136 (Main Street). Of these lands, approximately 261 hectares are proposed to be licenced under the Aggregate Resources Act and designated / zoned under the Planning Act to permit the proposed CBM Caledon Pit / Quarry. These lands are mapped as a Caledon High Potential Mineral Aggregate Resource Area (CHPMARA) in the Town of Caledon Official Plan and High Potential Mineral Aggregate Resource Area (HPMARA) in the Region of Peel Official Plan and are protected for their aggregate potential.

The remaining 62 hectares of land owned / controlled by CBM are not subject to the application. These lands are referred to as “CBM Additional Lands” and these lands include approximately 36 hectares of land that is located adjacent to the minor urban centre of Cataract. As part of the application, CBM is proposing to create an upland forest and meadow grassland on these lands and is exploring the potential of conveying them permanently to a public authority for long term protection.

The lands proposed to be licenced under the Aggregate Resources Act are referred to as the “Subject Site” or “Site” and are legally described as Part of Lots 15-18, Concession 4 WSCR and Part of Lot 16, Concession 3 WSCR (former Geographic Township of Caledon). The Subject Site is approximately 261 hectares and extraction is proposed on approximately 200 hectares. These lands are referred to as the “Extraction Area”. The remaining approximate 61 hectares within the Subject Site and outside of the Extraction Area are referred to as the “Setback / Buffer Lands”. The Setback / Buffer Lands are used to provide setbacks to surrounding land uses and natural heritage features and the majority of these lands include a 5-metre visual / acoustic berm and visual plantings (Figure 2). For the purpose of this study, “Adjacent Lands” are defined as lands within 120 m of the Subject Site and the Study Area for this assessment includes lands within 500 m of the Subject Site.

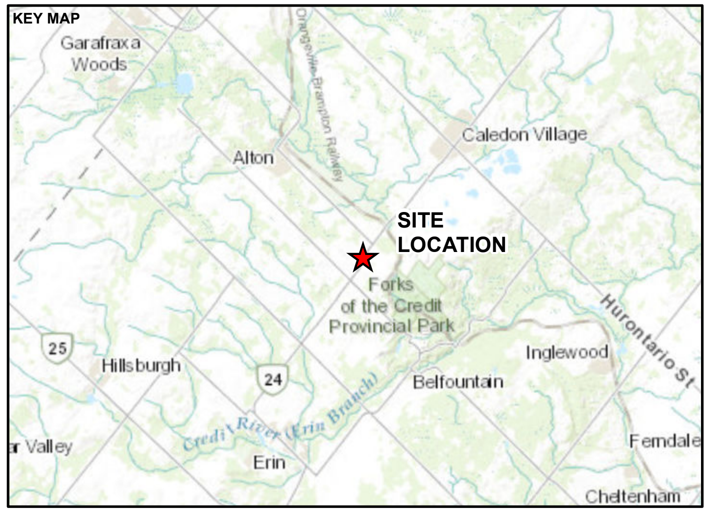
The proposed Extraction Area includes approximately 78 million tonnes of a high-quality bedrock resource and approximately 4 million tonnes of a high-quality sand and gravel resource. Testing has confirmed that the mineral aggregate resource found on-site is suitable for the production of a wide range of construction products, including the use for high performance concrete. The bedrock resource provides some of the strongest and most durable aggregate material in Southern Ontario. The primary market area for the proposed CBM Caledon Pit / Quarry is the Greater Toronto Area, including the Town of Caledon and the Region of Peel. This site represents a close to market source of a high-quality mineral aggregate resource.



LEGEND

- TOWN/VILLAGE
- LICENCE BOUNDARY
- ADDITIONAL LANDS OWNED / CONTROLLED BY CBM

KEY MAP



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REFERENCE(S)

1. BASE DATA MNRF LIO OBTAINED 2020
2. IMAGERY FIRSTBASE SOLUTIONS SPRING 2021, SPRING 2019 (15CM RESOLUTION) AND SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY SOURCE: ESRI, MAXAR, EARTHSTAR GEOGRAPHICS, AND THE GIS USER COMMUNITY
3. SITE TOPOGRAPHIC DATA - SPRING 2021, FIRSTBASE SOLUTIONS, 2021
4. LICENSE AND EXTRACTION LIMIT PROVIDED BY MHBC IN JULY 2023
5. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT

CBM AGGREGATES, A DIVISION OF ST. MARYS CEMENT INC. (CANADA).

PROJECT

CALEDON PIT / QUARRY

TITLE

SITE LOCATION PLAN

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2023-07-19
DESIGNED	CGE
PREPARED	CGE
REVIEWED	DC
APPROVED	HM

PROJECT NO.	CONTROL	REV.	FIGURE
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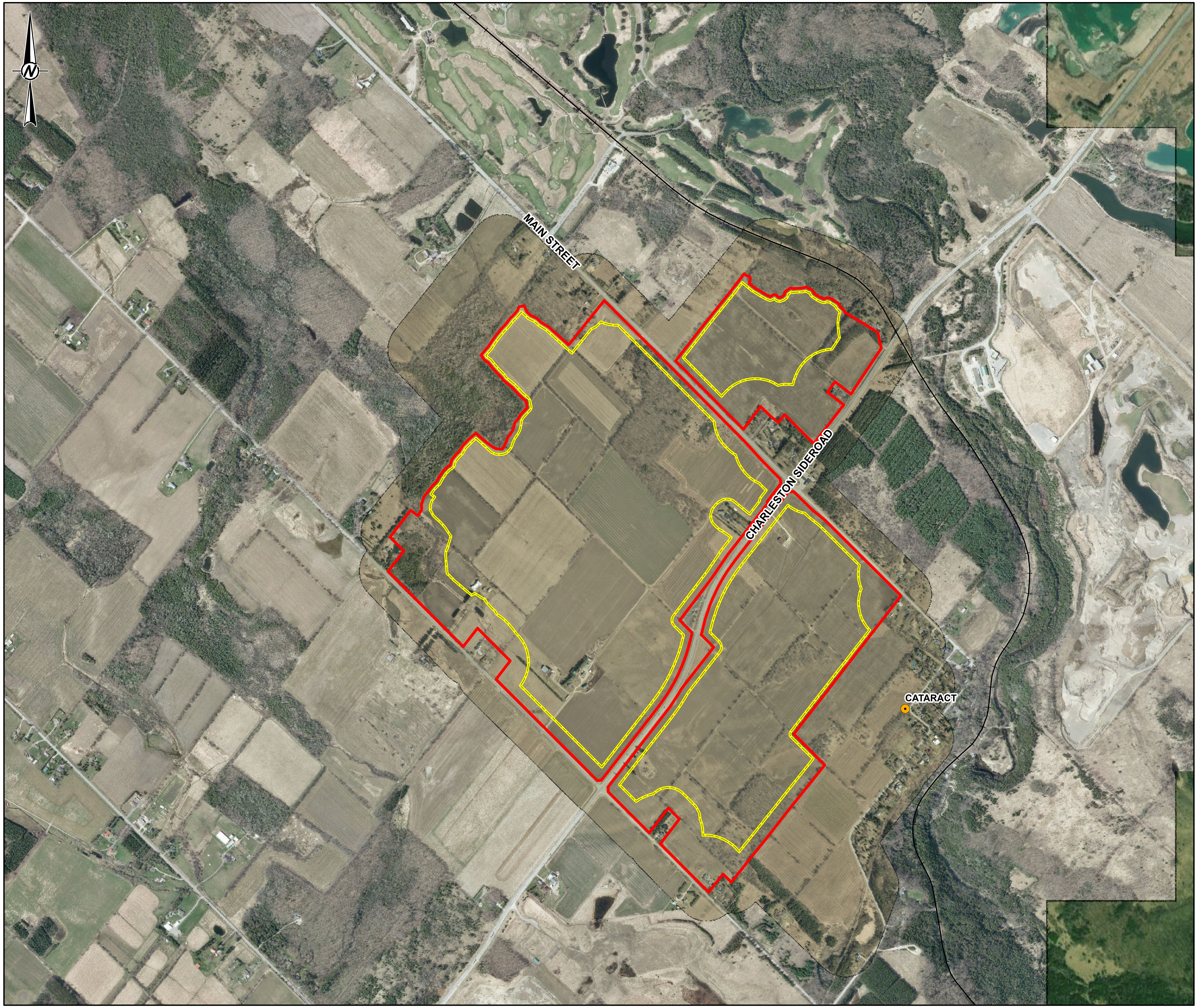

LEGEND

- TOWN/VILLAGE
- LIMIT OF EXTRACTION
- LICENCE BOUNDARY

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REFERENCE(S)

1. BASE DATA MNRF LIO OBTAINED 2020
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CLIENT
CBM AGGREGATES, A DIVISION OF ST. MARYS CEMENT INC. (CANADA).

PROJECT
CALEDON PIT / QUARRY

TITLE
PROPOSED QUARRY LICENCE BOUNDARY AND EXTRACTION LIMIT

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2023-07-19
DESIGNED	CGE
PREPARED	CGE
REVIEWED	DC
APPROVED	HM

PROJECT NO.	CONTROL	REV.	FIGURE
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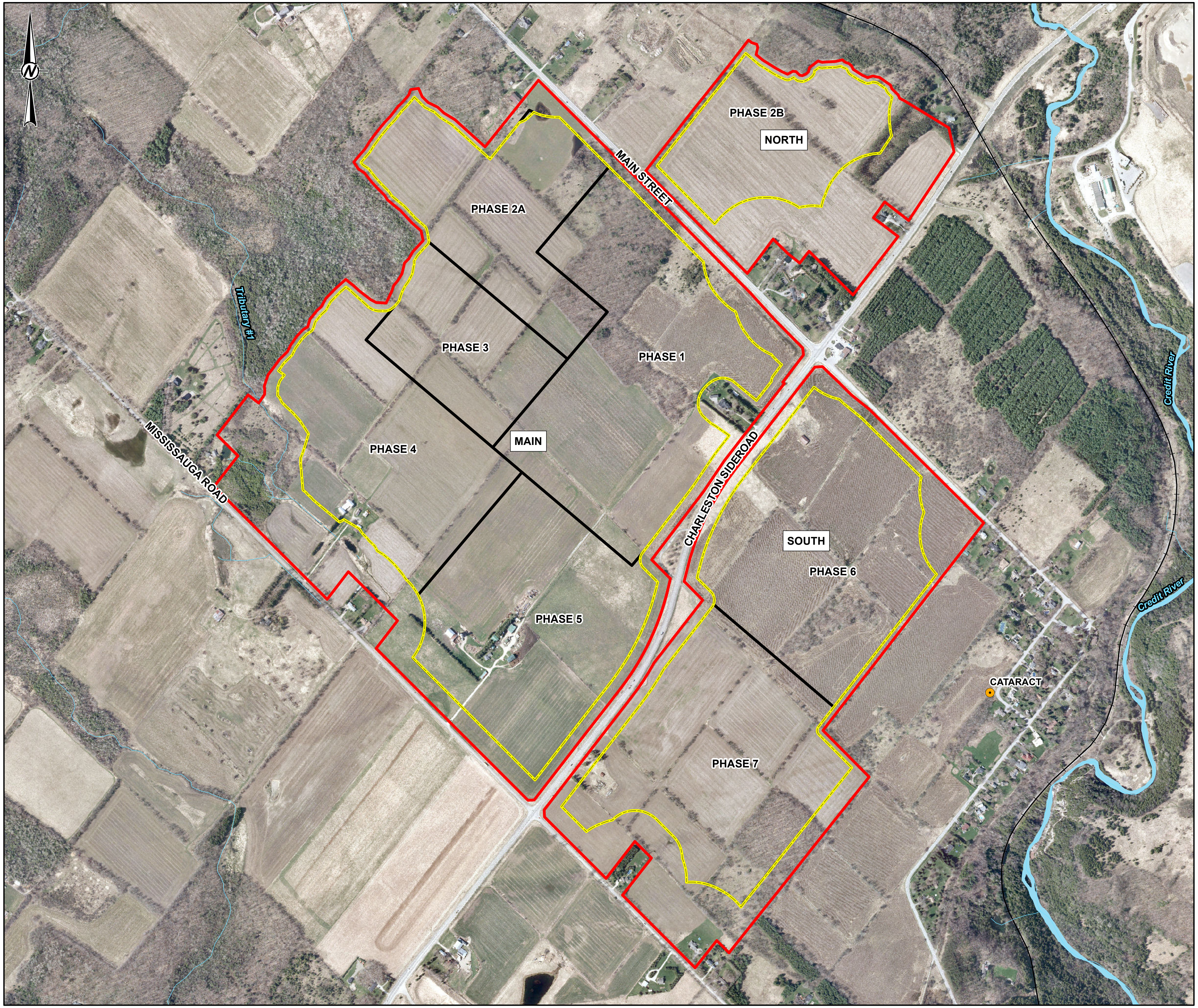
The proposed tonnage limit for the proposed CBM Caledon Pit / Quarry is 2.5 million tonnes per year and on average CBM anticipates shipping approximately 2.0 million tonnes per year. The proposed CBM Caledon Pit / Quarry is proposed to be operated in 7 phases. Phases 1, 2A, 3, 4, 5 are located to the northwest of the intersection of Regional Road 24 and 136. This area is referred to as the "Main Area". Phase 2B is located to the northeast of the intersection of Regional Road 24 and 136. This area is referred to as the "North Area". Phases 6 and 7 are located to the southwest of the intersection of Regional Road 24 and 136. This area is referred to as the "South Area". Figure 3 display the extraction phases for the site.

Operations would commence in the Main Area and Phase 1 would include the permanent processing area (crushing, screening and wash plant), aggregate recycling area and the entrance / exit for the CBM Caledon Pit / Quarry. Until such time as sufficient space is opened up to establish the permanent processing area, a temporary mobile crushing and processing plant is proposed to be used in Phase 1. The entrance / exit for the CBM Caledon Pit / Quarry is proposed to be located onto Regional Road 24, approximately 775 m west of Regional Road 136. The entrance / exit is proposed to be controlled by a new traffic light and the installation of taper lanes and acceleration lanes on Regional Road 24 at CBM's expense. The primary haul route for the proposed CBM Caledon Pit / Quarry is trucks will travel eastward on Regional Road 24 and then southward on Highway 10. The proposed haul route is an existing aggregate haul route and is designated as an aggregate haul route in the Town of Caledon Official Plan.

Access to the North Area for aggregate extraction is anticipated approximately 10 years after the start of the operations in the Main Area. There will be no processing in the North Area and aggregate extracted from the North Area is proposed to be moved to the Main Area through a proposed tunnel underneath Regional Road 136 or a truck crossing. Access to South Area is anticipated approximately 30 years after the start of the operations in the Main Area. In the South Area, CBM is proposing to permit a portable processing plant and the aggregate extracted and /or processed from the South Area is proposed to be moved to the Main Area through a proposed tunnel underneath Regional Road 24 or a truck crossing. Aside from the establishment of a 1 hectare stormwater settling pond on the easternmost portion of the North Area in the initial year of operation, the North and South areas will be maintained in their current state and agricultural uses until they are required for preparation for aggregate extraction.

The CBM Caledon Pit / Quarry is proposed to operate (extraction, processing and drilling) 7:00 am to 7:00 pm Monday to Saturday, excluding statutory holidays and shipping is proposed from 6:00 am to 7:00 pm Monday to Saturday consistent with other mineral aggregate operations in Caledon. CBM is also proposing to permit limited shipping in the nighttime (7:00 pm to 6:00 am) to support public authority contracts that require the delivery of aggregates during these hours to complete public infrastructure projects. These activities will be limited to only highway trucks and shipping loaders and no other operations will be permitted during nighttime hours. Site preparation and rehabilitation is proposed to be permitted 7:00 am to 7:00 pm Monday to Friday.

The proposed CBM Caledon Pit / Quarry involves stripping topsoil and overburden from the subject site to create perimeter berm and any excess soil will be temporarily stored in the northern portion of the Main Area or used for progressive rehabilitation of the site. The proposed Extraction Area includes extracting both sand and gravel below the water table and the site will be dewatered to allow operations in a dry state. The site will be extracted in sequence of the proposed phases (Phase 1 to 7) and following extraction of Phase 7 the permanent processing plant in Phase 1 will be removed and this will be the final area to be extracted and rehabilitated. The phasing of the proposed mineral aggregate operation has been designed to reach final extraction limits and depths within each phase so progressive rehabilitation of the side slopes can be completed.



LEGEND

- TOWN/VILLAGE
- ROAD
- RAILWAY
- WATERCOURSE
- WATERBODY
- LICENCE BOUNDARY
- LIMIT OF EXTRACTION
- EXTRACTION PHASE

REFERENCE(S)

1. BASEDATA MNRF LIO OBTAINED APRIL 2019
2. WATERCOURSES OBTAINED FROM CREDIT VALLEY CONSERVATION AUTHORITY OPEN DATA PORTAL, NOVEMBER 2022 IN COMBINATION WITH SITE WATERCOURSE SURVEY PROVIDED BY FIRST BASE SOLUTIONS NOVEMBER 2021.
3. IMAGERY FIRSTBASE SOLUTIONS SPRING 2019 (15CM RESOLUTION) AND SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY SOURCE: ESRI, MAXAR, EARTHSTAR GEOGRAPHICS, AND THE GIS USER COMMUNITY
4. LICENCE AND LIMIT OF EXTRACTION PROVIDED BY MHBC JUNE 2023
5. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
CBM AGGREGATES, A DIVISION OF ST. MARYS CEMENT INC. (CANADA)

PROJECT
CALEDON PIT / QUARRY

TITLE
EXTRACTION PHASES

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2023-07-19
DESIGNED	SO
PREPARED	SO
REVIEWED	GWS
APPROVED	HM

PROJECT NO.	CONTROL	REV.	FIGURE
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The overall goal of the final rehabilitation plan is to create a landform that represents an ecological and visual enhancement and provides future opportunities for conservation, recreational, tourism and water management. Overall, the progressive and final rehabilitation plan for the Site includes the creation of lakes, vegetated shorelines, hectares of islands, wetlands, upland forested areas, riparian plantings adjacent to the existing watercourse, nodal shrub and tree planting on upland areas, grassland meadows and specialized habitat features for bats and turtles. The proposed rehabilitation has been designed to use of all of the on-site topsoil and overburden and does not require the importation of additional soils.

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The BIA assessed the proposed CBM Caledon Pit / Quarry and based on the implementation of the recommendations found in Section 8.0 of this report, this assessment concluded the following:

- It is Golder's opinion that blasting operations may be performed at Site in compliance with the current quarry blasting guidelines published by the Ontario Ministry of Environment, Conservation and Parks (MECP) (NPC-119).
- This should be confirmed with the results of the monitoring program given that the analysis is based on largely on literature values, results from other quarries, and limited site data.
- Through proper blast design and diligence in inspecting the geology before every blast, flyrock will be maintained within the proposed quarry extraction limits.
- All blasting and blast monitoring would occur in accordance with the Aggregate Resources Act (Ontario Ministry of Natural Resources and Forestry, 2017) prescribed conditions in order to ensure compliance with the provincial guidelines.

The proposed Aggregate Resources Act Site Plans include all of the technical recommendations from this report to ensure that the site operates in accordance with applicable provincial standards and the applicable policy requirements of the Provincial Policy Statement, Places to Grow Plan, Greenbelt Plan, Region of Peel Official Plan and Town of Caledon Official Plan.

1.2 Study Overview

The blasting impact assessment addresses the environmental effects from blasting operations within the proposed extraction areas of the Site. The impact assessment specifically addresses whether the applicable MECP guideline (NPC-119) with respect to ground and air vibration effects can be met at the nearest sensitive Point(s) of Reception (POR(s)).

The investigation involved an initial site visit on August 12, 2021 to view the property, as well as a review of the ground and air vibration monitoring results from blasting operations at other limestone quarries in southern Ontario. A site visit was carried out on November 23, 2021 to identify the PORs for the proposed quarry site. A recent visit was made on November 18, 2022.

The following report is an assessment of the potential effects from blasting operations for the proposed quarry. Specifically, this report assesses the potential effects of ground and air vibration levels that could be produced by the proposed quarry blasting operations on neighbouring receptors, such as residences, pets and livestock, structures, water wells and fish spawning depressions, and whether these effects meet the applicable recommended provincial and federal guidelines. The report also assesses the potential impact of flyrock form the proposed quarry blasting operations.

This impact assessment specifically addressed whether the applicable MECP guidelines, with respect to ground and air vibration effects from quarry blasting operations, could be met at the nearest PORs. This report addresses the following topics:

- Review of current provincial and federal guidelines for the assessment of environmental impacts from blasting.
- Assessment of compliance with the current provincial and federal guidelines.
- Recommendations for the control of ground and air vibration and flyrock effects.
- The potential impact of the blasting operations on bedrock strata and adjacent water wells.
- The long-term impact of the blasting operations on surrounding structures.

2.0 DESCRIPTION OF PROPOSED DEVELOPMENT

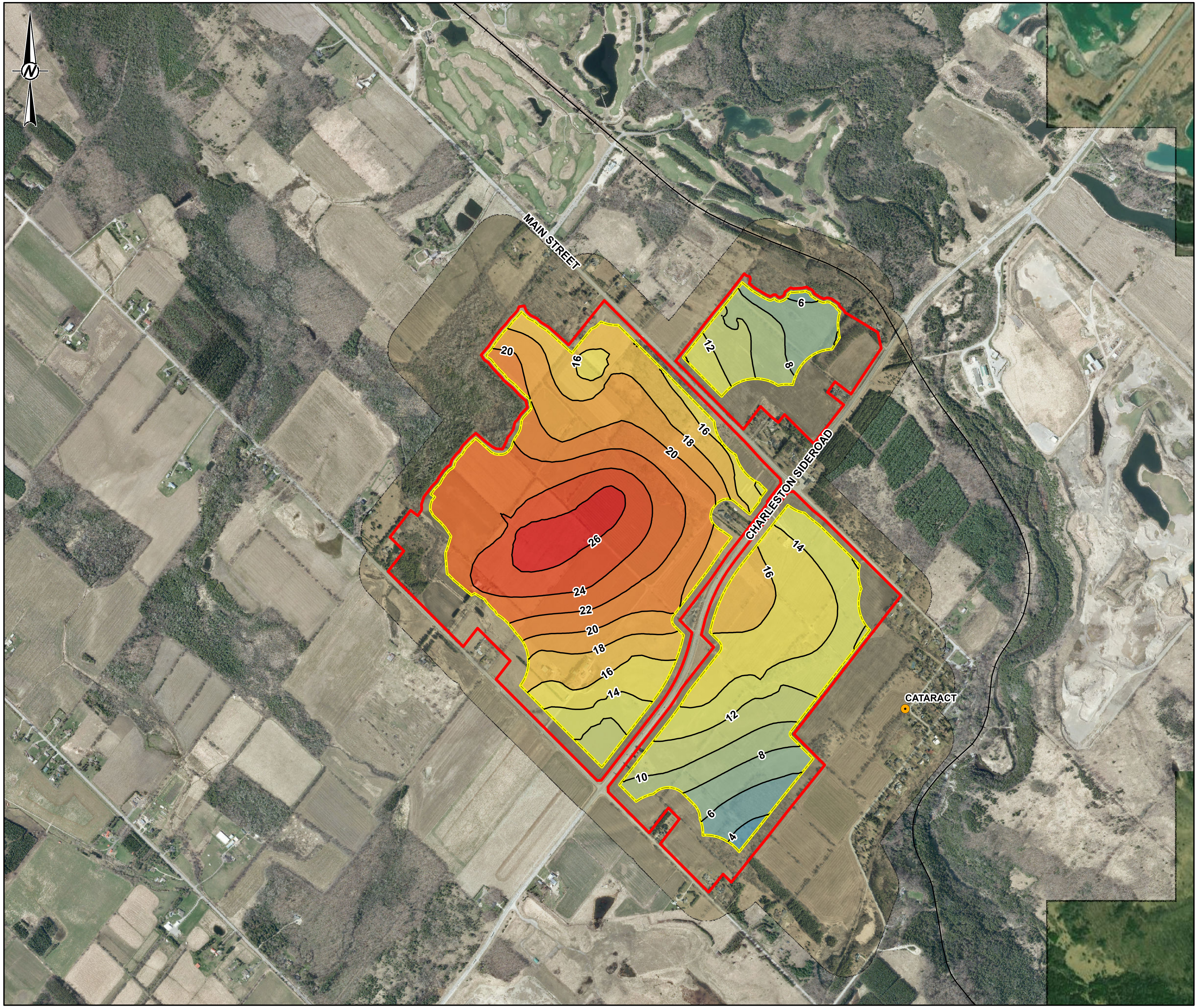
Class A Quarry Below Water Licence Aggregate extraction will occur below the water table. Aggregate extraction will also occur below the water table in three areas referred to as the “north pond”, “middle pond” and “south pond”. The elevation of the quarry floor will be to the base of the Gasport Formation with elevations ranging form approximately 370 m to 395 masl.

The pit walls above the water table will slope at 3:1 and the pit walls below the water table will slope at 2:1. The portion of the above water table extraction at the western border of the site will be connected to the adjacent pit. The below water extraction areas were designed to reduce potential impacts to the natural environment and avoid creating dams on the downgradient side of the “ponds”.

A permanent processing facility would be installed in Phase 1, situated generally in the centre of the site (north of Charleston Sideroad) approximately 5 years after start of operations.

A drilling program by Golder indicates that the thickness of the targeted limestone lithology (Gasport Formation) ranges from 8 m to 27 m (see Figure 4). In general, there is a thickening of the Gasport Formation from South to North and from East to West within the Site. The Ontario Occupational Health and Safety Act, R.R.O. 1990, Reg. 854, section 89.1.a states that where metallic or non-metallic rock is being removed from a surface mine, the vertical height of the working face shall not be more than twenty-five (25) metres. Thus, blasts can range from 8 m to 25 m in depth. Required extraction depths greater than 25 m will require two (2) benches to achieve full extraction. Figure 5 shows the area at the site where the Gasport formation thickness is greater than 25 m.
The initial blasts will have a bench height of about 8 m to 12 m. This will require a second bench to reach the bottom of the formation. From there the blasts are intended to excavate the full formation thickness in one bench.

It is estimated that a maximum of 2.5 million tonnes will be extracted annually. The quarry is anticipated to operate throughout the year.



LEGEND

- TOWN/VILLAGE
- INFERRED GASPORT FORMATION THICKNESS CONTOUR (2 m INTERVAL)
- LIMIT OF EXTRACTION
- LICENCE BOUNDARY

INFERRED GASPORT FORMATION THICKNESS (m)

- 1 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16 - 18
- 18 - 20
- 20 - 22
- 22 - 24
- 24 - 26
- 26 - 28

0 500 1,000

1:15,000 METRES

REFERENCE(S)

1. BASE DATA MNRF LIO OBTAINED 2020
2. IMAGERY FIRSTBASE SOLUTIONS SPRING 2021, SPRING 2019 (15CM RESOLUTION) AND SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY SOURCE: ESRI, MAXAR, EARTHSTAR GEOGRAPHICS, AND THE GIS USER COMMUNITY
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CLIENT

CBM AGGREGATES, A DIVISION OF ST. MARYS CEMENT INC. (CANADA).

PROJECT

CALEDON PIT / QUARRY

TITLE

INFERRED GASPORT FORMATION THICKNESS

CONSULTANT

GOLDER MEMBER OF WSP

YYYY-MM-DD	2023-07-19
DESIGNED	CGE
PREPARED	CGE
REVIEWED	DC
APPROVED	HM

PROJECT NO.	CONTROL	REV.	FIGURE
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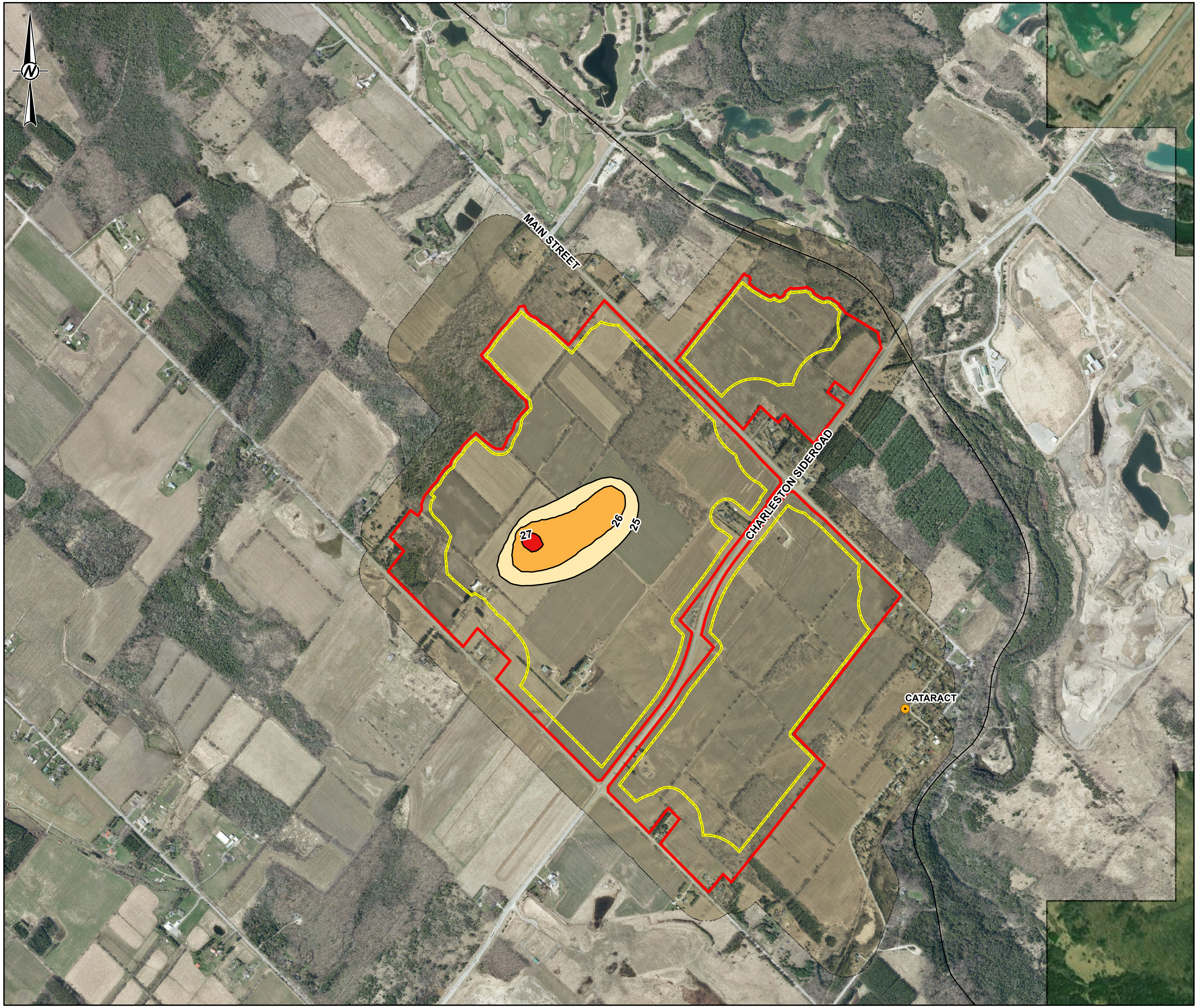

LEGEND

- TOWN/VILLAGE
- INFERRED GASPORT FORMATION THICKNESS CONTOUR (1 m INTERVAL)
- LIMIT OF EXTRACTION
- LICENCE BOUNDARY

INFERRED GASPORT FORMATION THICKNESS (m)

- 25 - 26
- 26 - 27
- 27 - 28

0 500 1,000

1:15,000 METRES

REFERENCE(S)

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CLIENT
CBM AGGREGATES, A DIVISION OF ST. MARYS CEMENT INC. (CANADA).

PROJECT
CALEDON PIT / QUARRY

TITLE
INFERRED GASPORT FORMATION GREATER THAN 25M THICKNESS

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2023-07-19
DESIGNED	CGE
PREPARED	CGE
REVIEWED	DC
APPROVED	HM

PROJECT NO.	CONTROL	REV.	FIGURE
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3.0 PROPOSED BLAST PROCEDURE

There have been no previous quarry blasts at the Site. However, Golder understands that the blasting procedures on the Site would be carried out in a manner similar to those currently being carried out within an existing CBM Osprey quarry, located south of Collingwood, Ontario. The proposed blast design details for the proposed Caledon Quarry, based on the those from the Osprey Quarry, are summarized in Table 1. Appendix B provides a glossary of terms relating to blast design and Figure A-1 illustrates a typical bench blast design.

Table 1: Blast Design Details – CBM Osprey Quarry

Parameter	Details [1)]
Hole Diameter	102 mm
Bench Height	8 m to 25 m [2)]
Sub-drill	0.6 m
Depth of Hole	8.6 m to 25.6 m
Blast Pattern (burden x spacing)	3.0 x 3.6 m (3.3 m to 3.6 m face holes)
Stemming Length	2.1 m
Stemming Type	¾ inch (19 mm) clear stone
Explosive Type	Chemically sensitized, gassed bulk emulsion
Explosive Density	1.20 g/cc
Explosive Weight per Delay	64 to 230 kg [3)]
Powder Factor	0.27 – 0.30 kg/tonne

1) Based on blast designs based on those by CBM for blasts at the Osprey Quarry.
2) As per R.R.O. 1990, Reg. 854, s. 89, the maximum working face shall not exceed 25 m.
3) Assuming 1 hole per delay and lithology depth (i.e., bench height from 8 m to 25 m).

All explosives used for the purposes of blasting will be brought to the Site on the day of each blast by a licenced and approved blasting contractor. No explosives will be stored on the Site at any time. Golder anticipates that blasting will typically occur from one to three times per week at peak production levels. The duration of each blast would generally be less than about one to two seconds.

4.0 IMPACT IDENTIFICATION

The environmental effects most often associated with blasting operations are ground vibrations and air vibrations (air concussion), the ejection of rock fragments (flyrock) and the potential impact on pets, livestock and fisheries habitat.

4.1 Ground and Air Vibrations

The intensity of ground vibrations, which is an elastic effect measured in units of peak particle velocity (PPV), is defined as the speed of excitation of particles within the ground resulting from vibratory motion. For the purposes of this report, PPV is measured in mm/s.

While ground vibration is an elastic effect, one must also consider the plastic or non-elastic effect produced locally by each detonation when assessing the effects on the bedrock strata and local water wells. The detonation of an explosive produces a very rapid and dramatic increase in volume due to the conversion of the explosive from a solid to a gaseous state. When this occurs within the confines of a borehole it has the following effect:

- The bedrock in the area immediately adjacent to the explosive product is crushed. As the energy from the detonation radiates outward from the borehole, the bedrock between the borehole and quarried face becomes fragmented and is displaced while the bedrock behind the borehole is fractured.
- Energy not used in the fracturing and displacement of the bedrock dissipates in the form of ground vibrations, sound and air concussion. This energy attenuates rapidly from the blast site due to geometric spreading and natural damping.

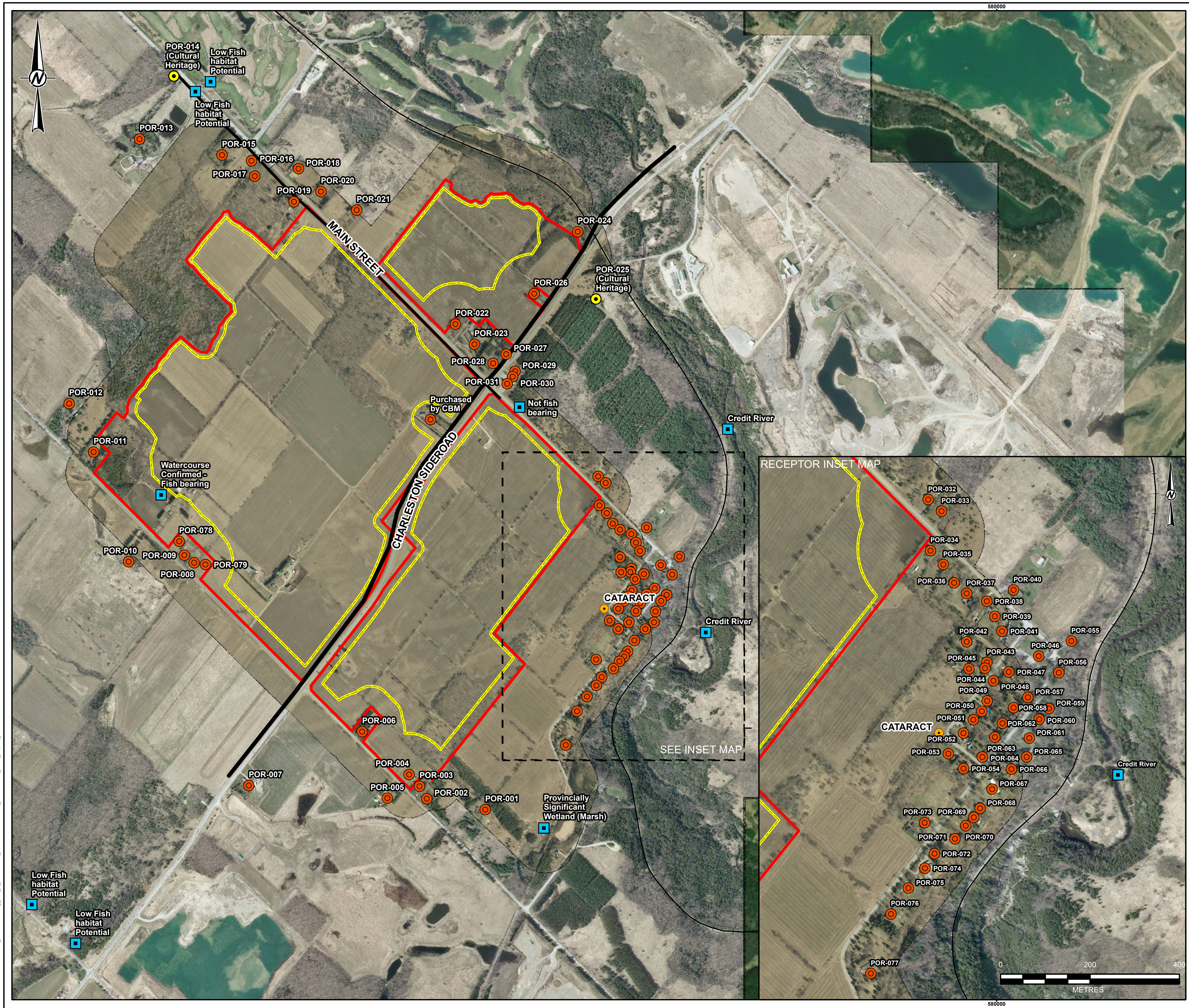
Air vibrations, or airblast is a pressure wave travelling through the air produced by the direct action of the explosive on air or the indirect action of a confining material subjected to explosive loading. Air vibrations from surface blasting operations consist primarily of acoustic energy below 20 Hz, where human hearing is less acute (Siskind et al., 1980), while noise is that portion of the spectrum of the air vibration lying within the audible range from 20 to 20,000 Hz. It is the lower frequency component (below 20 Hz) of air vibration, that which is less audible, that is of interest as it is often the source of secondary rattling and shaking within a structure. Air vibration is measured in units of Peak Sound Pressure Level (PSPL). For the purposes of this report PSPL is measured as decibels in the Linear or Unweighted mode (dBL). This differs from noise (above 20 Hz) which is measured in dBA.

Both ground and air vibration effects produced at private structures adjacent to surface or underground mining operations are subject to guidelines contained in NPC-119 of the Model Municipal Noise Control By-Law, dated August 1978, published by the Ontario Ministry of Environment (now Ministry of the Environment, Conservation and Parks (MECP)). The guideline limits for ground and air vibration levels at the nearest sensitive receptor to the quarry property are 12.5 mm/s and 128 dBL respectively. These limits apply under conditions where monitoring of the blasting operations is routinely carried out, which will be the case for the proposed Caledon quarry. A copy of Publication NPC-119 is contained in Appendix C.

Transmission and decay of ground and air vibrations can be estimated by the development of attenuation relations. These relations utilize empirical data relating measured velocities at specific separation distances from the vibration source to predict particle velocities at variable distances from the source. While the resultant prediction equations are reliable, divergence of data occurs as a result of a wide variety of variables, most notably site-specific geological conditions and blast geometry and design for ground vibrations and local prevailing climatic conditions for overpressure.

Seventy-seven (77) sensitive receptors for the Site have been identified. These are listed in Appendix D and displayed on Figure 6. Separation distances, from the receptor to the extraction limit, shown in Appendix D are based on the extraction limit as shown in Figure 6.

A gas station and confectionary are located 1521 Charleston Sideroad (POR031), which is at the intersection of Main St. and Charleston Sideroad. This is not considered a sensitive receptor, unless it is inhabited as a residence.



LEGEND

- TOWN/VILLAGE
- RESIDENTIAL RECEPTOR
- CULTURAL HERITAGE RECEPTOR
- FISH HABITAT RECEPTOR
- NATURAL GAS PIPELINE
- LIMIT OF EXTRACTION
- LICENCE BOUNDARY

0 500 1,000

1:15,000 METRES

REFERENCE(S)

1. BASE DATA MNRF LIO OBTAINED 2020
2. IMAGERY FIRSTBASE SOLUTIONS SPRING 2021, SPRING 2019 (15CM RESOLUTION) AND SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY SOURCE: ESRI, MAXAR, EARTHSTAR GEOGRAPHICS, AND THE GIS USER COMMUNITY
3. SITE TOPOGRAPHIC DATA - SPRING 2021, FIRSTBASE SOLUTIONS, 2021
4. LICENSE AND EXTRACTION LIMIT PROVIDED BY MHBC IN JULY 2023
5. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
CBM AGGREGATES, A DIVISION OF ST. MARYS CEMENT INC. (CANADA).

PROJECT
CALEDON PIT / QUARRY

TITLE
IDENTIFIED VIBRATION SENSITIVE RECEPTORS

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2023-07-19
DESIGNED	CGE
PREPARED	CGE
REVIEWED	DC
APPROVED	HM

PROJECT NO.	CONTROL	REV.	FIGURE
19129150	0034	0.0	6

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

25mm

Two (2) buried Enbridge Gas Distribution and Storage (Enbridge) pipelines are located adjacent the property boundary and shown in Figure 6. They are as follows:

- Southwest of Main St. from northwest of the site to 160 m southeast of the intersection with Charleston Sideroad.
- Northwest of Charleston Sideroad along the entire site between the Main and South sections of the site.

Enbridge requires that the maximum horizontal peak particle velocity ground vibration, measured in the ground above their closest pipeline, shall not exceed 50 mm/s and have a maximum amplitude of 0.15 mm. A copy of Enbridge's blasting requirements is attached in APPENDIX E.

Five potential Heritage Attributes (historic houses and historic barns) have been identified within the proposed License Boundary for the site and are shown in Figure 7. They are as follows:

- 18722 Main Street
- 1055 Charleston Sideroad
- 1420 Charleston Sideroad
- 18501 Mississauga Road
- 18667 Mississauga Road

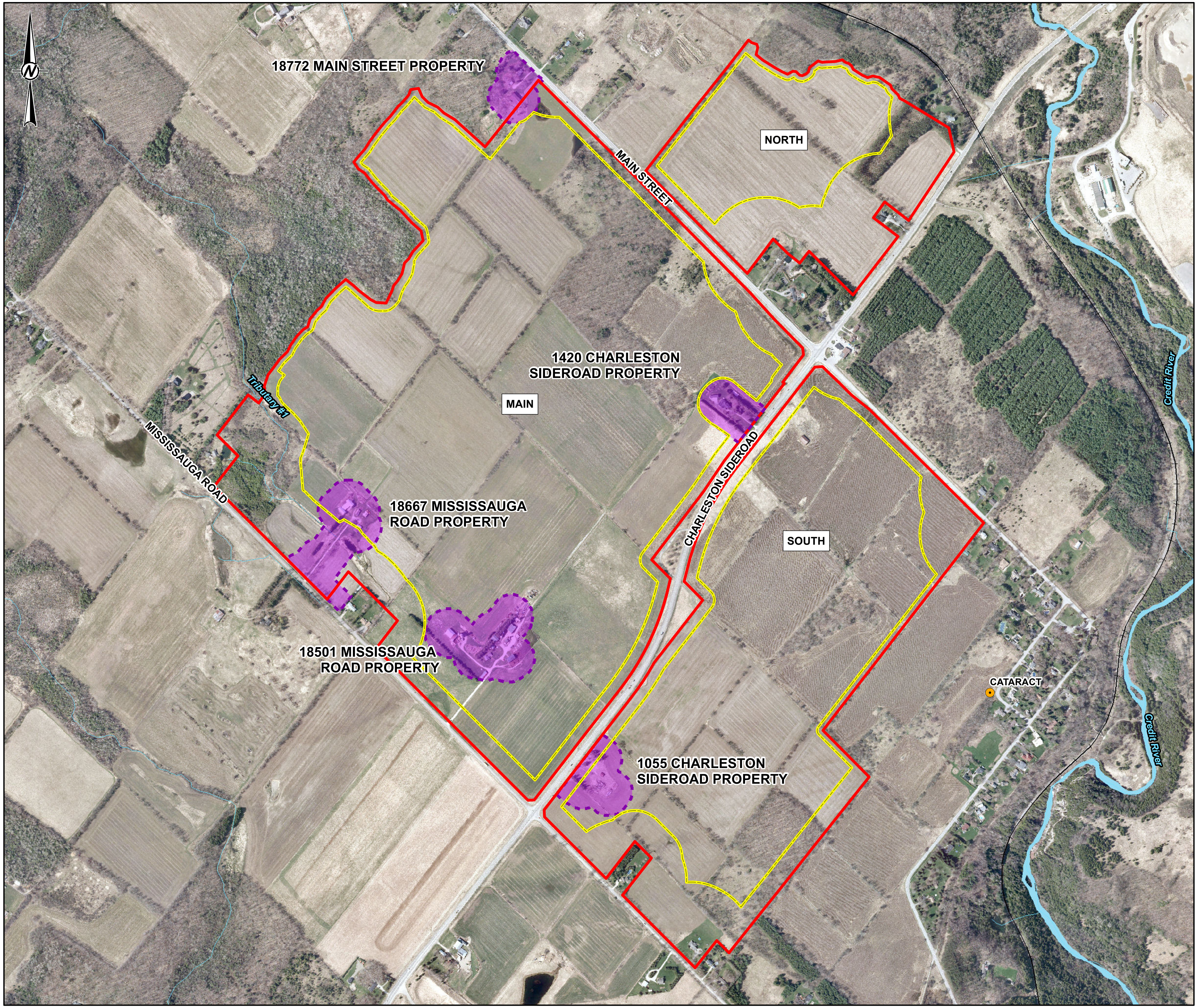
Two heritage buildings located at 18667 Mississauga Road and 18501 Mississauga Road were identified and assessed in respective Heritage Impact Assessments (HIAs) (submitted separately as part of the overall application). The HIAs proposed to conserve the historical residences within these properties through relocation within the existing property parcels but beyond the proposed extraction zone. The purpose of the proposed relocation is to retain the general geographic and visual setting of the historical residences and conserve the contextual setting of the built heritage resource. Plots for relocation with the existing properties have been identified on Mississauga Road and temporary centre points within these plots have been defined for modelling and prediction purposes. The precise relocation position within the plot will be determined through the completion of a Heritage Conservation Plan (HCP).Until such time that further study can be completed, a 50 m construction buffer has been established to mitigate potential damage by construction equipment. This is shown in Figure 7.

1420 Charleston Sideroad will remain on site but will not be considered a sensitive receptor. The building will be used as an 'office and quality control lab' for the proposed CBM Caledon Pit / Quarry.

Heritage buildings which have been reasonably well maintained are typically able withstand vibration levels of 100 mm/s to 150 mm/s without sustaining structural damage (Oriard 2002). However, the general accepted limit for limiting damage in residential structures of 50 mm/s is suggested for the proposed Heritage Attributes. This agrees with the vibration level proposed by the United States Bureau of Mines to mitigate blast vibration damage to residences and provides a conservative limit to mitigate structural damage to the proposed Heritage Attributes.

4.2 Flyrock

The movement of rock from a blast is a predictable and necessary component of any blast. The distinction must be made between 'flyrock' being the normal projection of broken rock from a blast and 'wild flyrock', the unplanned and unexpected violent projection of rock fragments at a great velocity from a blast. Wild flyrock can be considered as the ejection of rock fragments through the air or along the ground beyond the blast zone. It occurs when the explosive within the blasthole is either excessive or poorly confined and high-pressure gas propels broken rock fragments. Flyrock generally results from a mismatch between the available energy and the work to be done. This results from either too much energy for a fixed burden (rock mass in front of the explosive charge) or insufficient burden for a fixed charge. The movement of rock from a blast is a predictable and necessary component of that blast. As such, it requires that every blast have an exclusion zone established within which no persons or property which may be harmed are permitted. Numerous researchers have studied the mechanisms by which flyrock occurs, developed models to estimate the maximum range for a given site and blast design and provided suitable safety factors. Published empirical models have been employed to estimate the maximum flyrock for the proposed Quarry.



LEGEND

- TOWN/VILLAGE
- ROAD
- RAILWAY
- WATERCOURSE
- WATERBODY
- LICENCE BOUNDARY
- LIMIT OF EXTRACTION
- 50 m BUFFER

0 250 500

1:10,000 METRES

REFERENCE(S)

1. BASEDATA MNRF LIO OBTAINED APRIL 2019
2. WATERCOURSES OBTAINED FROM CREDIT VALLEY CONSERVATION AUTHORITY OPEN DATA PORTAL, NOVEMBER 2022 IN COMBINATION WITH SITE WATERCOURSE SURVEY PROVIDED BY FIRST BASE SOLUTIONS NOVEMBER 2021.
3. IMAGERY FIRSTBASE SOLUTIONS SPRING 2019 (15CM RESOLUTION) AND SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
SOURCE: ESRI, MAXAR, EARTHSTAR GEOGRAPHICS, AND THE GIS USER COMMUNITY
4. LICENSE AND EXTRACTION LIMIT PROVIDED BY MHBC IN JULY 2023
5. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
CBM AGGREGATES, A DIVISION OF ST. MARYS CEMENT INC. (CANADA)

PROJECT
CALEDON PIT / QUARRY

TITLE
CULTURAL HERITAGE RECEPTORS

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2023-07-19
DESIGNED	SO
PREPARED	SO
REVIEWED	CH
APPROVED	HM

PROJECT NO.	CONTROL	REV.	FIGURE
19129150	0034	0.0	7

4.3 Potential Fisheries Impact

The detonation of explosives in or near water can produce compressive shock waves which initiate damage to the internal organs of fish in close proximity and may result in the death of the fish. Ground vibrations induced at active spawning beds may adversely impact incubating eggs. In an effort to mitigate potential impacts on fish populations, Fisheries and Oceans Canada (DFO) developed the Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters (Wright and Hopky 1998). The limits set out in the document are as follows:

- Maximum water overpressure – 100 kPa; and
- Maximum PPV at active spawning beds – 13 mm/s.

The fish-bearing Credit River is located to the southeast of the proposed extraction boundaries of the Site. The closest approach of the river to the extraction boundary is about 400 m (see Figure 6). A small watercourse, Watercourse # 1 (WC #1), was identified and confirmed near Mississauga Road within the northwestern corner of the proposed extraction area (see Figure 6). While WC #1 is connected, although poorly, to the pond downstream which has fish, Golder considers it to be fish habitat, but the overall fish potential is low and no spawning occurs at this location. Finally, a section of marsh was confirmed at approximately 495 m southeast of the proposed extraction boundary. Although the marsh is associated with a provincially sensitive watercourse (PSW), it is not considered to contain spawning beds.

4.4 Potential Impact on Pets and Livestock

Input received during public consultation for the Project, indicated a concern regarding the potential effects of blasting and vibration on livestock, pets, animal stress and foaling as a result of the blasting operations required for the proposed quarry. A literature was carried out to assess the potential impact of the proposed quarry on these animals. Little research into the effects of the blast induced vibration on livestock, poultry and domestic animals. The results of our literature review are discussed in Section 7.7.

5.0 VIBRATION ATTENUATION MODELS

5.1 Blast Vibrations

Both ground and air vibration levels lose energy and dissipate with increasing distance from the blast source. The rate at which these effects attenuate or dissipate from a particular site are dependent on geologic and environmental conditions, topography and the particulars of the blast design. The intensity of ground and air vibration effects from any surface blasting operation are primarily governed by the distance between the receptor and the blast and the maximum weight of explosive detonated per delay period within the blast. Since no blasting has yet been carried out at the proposed quarry location, attenuation characteristics are estimated based on a literature review and the use of blast monitoring data provided by CBM at similar limestone quarry operation to the north of the Site and south of Collingwood, Ontario.

5.2 Ground Vibration Model

The rate ground vibrations attenuate from a blast site is dependent on a number of variables. These include the characteristics of the blast (delay timing, type of explosive, etc.), topography of the site, as well as the characteristics of the bedrock and/or soil materials. The rate ground vibrations decay or attenuate from a blast site can be expressed by the Scaled Distance, which is defined as:

$$Scaled\ Distance\ (SD) = \left(\frac{D}{\sqrt{W}}\right)$$

where D= the distance (m) between the blast and receptor

W= the maximum weight of explosive (kg) detonated per delay period

The ground vibration level is given by:

$$PPV = K(SD)^{-e}$$

where PPV = Peak Particle Velocity (mm/sec)

SD = Scaled Distance (m/kg$^{1/2}$) as defined above

K, e = Site factors typically derived from monitoring

In support of the permitting for the Highland Quarry (now CBM's Osprey Quarry), Explotech Engineering Ltd. (Explotech) prepared a Blast Impact Assessment (BIA). CBM retained Explotech to monitor the initial blasts at the Osprey Quarry in order to collect data needed to develop a site-specific attenuation formula. The vibration attenuation model developed during the Explotech's attenuation study for the Osprey Quarry is shown below and presented graphically in Figure 8.

$$PPV_{95} = 3087\left(\frac{D}{\sqrt{W}}\right)^{-1.46}$$

where D= the distance (m) between the blast and receptor

W= the maximum weight of explosive (kg) detonated per delay period

The calculated SD for a peak ground vibration level of 12.5 mm/s would be equal to 43.50 m/kg$^{1/2}$.

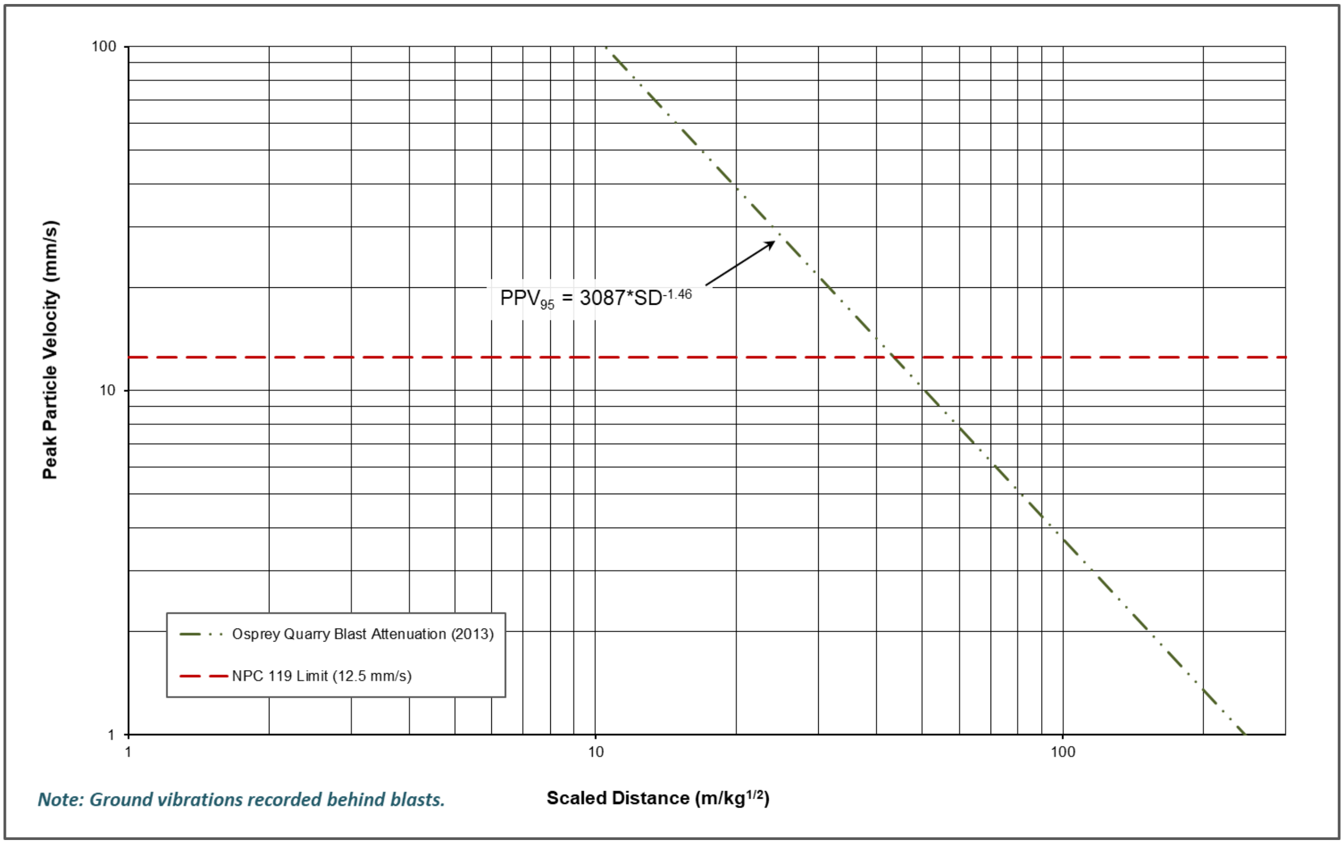


Figure 8: Proposed Ground Vibration Attenuation Model

The purpose of this equation is not so much to predict what a given vibration level would be at a particular location for a given blast, but to indicate that the peak vibration would fall below the level indicated by the equation for a given distance and maximum explosive weight. The equation is, therefore, a useful blast design tool in establishing maximum charge weights for various distances from a blast site for a given maximum ground vibration level. It is important to note that the blast vibration model proposed above would need to be calibrated with site-specific data collected during the initial blasts carried out at the proposed quarry.

5.3 Air Vibration Model

Blasting for the quarry operations on the Site will result in air vibrations. This section describes the attenuation (i.e., reduction in intensity) of air vibrations from blasting.

Air overpressure attenuates from a blast site as the distance to the receptor increases (Siskind 2005). Air vibrations attenuate from a blast site at a slower rate than ground vibrations. The distribution of air vibration energy from a blast is strongly influenced by the prevailing weather conditions during the blast. For example, wind can increase downwind levels by 10 to 15 dBL above what would otherwise be measured (Dowding 1985). Low cloud ceilings and temperature inversions also contribute to air vibrations propagating further than would typically be the case. Other factors influencing air vibration distribution from a blast include orientation of the blast face, local topography and vegetation, length of collar and type of stemming material, differences in explosive types and variations in burden distance.

The rate air vibrations decay or attenuate from a blast site can be expressed by the Scaled Distance, which is defined as:

$$Scaled\ Distance\ (SD) = \left(\frac{D}{\sqrt[3]{W}}\right)$$

where D is the distance (m) between the blast and receptor

W is the maximum weight of explosive (kg) detonated per delay period.

Where no site-specific data is available, the model factors can be estimated based on literature derived models or models based on applicable experience. The air overpressure is likely to be significantly different than that calculated for the Osprey quarry BIA as much of that quarry is surrounded by forest and the proposed Caledon quarry is surrounded by farm fields. The air overpressure level is different when measured in front of the blast face from that measured behind the blast face. A single model was developed during the initial Osprey quarry blasts for the estimated air overpressure level measured in front of the blast face. Since the air overpressure levels at the closest receptors when the quarry blasts approach the perimeter of the proposed excavation, it is preferable to implement a model developed for overpressure measured behind the blast face. Research by the United States Bureau of Mines (USBM) provided models for the assessment of air overpressure in front and behind the blast face (Siskind et al. 1980). When converted to metric units, the models are as follows:

$$PSPL = 3.7148\left(\frac{D}{\sqrt[3]{W}}\right)^{-0.966}$$ (in front of the face)

$$PSPL = 0.056\left(\frac{D}{\sqrt[3]{W}}\right)^{-0.515}$$ (behind the face)

where PSPL = Peak Sound Pressure Level (kPa)

D = distance (m) between the blast and receptor

W = maximum weight of explosive (kg) detonated per delay period

When expressed in term of linear decibels and scaled distance, the models are shown below:

$$PSPL_{dBL} = 165.38 - 8.391\ln(SD)$$ (in front of the quarry face)

$$PSPL_{dBL} = 141.57 - 4.583\ln(SD)$$ (in behind the quarry face)

where PSPL= Peak Sound Pressure Level (dBL)

SD = Scaled Distance (m/kg$^{1/3}$) as defined above

The MOE (now MECP) used the models provided above for the assessment of blasting overpressure (in front and behind the blast face) (MOE 1985). The models above have been used in this air overpressure assessment and are plotted on Figure 9.

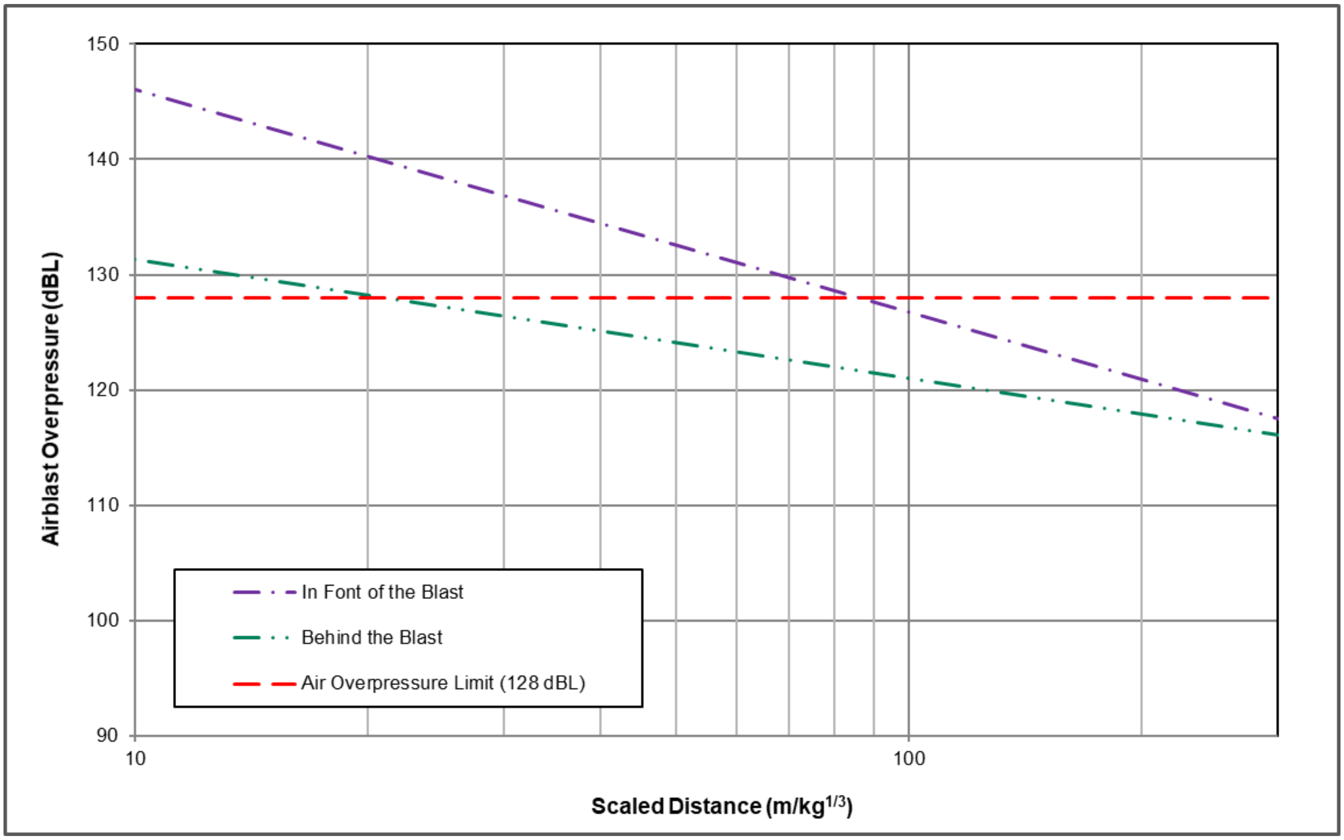


Figure 9: Proposed Air Vibration Attenuation Model

The calculated SDs for an air overpressure level of 128 dBL would be equal to the following

- In front of the blast face - 86.42 $m/kg^{1/3}$
- Behind the blast face - 20.55 $m/kg^{1/3}$

The blasting operation will progress toward the extraction perimeter with the nearest sensitive receptors located behind the blast face.

6.0 FLYROCK RANGE MODELS

6.1 Causes and Mechanisms

Flyrock is caused by a mismatch of energy released by the detonated explosive and the blast. The main causes of flyrock in quarry operations are as follows:

- Design faults
- Deviations from designs
- Geological conditions

Flyrock occurs when explosives in a hole are poorly confined by the stemming or rock mass and the high-pressure gas breaks out of confinement and launches rock fragments into the air. The three (3) main flyrock mechanisms are listed below and shown graphically illustrated in Figure 10:

- Face burst
- Cratering
- Rifling

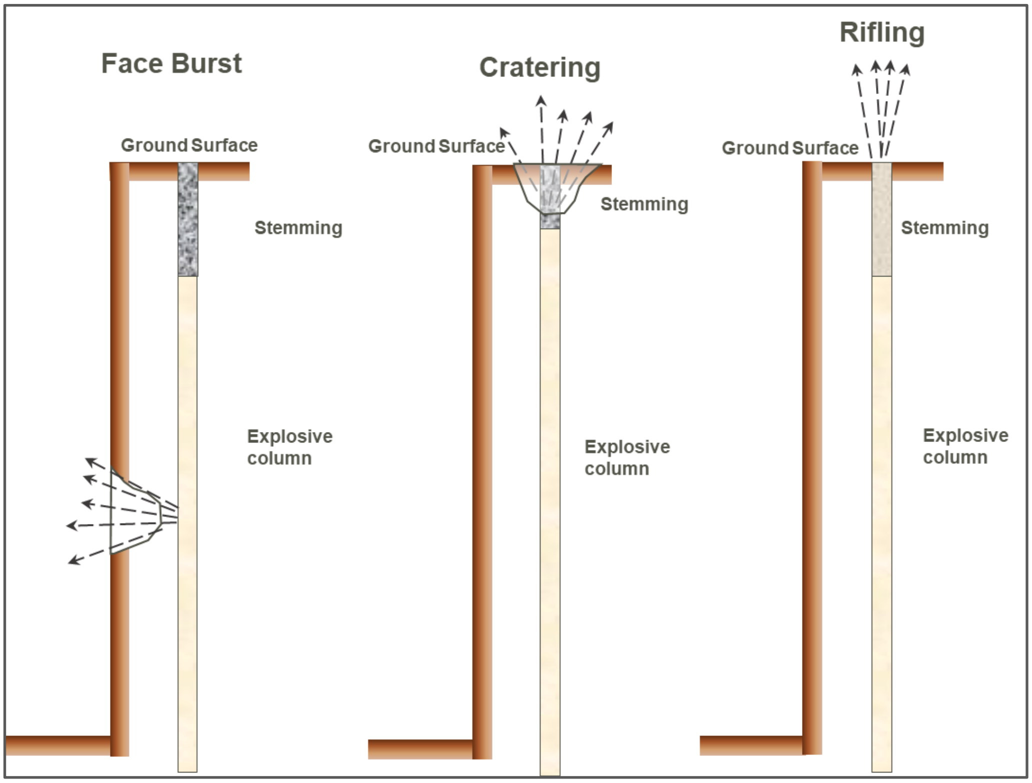


Figure 10: Flyrock Mechanisms

Face burst results from insufficient confinement by the rock mass in front of the blast holes at the face. This can result from the blast design or a zone of geological weakness. Cratering results from insufficient stemming height or weakened collar rock that results in a crater being formed around the hole collar with rock projected from the top of the hole. This can be exacerbated by poor inappropriate blasthole timing. Poor stemming practice can result in a high angle throw of the stemming material and loose rocks from the blasthole wall and collar. This is known as rifling and is most commonly the result of insufficient or poor-quality stemming. For vertical blastholes, the maximum rifling range will be negligible (throw will be primarily vertical or up-down).

6.2 Flyrock Range Models

The model for estimating the flyrock range is based on the fundamental laws of projectile motion and empirical formulae that relate face velocity to the scaled burden. While standard assumptions for site-specific constants provide initial estimates, the model is ultimately intended to be calibrated for each site (Little, 2007). Richards and Moore (2004) presented a model which is partly based on the fundamental laws of projectile motion coupled with the empirical relationship between face velocity and scaled burden. The procedure for estimating the maximum flyrock range can be summarized as follows:

Face Bursting $R_1 = \frac{k^2}{g}\left(\frac{\sqrt{m}}{B}\right)^{2.6}$

Cratering $R_1 = \frac{k^2}{g}\left(\frac{\sqrt{m}}{SH}\right)^{2.6}$

Rifling $R_1 = \frac{k^2}{g}\left(\frac{\sqrt{m}}{SH}\right)^{2.6} \sin 2\theta_{DH}$

where: V_0 = fragment launch velocity (m/s)

θ_{LA} = launch angle from horizontal

B = burden (m)

SH = stemming height (m)

m = charge weight per m (kg/m)

k = is a constant (13.5 for softer competent rocks and 27 for harder competent rocks (Richards and Moore, 2004))

Given limestones bedrock in the area, we have applied a “k” value of 20. Within this report, we will assume the blastholes are vertical and the maximum rifling range will be approximately zero. Thus, only the cases of Face Bursting and Cratering were considered.

Once the maximum projection distance has been calculated, an appropriate factor of safety should be applied. MacKenzie (2009) proposed that if the nearby sensitive structure is occupied, then the factor of safety (FOS) of 1.5 should be retained. However, the US Office of Surface Mining (Dick et al., 1989) prohibit throwing flyrock more than one-half the distance to the nearest dwelling or occupied structure, demanding that a minimum FOS of 2 be used in the US. In this report we have used the more conservative FOS of 2.

McKenzie (2009) suggested that the recommended procedure is to use the prediction of the maximum projection range as the basis for determining clearance distance, with an appropriate Factor of Safety applied. Clearly, this estimation must be conducted with full knowledge of the length of stemming and actual charge configurations in every blasthole, and distances adjusted according to the particular charge configuration with the largest estimated projection distance.

7.0 IMPACT ASSESSMENT

7.1 Vibration Predictions

7.1.1 Ground Vibration Prediction

The prediction of peak ground vibration levels is carried out at differing distances from a blast based on an expected maximum explosive weight per delay period for a given bench height. Figure 11 shows the estimated ground vibration amplitudes for the proposed blast design at a range of distances from the blast for the following bench heights:

- 12 m – upper bench height for the initial blast near the future processing plant
- 20 m – average bench height
- 25 m – bench height at the maximum thickness of the Gasport Formation

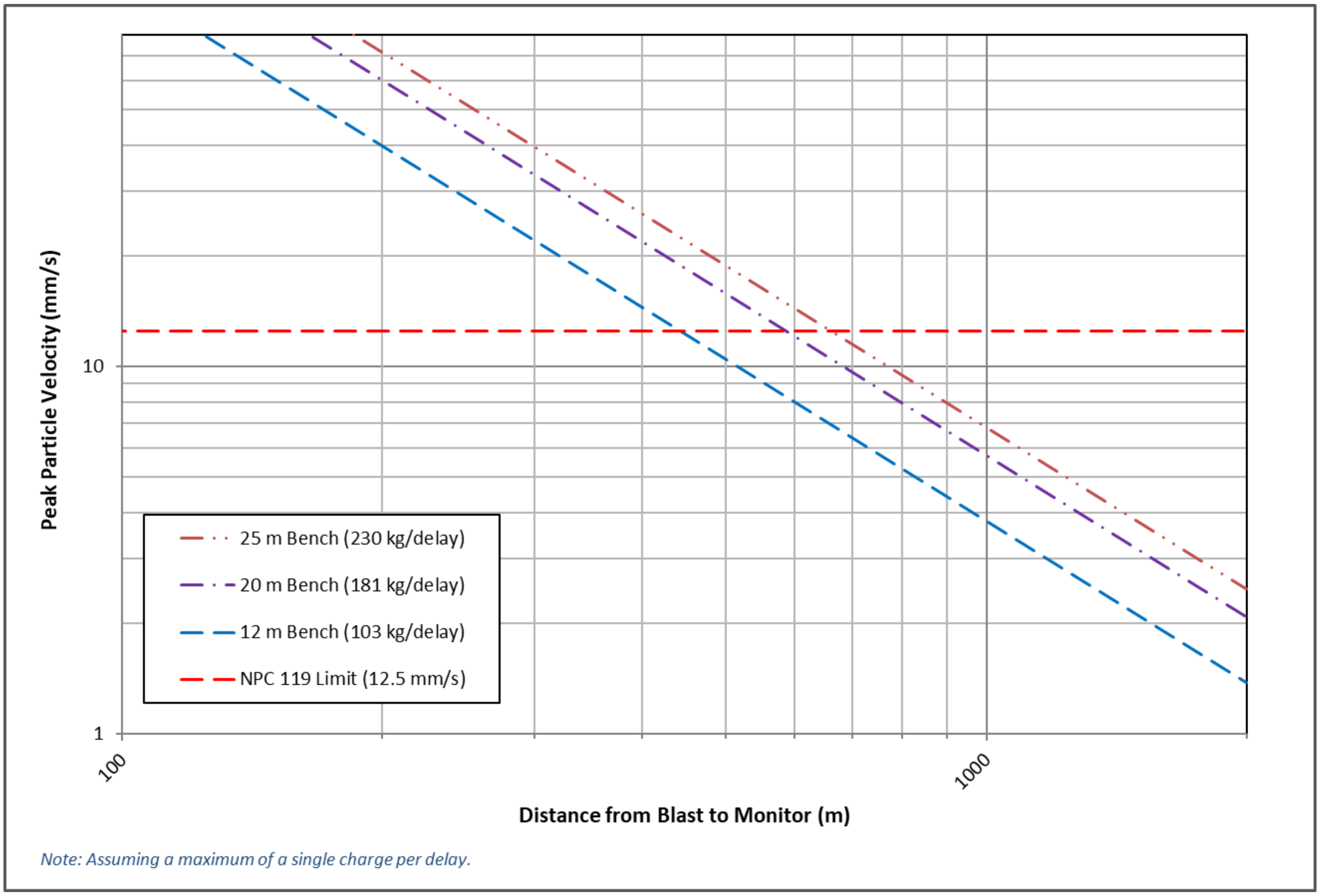


Figure 11: Estimated Maximum Ground Vibration for the Proposed Blast Design at a Range of Distances

The estimated vibration levels shown above are summarized in Table 2, below.

Table 2: Estimated Ground Vibrations for the Proposed Blast Design at a Range of Distances

Distance [1] (m)	PPV [2] (mm/s)		
	12 m Bench (103 kg/delay)	20 m Bench (181 kg/delay)	25 m Bench (230 kg/delay)
100	109	165	197
200	40	60	72
300	22	33	40
400	14	22	26
500	10	16	19
600	8.0	12	14
700	6.4	9.6	12
800	5.3	7.9	9.4
900	4.4	6.7	8.0
1000	3.8	5.7	6.8

[1] Distance between the blast and the sensitive receptor.
[2] Assuming the attenuation model proposed above.

Assuming a single hole per delay, the MECP guideline limit of 12.5 mm/s may be complied with for all blasting beyond the following estimated standoff distances from adjacent receptor residences:

- 441 m - for a 12 m bench
- 585 m - for a 20 m bench
- 660 m - for a 25 m bench

Assuming a single hole per delay, the Enbridge limit and proposed interim limit of 50 mm/s may be complied with for all blasting beyond the following estimated standoff distances from the Enbridge lines and the potential Heritage Attributes:

- 171 m - for a 12 m bench
- 227 m - for a 20 m bench
- 256 m - for a 25 m bench

7.1.2 Air Vibration Prediction

The prediction of peak air vibration levels is carried out at differing distances from a blast based on an expected maximum explosive weight per delay period. Based on the models presented in Section 5.3, the air vibration levels from the Site are expected to be below the limits for blasts monitored behind the face (i.e., as blast progress toward the extraction perimeter).

7.1.2.1 In Front of the Blast

Figure 12 shows the estimated air vibration amplitudes for the proposed blast designs and bench heights at a range of distances from the blast. This is summarized in Table 3.

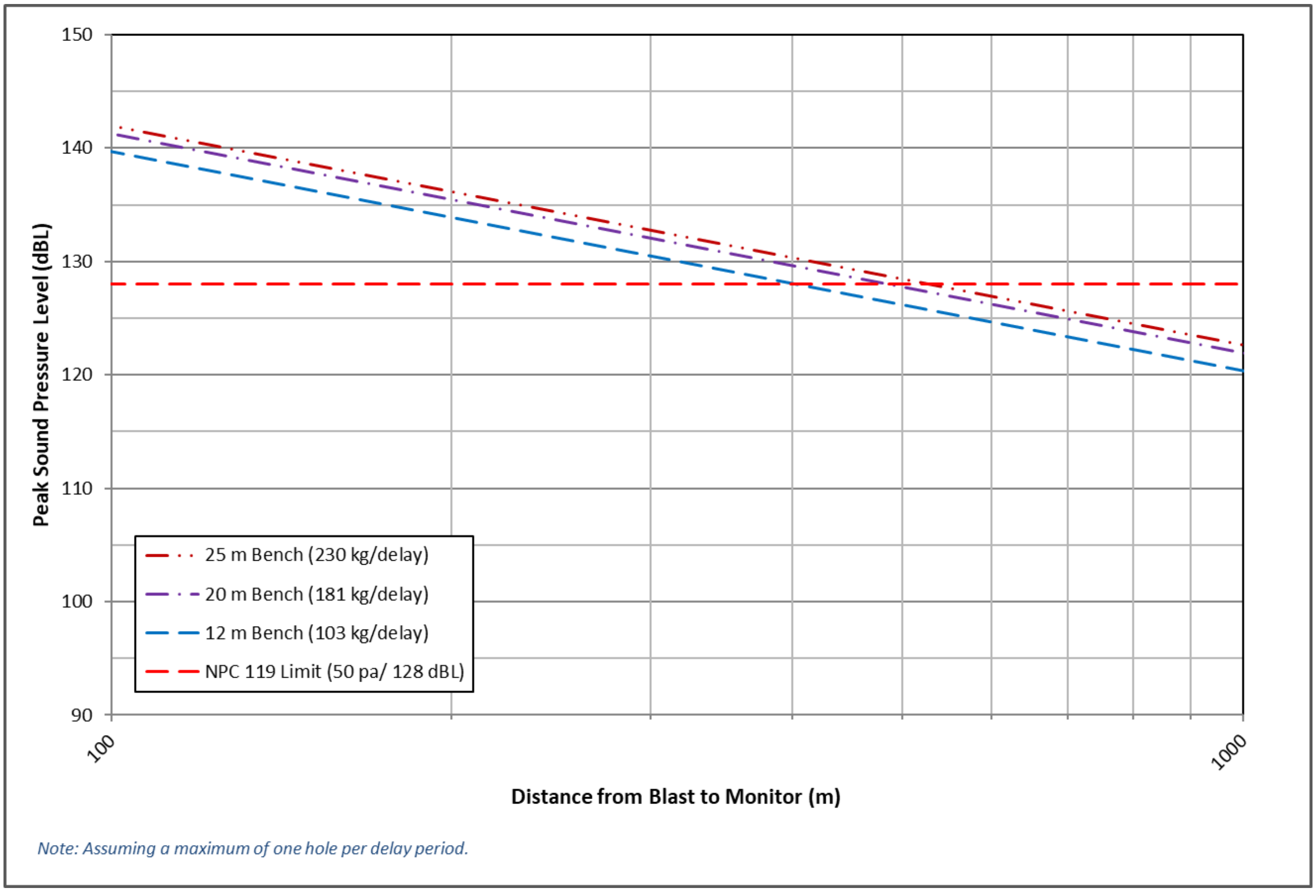


Figure 12: Estimated Maximum Air Vibration in Front of the Blast at a Range of Distances

Table 3: Estimated Maximum Air Vibration in Front of the Blast at a Range of Distances

Distance [1] (m)	PSPL [2] (dBL)		
	12 m Bench (103 kg/delay)	20 m Bench (181 kg/delay)	25 m Bench (230 kg/delay)
100	140	141	142
200	134	135	136
300	130	132	133
400	128	130	130
500	126	128	128
600	125	126	127
700	123	125	126
800	122	124	124
900	121	123	124
1000	120	122	123

[1] Distance between the blast and the sensitive receptor.
[2] Assuming the attenuation model proposed above.

Assuming a single hole per delay, the MECP guideline limit of 128 dBL may be complied with for all blasting beyond the following estimated standoff distances from adjacent receptor residences:

- 400 m - for a 12 m bench
- 500 m - for a 20 m bench
- 530 m - for a 25 m bench

7.1.2.2 Behind the Blast

Figure 13 shows the estimated air vibration amplitudes for the proposed blast designs and bench heights at a range of distances from the blast. This is summarized in Table 4.

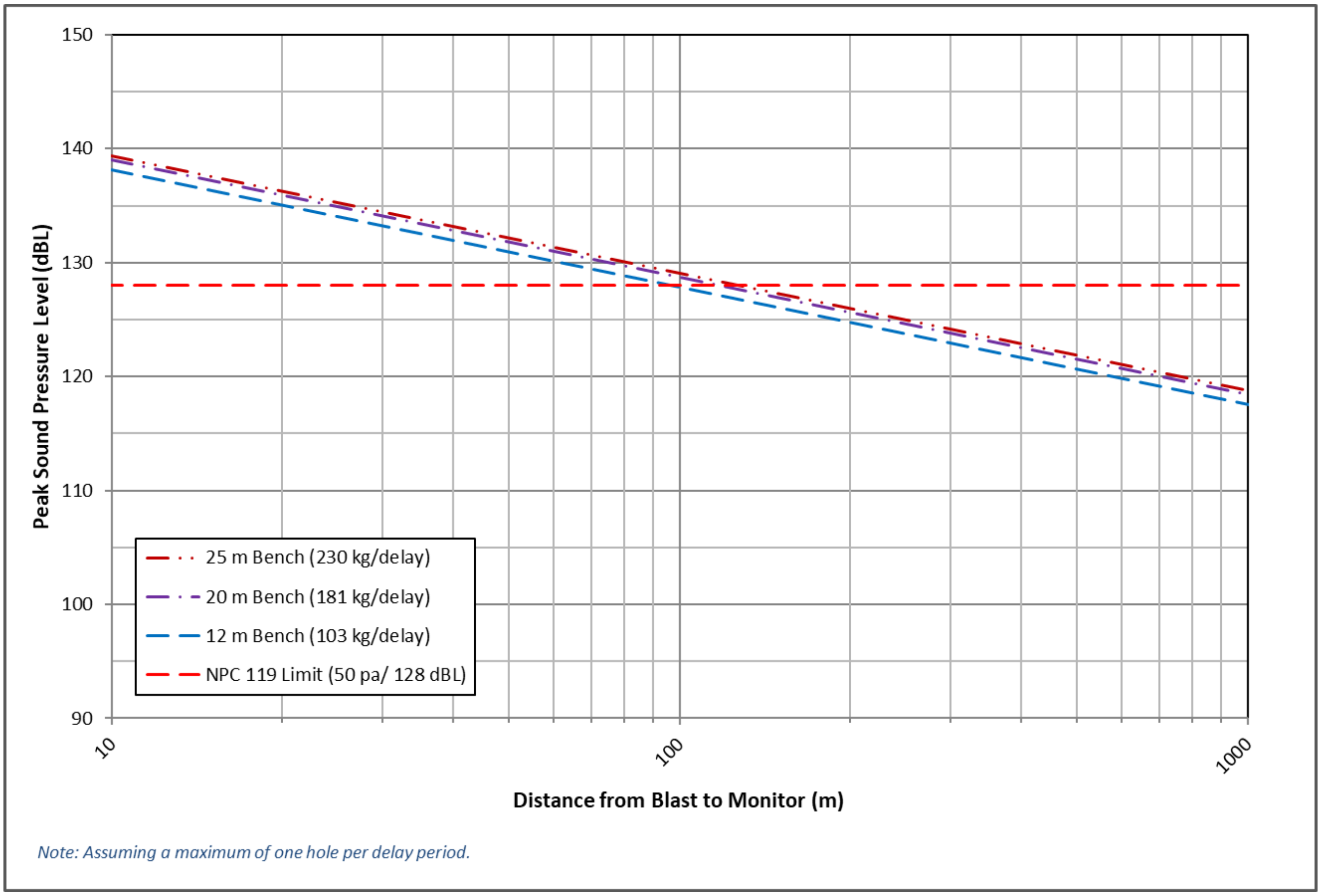


Figure 13: Estimated Maximum Air Vibration in Behind the Blast at a Range of Distances

Table 4: Estimated Maximum Air Vibration Behind the Blast at a Range of Distances

Distance [1)] (m)	PSPL [2)] (dBL)		
	12 m Bench (103 kg/delay)	20 m Bench (181 kg/delay)	25 m Bench (230 kg/delay)
100	127.9	128.7	129.1
200	124.8	125.6	126.0
300	123.0	123.8	124.2
400	121.7	122.5	122.9
500	120.7	121.5	121.9
600	119.9	120.7	121.1
700	119.2	120.0	120.4
800	118.6	119.4	119.8
900	118.1	118.9	119.3
1000	117.6	118.4	118.8

[1)] *Distance between the blast and the sensitive receptor.*
[2)] *Assuming the attenuation model proposed above.*

Assuming a single hole per delay, the MECP guideline limit of 128 dBL may be complied with for all blasting beyond the following estimated standoff distances from adjacent receptor residences:

- 97 m - for a 12 m bench
- 118 m - for a 20 m bench
- 128 m - for a 25 m bench

7.1.3 Vibration Prediction Summary

Site-specific SD plots are commonly used as a blast design tool since maximum peak ground vibrations levels can reasonable be predicted at specific distances from a blast. Based on the regression models developed in Section 5.0, Table 5 shows the maximum suggested explosive loads (MICs) for various distances from the blast site based on the provincial guideline limits of 12.5 mm/s and 128 dBL respectively. This is shown graphically on Figure 14.

Table 5: Summary of Maximum Explosive Loads to Comply with NPC-119

Distance [1] (m)	Max. Explosive Charge Weight (kg) [2]		
	PPV = 12.5 mm/s SD = 43.50 m/kg$^{1/2}$	$PSPL_{front}$ = 128 dBL SD = 86.42 m/kg$^{1/3}$	$PSPL_{behind}$ = 128 dBL SD = 86.42 m/kg$^{1/3}$
150	12	5	389
200	21	12	922
300	48	42	3,111
400	85	99	7,375
500	132	194	14,404
600	190	335	24,890
700	259	531	39,524
800	338	793	58,998
900	428	1,129	84,002
1,000	528	1,549	115,230

[1] Distance between the blast and the sensitive receptor.
[2] Assuming the attenuation models proposed above.

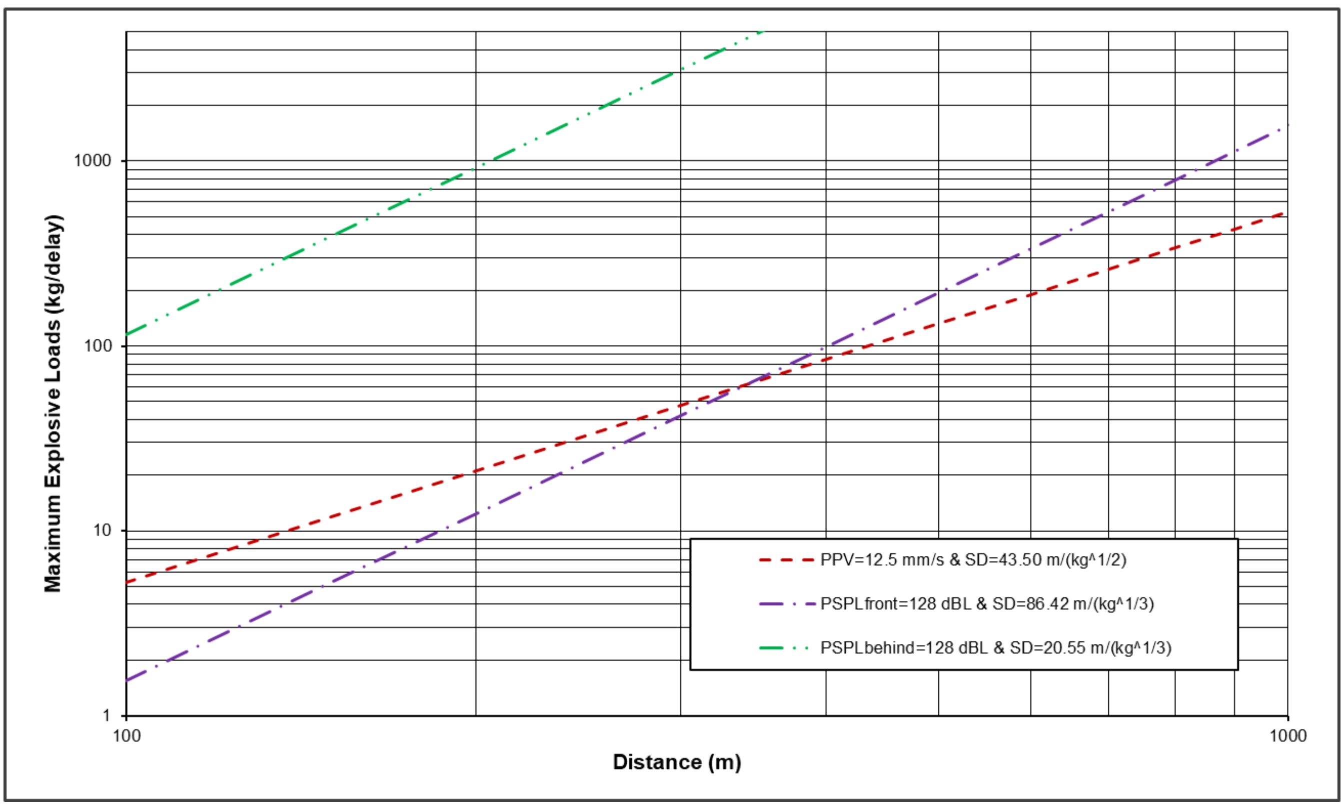


Figure 14: Maximum Explosive Charge Weights to Comply with NPC-119 Ground and Air Vibration Limits

The results demonstrate that the ground vibration limit of 12.5 mm/s becomes the most restrictive guideline when determining the maximum explosive loads beyond 341 m from proposed Caledon Quarry's blasting operations. While the air vibration limit of 128 dBL would tend to dictate the maximum loads inside 341 m, implementing blast design changes to reduce ground vibration intensities typically also results in a corresponding reduction in air vibration effects.

7.2 Compliance With NPC-119

All blasting at the Site would be carried out such that ground and air vibration effects would comply with the recommended provincial guideline limits of 12.5 mm/s and 128 dBL, respectively. It is evident from the regression equations discussed in Section 5.0 that the distance from the blast, the amount of explosive detonated per delay period and the geographical location of the receptor are the principal parameters in controlling ground and air vibration effects. The maximum explosive charge load ranges from approximately 64 to 230 kg depending on the lithology thickness at a given location (see Table 1). The maximum explosive loads given on Figure 11 for limiting peak ground vibrations to 12.5 mm/s, indicate that the provincial guideline may be complied with for blasting beyond a distance of about 441 to 660 m from adjacent residential properties depending on the bench height.

The closest separation distance between a sensitive receptor and any blast over the life of the Site (i.e., extraction boundary) is 100 m. When blasting approaches to within about 440 m of adjacent residences, depending on bench height, it may become necessary to reduce the maximum explosive weight detonated (MIC) within the blast. Any one or combination of the following operations would achieve this:

1) Reduce the borehole diameter with a corresponding reduction in the drill pattern parameters.

2) Introduce additional decked charges within each borehole, as illustrated on Figure A-1 (Appendix B).

3) Reduce the borehole length (depth) by reducing the bench height.

For example, a reduction in the borehole diameter from 102 mm to 89 mm would effectively reduce the explosive weight per hole, assuming the same loading and blast procedures, by approximately 24%. Adding an additional deck to the explosive column could further reduce the maximum explosive weight per delay by about another 60%. Additional decking and reductions in bench heights, as identified above, could achieve further reductions in maximum explosive weights. This would allow extraction of those areas within the proposed quarry closest to off site receptors.

As it is the intention of the SMC to monitor all blasts for the Site, the attenuation curves discussed previously could be used in conjunction with the monitoring data collected at adjacent properties to dictate when changes to the blast procedure become necessary when approaching adjacent residences. Although a reduction in the maximum instantaneous explosive load is anticipated as blasting approaches the extraction boundary, the ground and air vibration guideline limits contained within NPC-119 would continue to be maintained.

7.3 Compliance with Enbridge Requirements

Enbridge has established guidelines to protect the integrity of their pipeline facilities by third parties operating within or adjacent to their right-of-way (see Appendix E). CBM would comply with the following procedures, which are included in the Enbridge guidelines, would be carried out when blasting within the proposed site.

- Blasting activities in the vicinity of Enbridge facilities require prior approval by Enbridge.
- A recognized independent blasting consultant must be retained at the applicant’s expense to perform an evaluation of the blast design.
- A copy of the stamped consultant’s validation report must be submitted to Enbridge for review if blasting is to occur within 30 m of facilities.
- The blasting consultant is responsible for the monitoring of blasting vibrations with a portable seismograph capable of transmitting data instantaneously (e.g., via email or cellular) to the required reviewer in the vicinity of Enbridge’s facilities is mandatory to confirm that predicted vibration levels are respected.
- On a daily basis, a copy of the seismographic report must be provided to Enbridge.
- Ground vibration levels would be limited to 50 mm/s PPV and the maximum amplitude must be limited to 0.15 mm when measured at the ground surface immediately above the closest pipeline to the blasting.

Based on the ground vibration decay characteristics identified within this report, it is anticipated that changes to the blasting procedures, would not be required until blasting approached to within about 171 m to 256 m of the closest pipeline, depending on the quarry bench height. Although Enbridge only requires monitoring when blasting within 30 m of their pipeline, the proposed quarry would commence monitoring when blasting had approached to within 300 m of the Enbridge pipelines. The monitoring results would dictate if and when changes to the blast procedure are required. Peak ground vibration levels can be reduced by reducing the maximum explosive weight detonated per delay period as discussed in Section 7.2.

7.4 Blast Effects on Proposed Heritage Attributes

Blasting at the Site would be carried out such that ground vibration effects on the proposed Heritage Attributes would comply with the proposed limit of 50 mm/s. The maximum explosive loads given on Figure 11 for limiting peak ground vibrations to 50 mm/s, indicate that the guideline may be complied with for blasting beyond a distance of about 171 m and 256 m from nearest Heritage Attributes depending on the bench height.

When blasting approaches to within about 300 m of nearest Heritage Attributes, depending on bench height, it may become necessary to reduce the maximum explosive weight detonated (MIC) within the blast.

7.5 Blast Effects on Bedrock and Water Wells

As discussed previously, under typical blasting conditions stresses introduced into the bedrock by the explosive detonation and the accompanying gas pressures create and extend fractures within the bedrock around each borehole. Fracture development is usually limited to a distance of about 20 to 30 times the borehole diameter. In the case of the blast procedures given for the proposed quarry, this would be limited to an area immediately around each blast. The gas pressures within the hole may extend micro-cracks or existing natural discontinuities within the bedrock, such as joints or bedding planes. Studies on crack development within bedrock from blast detonations (Keil et al., 1977) indicate that peak ground vibration levels of 300 to 600 mm/s are required to create micro-cracks or open existing discontinuities. Golder's experience within the limestone of Southern Ontario indicates that such values would not be anticipated beyond a distance of about 5 to 10 m from the blast, depending on such parameters as blasthole diameter and the type of explosive product. The creation or extension of fractures within the bedrock would remain confined to an area immediately around the blast site. This is the principal reason why each blast is made up of a pattern of holes. The explosive in each hole has only sufficient energy to fracture the bedrock around that particular hole.

Several studies have been carried out to investigate the effects of blasting on ground water wells (Froedge, 1983). These studies have concluded that:

1) When blast-induced ground vibrations are less than about 25 mm/s maximum resultant particle velocity, the response of the well is limited to a slight temporary variation in water level on the order of 3 to 6 cm either up or down. The specific capacity of the water well is unchanged based on drawdown tests.

2) Vibration measurements made at the surface and at the bottom of the observation wells indicate the vibration levels are always lower at the bottom of the well.

3) All of the data collected indicates that a ground vibration limit of 50 mm/s peak particle velocity is adequate to protect the wells from any significant damage. There is a possibility that temporary turbidity may be caused at lower levels periodically, although not at any constant threshold level.

The research consistently indicates that blast vibrations below 25 mm/s should have no adverse effects on nearby wells. As the maximum provincial guideline vibration limitation at the nearest residence is only half of this value, at 12.5 mm/s, the ground vibrations produced from the quarry's blasting operations would have no effect on the neighbouring water wells.

7.6 Repeated Vibration Effects on Structures

Blast vibrations characteristically produce temporary transient strains within the various materials that makeup a residential structure. These strains would typically have durations of no more than one or two seconds for each blast as the vibration passed the structure. While the blasting may introduce these temporary strains a few times each week for one or two seconds, Table 6 shows the strain levels produced in a household by changes in temperature and humidity (environmental changes), as well as those produced by regular household activities (Dowding, 1985), which take place on a recurring and significantly more frequent basis. These strain levels are compared to equivalent levels of ground vibration produced from blasting operations. It is evident from Table 6 that routine household activities and environmental changes can produce strains within a structure that are well in excess of those produced by blasting.

Table 6: Strain Levels Induced by Household Activities, Environmental Changes and Blasting

Loading Phenomena	Site[a)]	Microstrain Induced by Phenomena (µin/in)	Corresponding Blast Vibration Level[b)] (mm/s)
Daily environmental changes	K_1 K_2	149 385	30.0 76.0
Household Activities 1. Walking 2. Jumping 3. Door slams 4. Pounding nails	S_2 S_2 S_1 S_{12}	9.1 37.3 48.8 88.7	0.8 7.1 12.7 22.4

a) K_1 and K_2 were placed across a taped joint between two sheets of gypsum wallboard.
b) Blast equivalent based on envelope line of strain versus ground vibration.
Source: Dowding (1985)

Several studies have also been carried out to look at the long-term effects of repeated blasting on structures (Stagg et al., 1984, Siskind et al., 1980). These studies concluded that repeated blasting over several decades, producing peak vibration levels well in excess of the provincial guideline limit, were required to cause cosmetic threshold cracking to occur. By ensuring that blasting continues to remain within the provincial guideline limits, there would not be any noticeable cumulative effect associated with the blasting operations from the proposed quarry.

7.7 Effect on Canadian Fisheries Waters

Golder's observations while on the Site have indicated that the closest fish habitat near the Site was the small watercourse near Mississauga Road within the northwestern corner of the proposed extraction area (WC#1). It has a minimum separation from the proposed extraction area of about 100 m. It has not considered to have spawning potential but contain fish. As such, the blasting is limited to 100 kPa underwater overpressure.

Assuming a single hole per delay, and assuming the methodology proposed by the DFO in Wright and Hopky (1998) the water overpressure limit of 100 kPa may be complied with for all blasting beyond the following estimated standoff distances from WC#1 watercourse:

- 52 m - for a 12 m bench
- 69 m - for a 20 m bench
- 77 m - for a 25 m bench

As the minimum standoff distance from the limit of excavation to WC#1 of 100 m, it is estimated that the water overpressure will comply with the DFO limits for the proposed quarry blasts.

The Credit River is the primary watercourse near the Site and has at a minimum separation of about 400 m. With the exception of WC#1, there is no indication that there are any other nearby watercourses in the nearby area with significant fisheries potential or the likelihood of containing spawning beds. Along the length of the Credit River located near the Site, there are sensitive receptors at much closer separation distances. The vibration limit for the residential receptors (12.5 mm/s) is less that that for active spawning beds (13.0 mm/s). As the vibrations induced by the blasting must remain below the NPC-119 limit at the much closer sensitive receptors, the levels at the Credit River would be far below the DFO vibration limit. As such, the proposed blasting operations at the Site are not anticipated to have an adverse effect on the local fish habitat.

7.8 Flyrock Estimates

The estimates provided within this section are based on the theory presented with Section 5 and the proposed blast designs presented in Table 1. As noted in Section 5, the range of rifling will be negligible, and only the cases of Face Bursting and Cratering were considered. As the blasting operations proceed toward the nearest sensitive receptor, it is likely necessary to increase the stemming height to limit the range of flyrock throw. We have assumed an example of 102 mm diameter holes on a 3.3 m x 3.3 m pattern and stemming lengths from 2.1 m to 3.5 m.

The results of the flyrock analysis are summarized in Table 7.

Table 7: Estimated Maximum Flyrock Range for a Range of blast Designs for the Proposed Caledon Quarry

Blasthole Diameter (mm)	Burden (m)	Stemming (m)	Maximum Throw (m) 1)		Minimum 2) 3) Separation (m)
			Face Burst	Cratering	
102	3.3 4)	2.1 5)	36	115	330
102	3.3 4)	2.5	36	73	146
102	3.3 4)	3.0	36	46	92
102	3.3 4)	3.5	36	31	62

1) *Horizontal throw.*
2) *Minimum separation distance between the blast and the nearest residence assuming a FOS of 2.0*
3) *Assuming retreat toward to residences and face burst away from the residences.*
4) *Front row burden*
5) *Stemming length for the initially proposed blast.*

The analysis indicates that the initially proposed blast would have a maximum horizontal flyrock range of 115 m.

Through proper blast design and diligence in inspecting the geology before every blast, flyrock can be maintained within the proposed quarry extraction limits. It may be necessary to reduce the blasthole diameter and increase the stemming lengths when blasting along the perimeter. The operational plan for the quarry has been designed to retreat towards the closest receptors thereby projecting flyrock and overpressures away from the receptors.

7.9 Potential Impact on Pets and Livestock

Input received during public consultation for the Project, indicated a concern regarding the potential effects of blasting and vibration on livestock, pets, animal stress and foaling as a result of the blasting operations required for the proposed quarry. Certain animals are known to react adversely to loud sounds and strong vibrations. However, most domesticated animals pay little attention to human activity unless it appears truly threatening (Oriard 2002). Oriard (2002) described a project that observed zoo animals that were exposed to a nearby blasting operation. At first, some animals would look up or look nervous for a few seconds after the blasts. After the first few blasts, they became habituated and paid little or no attention. Because the initial blasts would be near the center of the site with the lower ground and air vibrations at lower levels (than at the extraction perimeter) the pets and livestock with have a chance to become habituated prior to the increased levels later on as the Project Progresses.

Richards and Moore (2022) noted that regular observations around quarries taken over many years show that quarry blasting presents a negligible risk to the health and wellbeing of domestic animals including livestock. Livestock located within 100 m of blast sites may walk a short distance away from the source of the disturbance, though spooking or obvious distress has not been observed. The impact of airblast to livestock on adjacent land can be likened with the response to a short rumble of distant thunder. Some dogs may bark or howl in response to warning sirens that are typically sounded before and after blasts. There is no evidence that exposure to brief blast vibration events causes harm to domestic or native animals (Richards and Moore 2022).

8.0 TECHNICAL RECOMMENDATIONS

The results of the Blast Impact Assessment provide the basis for the following technical recommendations to be included in the Aggregate Resources Act Site Plans for the proposed Caledon Pit / Quarry:

- All quarry blasts shall be monitored at the closest residences in front of and behind the blast for ground and air vibration effects to ensure compliance with the current MECP guideline limits.
- All quarry blasts shall be monitored within 300 m of the nearest pipeline on the ground above that pipeline to ensure compliance with Enbridge's ground vibrations limits.
- All quarry blasts shall be monitored within 300 m the farmhouse and barn located at 18722 Main Street, the farmhouse located at 18501 Mississauga Road, the farmhouse located at 18667 Mississauga Road and the house (to be converted to office/laboratory during operation) located at 1420 Charleston Sideroad to ensure compliance with the ground vibration limit of 50 mm/s. Once the farmhouse(s) located at 18501 Mississauga Road and 18667 Mississauga Road is relocated outside of the licence area, all quarry blasts shall be monitored to ensure compliance with the current MECP guideline limits.
- The vibration monitoring shall be carried out by an independent third-party engineering firm with expertise in blasting and monitoring.
- Notification shall be provided to Enbridge when blasting approaches within 300 m of the pipeline.
- No extraction within 30 m of the pipeline without authorization from Enbridge.
- Blasting shall be carried out by persons experienced, trained and qualified to conduct blasting operations.
- The licensee shall establish a blasting notification program for residents within 500 m.
- Blasting shall not occur on Saturday, Sunday and all Statutory holidays.
- If there are exceedances of the vibration limits, blast design parameters shall be altered to bring results back into compliance.
- When blasting within approximately 440 m of adjacent residences, the quarry shall regularly review their blast procedures in conjunction with the blast monitoring results to assess if it is necessary to modify blast design parameters of the blasts.
- Blasting procedures such as drilling and loading shall be reviewed annually and modified as required to ensure compliance with industry standards.
- The licensee shall maintain a record of all blasting details including a seismic record of the ground and air vibration monitoring results. The blast details and monitoring results shall be made available to the MNRF and the MECP, upon written request. The blasting reports shall include the following information:
  - Location, date and time of the blast.

- Dimensioned sketch including photographs, if necessary, of the location of the blasting operation, and nearest point of reception.
- Physical and topographical description of the ground between the source and the receptor location.
- Type of material being blasted.
- Sub-soil conditions, if known.
- Prevailing meteorological conditions including wind speed in m/s, wind direction, air temperature in ^{o}C, relative humidity, degree of cloud cover and ground moisture content.
- Number of drill holes.
- Pattern and pitch of drill holes.
- Size of holes.
- Depth of drilling.
- Depth of collar (or stemming).
- Depth of toe-load.
- Weight of charge per delay.
- Number and times of delays.
- The result and calculated value of Peak Pressure Level in dBL and Peak Vibration Velocity in mm/s.
- Applicable limits.
- The excess, if any, over the prescribed limit.

- The first five regular production blasts in the Main Area of the Licence shall be monitored at a minimum of five locations at varying distances from each blast to better define the ground and air vibration attenuation characteristics at the nearest receptors to assist with future blast designs. This shall entail establishing monitoring stations between the blast site and neighbouring receptors (residences).

9.0 CONCLUSIONS

Based on the foregoing considerations, it is Golder's opinion that:

- With the implementation of the recommendations contained in this report the site will be operated in accordance with the current quarry blasting guidelines published by the MECP (NPC-119) at all surrounding sensitive land uses.
- The site has been designed to minimize and mitigate to acceptable levels any potential adverse effects from blasting in accordance with provincial guidelines, standards and procedures.

- All blasting and blast monitoring would occur in accordance with the *Aggregate Resources Act (*Ontario Ministry of Natural Resources and Forestry, 2017*)* prescribed conditions in order to ensure compliance with the provincial guidelines.
- Through proper blast design and diligence in inspecting the geology before every blast, flyrock will be maintained within the proposed quarry limits.

This assessment was carried out by Mr. Daniel Corkery, a Principal Blasting Consultant with WSP Golder, who has been involved in blast engineering and vibration impact analyses for 33 years. Mr. Corkery provides supervision and technical involvement in all aspects of blasting control, including design, blast optimization, feasibility studies, preparation of specifications, design and implementation of monitoring programs, and assessing the environmental impact of blasting operations on adjacent facilities. Mr. Corkery, whose curriculum vitae is found in Appendix F has been involved with blasting projects throughout North and South America, Asia, Europe, Africa and Australia.

Signature Page

Golder Associates Ltd.

Daniel Corkery
Principal Blasting Consultant

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Senior Principal/Fellow, Senior Hydrogeologist

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https://golderassociates.sharepoint.com/sites/114392/project files/6 deliverables/ph 2800-blast design/_revised report - july 2023/blast impact assessment-final rev july 2023.docx

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APPENDIX A

Terms of Reference

TECHNICAL MEMORANDUM

DATE April 25, 2022 **Project No.** 19129150

TO David Hanratty, PGeo
CBM Aggregates

CC Jennifer Deleemans, Mike Lebreton

FROM Heather Melcher **EMAIL heather_melcher@golder.com**

PROPOSED CBM CALEDON QUARRY TERMS OF REFERENCE – AIR, NOISE AND BLASTING

Golder Associates Ltd. (Golder) has been retained by CBM Aggregates (CBM), a division of St. Marys Cement Inc. (Canada) to complete technical studies to accompany an application to the Ministry of Northern Development, Mines, Natural Resources and Forestry (NDMNRF) for a new Class A Quarry Below Water licence under the *Aggregate Resources Act* (ARA) (project). The assessment will also be used for a Planning Act approval and application for Town of Caledon Official Plan and Zoning By-law amendment. The properties to be licensed are located on Charleston Sideroad and Mississauga Road, Town of Caledon, Region of Peel, Ontario (site). The site is approximately 287 hectares (ha) in size (Figure 1).

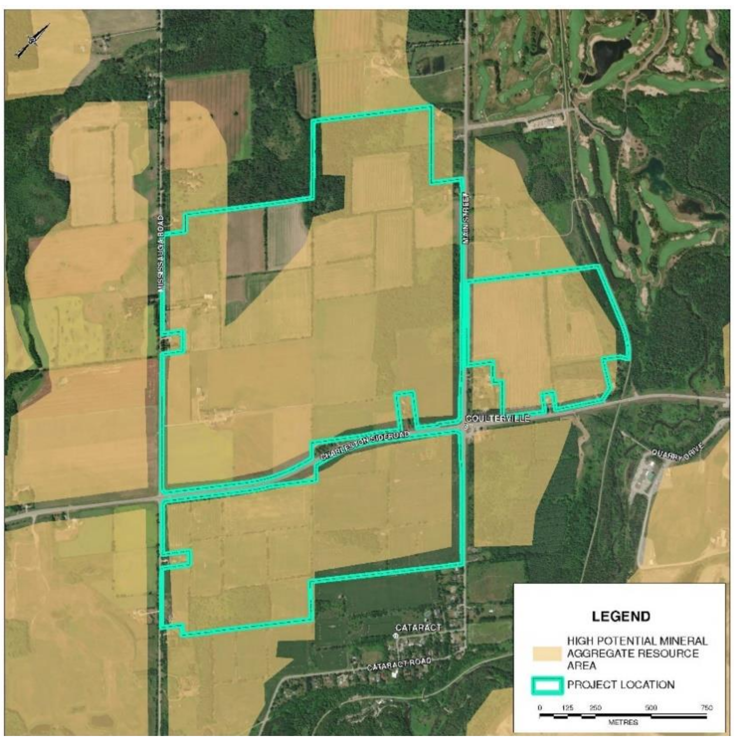

Figure 1: Proposed CBM Caledon Quarry Location

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This Terms of Reference (TOR) includes a summary of the assessment and deliverables associated with the air quality, noise, and vibration/blasting components. In addition, this TOR includes the approach to additional studies (associated with the atmospheric environment) that are being completed for the project as a result of input CBM received during public consultation efforts completed for the project to date.

1.0 AIR QUALITY

1.1 Air Quality Impact Assessment

As the ARA does not provide specific guidance and standards for air quality assessments, the preparation of a detailed air quality assessment is not typically required for a licence application. However, the preparation of an air quality assessment (including dust) is required per Sec 5.11.2.4.2 the Town of Caledon's Official Plan and will be required as part of the *Planning Act* application for the Project. The air quality assessment will include quantification of baseline air quality, specifically dust, in the vicinity of the site as well as numerical modelling of the proposed operations of the project to determine the change in air quality as well as comparison to provincial/federal standards, guidelines or regulations. This will be completed through four tasks, as described below.

1.1.1 Desktop Baseline Study

Golder will quantify the baseline or existing air quality in the vicinity of the site using publicly available ambient air monitoring data from Environment and Climate Change Canada (ECCC) National Air Pollution Surveillance (NAPS) system and/or information reported to the National Pollutant Release Inventory (NPRI) by facilities located close to the site. These data will be used to prepare a summary of existing local air quality. The locations of the closest NAPS monitoring stations that will be considered to describe background air quality data are located in Brampton (NAPS IDs 60428 and 60450), approximately 30 km southeast of the project and Guelph (NAPS ID 61802), approximately 35 km southwest of the project. These monitoring stations are the closest NAPS monitoring stations to the Project but are located in more suburban environments. They are therefore expected to provide a conservative assessment of baseline air quality as they are surrounded by a greater density of residential and commercial emission sources.

1.1.2 Baseline Monitoring

Golder will organize and manage an ambient air quality monitoring program for dust (over a one-year period) to assess the baseline levels of particulate matter in the vicinity of the project prior to operations.

Golder will install one ambient dust continuous monitoring station at the site. Meteorological parameters will also be recorded. The dust monitoring program will include continuous monitoring of Total Suspended Particulate (TSP), Coarse Particulate Matter (PM_{10}), and Fine Particulate Matter ($PM_{2.5}$). The monitoring station will be equipped with an Aeroqual Dust Sentry Pro (Dust Sentry Pro) that measures dust and fine particulates (TSP, PM_{10}, and $PM_{2.5}$) continuously in real-time.

The Dust Sentry Pro is an instrument that delivers simultaneous measurements of dust particulates and reports real-time data in one-minute intervals. Meteorological conditions will also be monitored. The monitoring of meteorological conditions will be completed with a Vaisala WXT536 Weather Transmitter connected directly to the Dust Sentry Pro.

The baseline monitoring data will be used to supplement the data collected from publicly available sources, identified in Section 1.1.1. A comparison of data from all three stations will be provided.

1.1.3 Predictive Modelling

Predictive impacts on air quality from the proposed operations require an estimate of the emissions released into the atmosphere as well as representative local meteorology. Impacts are predicted using an approved regulatory atmospheric dispersion model to provide estimates of contaminant concentrations at various receptors around the project. These estimates will be combined with baseline data to provide a cumulative impact of the operations which can be compared to various regulatory standards, guidelines, and objectives. Generally, air quality modelling results are compared to provincial and/or federal Ambient Air Quality Criteria.

Golder will prepare emission estimates of indicator compounds during project operations. This includes consideration of the 1-hour, 24-hour, and annual operating scenarios that the project may be subject to. The relevant indicator compounds will include the following:

- Carbon monoxide (CO)
- Nitrogen oxides, expressed as nitrogen dioxide (NO_2)
- Suspended particulate matter[1] (SPM)
- PM_{10}
- $PM_{2.5}$
- Respirable Crystalline Silica.

The emission estimates for all indicator compounds will be used to complete atmospheric dispersion modelling for the following scenarios:

- Effects of the project operations only.
- Cumulative effects of the project in addition to baseline ambient air quality.

All dispersion modelling will be completed using the US EPA AERMOD dispersion model and carried out in accordance with the Ministry of the Environment, Conservation and Parks (MECP) "*Air Dispersion Modelling Guideline for Ontario – Version 3.0*" dated March 2017. Golder will use a 5-year hourly meteorological data set from the MECP.

1.1.4 Impact Assessment and Reporting

Time-averaged concentrations of all indicator compounds will be predicted at identified sensitive receptors with results compared to provincial and/or federal ambient air quality standards, guidelines and/or criteria. If necessary, Golder will identify proposed mitigation measures to reduce the potential for nuisance as a result of the Project. The results of the air quality impact assessment will be documented in a report.

[1] SPM can also be referred to as total suspended particulate or TSP

1.2 Fugitive Dust Best Management Practices Plan

Golder will use the results of the air quality impact assessment and recommended mitigation measures to prepare a comprehensive fugitive dust Best Management Practices plan (BMPP). The BMPP will document CBM's commitment to control the fugitive dust emissions from being carried beyond the limits of the site. The BMPP will give consideration to the following:

- Identification of the main sources of fugitive dust emissions.
- Identification of potential causes for high dust emissions and opacity from these sources.
- Description of preventative and control measures in place or under development to minimize the likelihood of high dust emissions and opacity from the sources of fugitive dust identified above.
- Implementation schedule for the BMPP.
- Inspection and maintenance procedures and monitoring initiatives to allow effective implementation of the preventative and control measures.

2.0 NOISE

A noise impact assessment will be completed in accordance with applicable NDMNRF and MECP requirements to identify potential noise levels from the project onto sensitive Point(s) of Reception (POR(s)) in the vicinity of the site. This will be completed through the tasks described below.

2.1 Site Reconnaissance and Establishment of Existing Conditions (Baseline Noise Monitoring Program)

Golder will complete a site reconnaissance field program to review the site surroundings and to complete a ground-based review of PORs. Golder will also gather noise data to document existing noise levels in the vicinity of PORs that could be impacted by the proposed project.

Based on an initial review of publicly available imagery of the site and surrounding environment, it is expected the POR(s) in the vicinity of the site are in an area defined by the MECP as either Class 2 or Class 3 (Rural). This will be confirmed by the site reconnaissance. Documented levels will be compared against any previous noise studies completed for other lands in the area, if available.

In establishing existing conditions Golder will complete a noise monitoring program where existing baseline noise levels will be documented through unattended noise monitoring at four locations to establish representative noise levels at PORs located in the vicinity of the site. The monitoring will be completed over a period of approximately one week.

2.2 Predictive Modelling and Impact Assessment

Golder will complete noise prediction modelling based on proposed operational information provided by CBM. Golder will also use available information, including Golder's database of similar noise sources, manufacturer's sound level data (to be provided by CBM, if required) and data gathered from operations at an existing CBM site (i.e., CBM's Osprey Quarry) using similar equipment to predict the off-site noise levels at the identified sensitive

POR(s) using the International Standard "*Acoustics – Attenuation of Sound During Propagation Outdoors"* (i.e., ISO 9613 part 2) as required by the NDMNRF and MECP.

Through a review of publicly readily-available information, if it is determined that an identified POR could also be directly impacted (through noise) from other aggregate operations in the area, a semi-quantitative cumulative noise impact assessment will be completed. A semi-quantitative haul-route analysis will also be completed to assess haul-route project truck noise levels resulting from project-associated truck travel on local roadways.

Prediction results from project on-site operations will be compared to the MECP exclusionary noise limits at the identified sensitive POR(s). Based on modelling results, Golder will identify mitigation that will need to be incorporated into the design of the project in order to be in compliance with applicable noise limits.

2.3 Reporting

Once the noise modelling is complete and demonstrates that the project can operate in compliance with the applicable MECP noise limits, Golder will prepare a noise impact assessment report documenting the findings of the assessment.

3.0 VIBRATION

3.1 Background Data Compilation and Review

Background data review for this phase of the project will include a review of existing documents and a number of information sources. These sources include, but are not limited to:

- Existing provincial and federal guidelines for the assessment of environmental impacts from blasting.
- Proposed blasting parameters.
- Current vibration monitoring records from an existing nearby quarry operated by CBM (Osprey Quarry).
- Blast vibration attenuation models from Golder's experience and from published literature.

3.2 Site Reconnaissance and Existing Conditions

The field investigation includes a site visit to identify the sensitive receptors and other features that may be potentially impacted.

3.3 Predictive Modelling

Predictive modelling to estimate the attenuation characteristics of ground and air vibration levels from blasting operations at sensitive receptors would typically involve monitoring a number of site blasts at specific locations. Since there are currently no blasting operations at the site, the investigation includes the compilation and analysis vibration monitoring information currently being collected at residential properties located nearby to a similar quarry operation (i.e., CBM's Osprey Quarry). A site visit will also be arranged to visit a nearby CBM operated aggregate quarry (Osprey Quarry) where the blasting operations are similar to those proposed for the site. Predictive modelling of both ground and air vibrations from the proposed blasting operations will be carried out using the historic data from the existing CBM Osprey Quarry. The impact assessment will assume maximum explosive weights per delay period and minimum distances between the blast source and receptor.

3.4 Impact Assessment and Reporting

The data collected during the site reconnaissance will be analyzed with the data provided by CBM to assess the ground and air vibration decay characteristics. This will provide ground and air attenuation models. The impact assessment will address the following topics:

- An estimate of the potential ground and air vibration levels at potential points of impact.
- Evaluations of:
  - The potential impact on the nearby sensitive receptors.
  - The potential impact of the blasting operations on bedrock strata and adjacent water wells.
  - The long-term impact of the blasting operations on surrounding structures.
  - The impact of ground vibration effects at adjacent Canadian Fisheries waters if and where applicable.
  - The risk for flyrock.
- Recommendations for the continued control of ground and air vibration effects, and to prevent wild flyrock events.

The study findings, impact assessment, and recommended mitigation strategies will be presented in a report.

4.0 CARBON FOOTPRINT STUDY

Golder will complete a carbon footprint study which will include analyses of direct and purchased electricity related greenhouse gas (GHG) emissions associated with the following aspects of the project:

- Land clearing of the project site
- Project operations
- GHG removals as a result of rehabilitation of the project site

The analysis will be conducted in accordance with applicable guidance from the GHG Protocol Initiative document *"GHG Protocol Corporate Accounting and Reporting Standard"* and the recently released Environment and Climate Change Canada document entitled *"Technical Guide Related to the Strategic Assessment of Climate Change"* (SACC). In order to prepare the above analysis, current and post-rehabilitation land use information will be incorporated, along with fuel and electricity consumption projections for the project during operations. Fuel and electricity consumption estimates for the project will be developed by Golder, in consultation with CBM, based on projected equipment lists and electricity consumption. The assessment will also include a comparison if the material was imported further from market.

A technical memorandum will be developed, which will include a description of the methodology and the results of the assessment. The magnitude of GHG estimates associated with the project will be put into context using metrics available in public literature (e.g., the project's contribution to local/regional GHG emissions).

5.0 CLOSURE

We trust that this technical memorandum meets your current needs. Please contact Golder and CBM with any questions or comments.

Golder Associates Ltd.

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https://golderassociates.sharepoint.com/sites/114392/project files/6 deliverables/terms of reference/atmospheric tor/19129150-tm-rev0-cbm caledon quarry atmospheric tor-25apr2022.docx

APPENDIX B

Definition of Blasting Terms and Glossary of Blasting Terms

DEFINITIONS OF BLASTING TERMS

Figure A-1 illustrates blasting terminology used in this report.

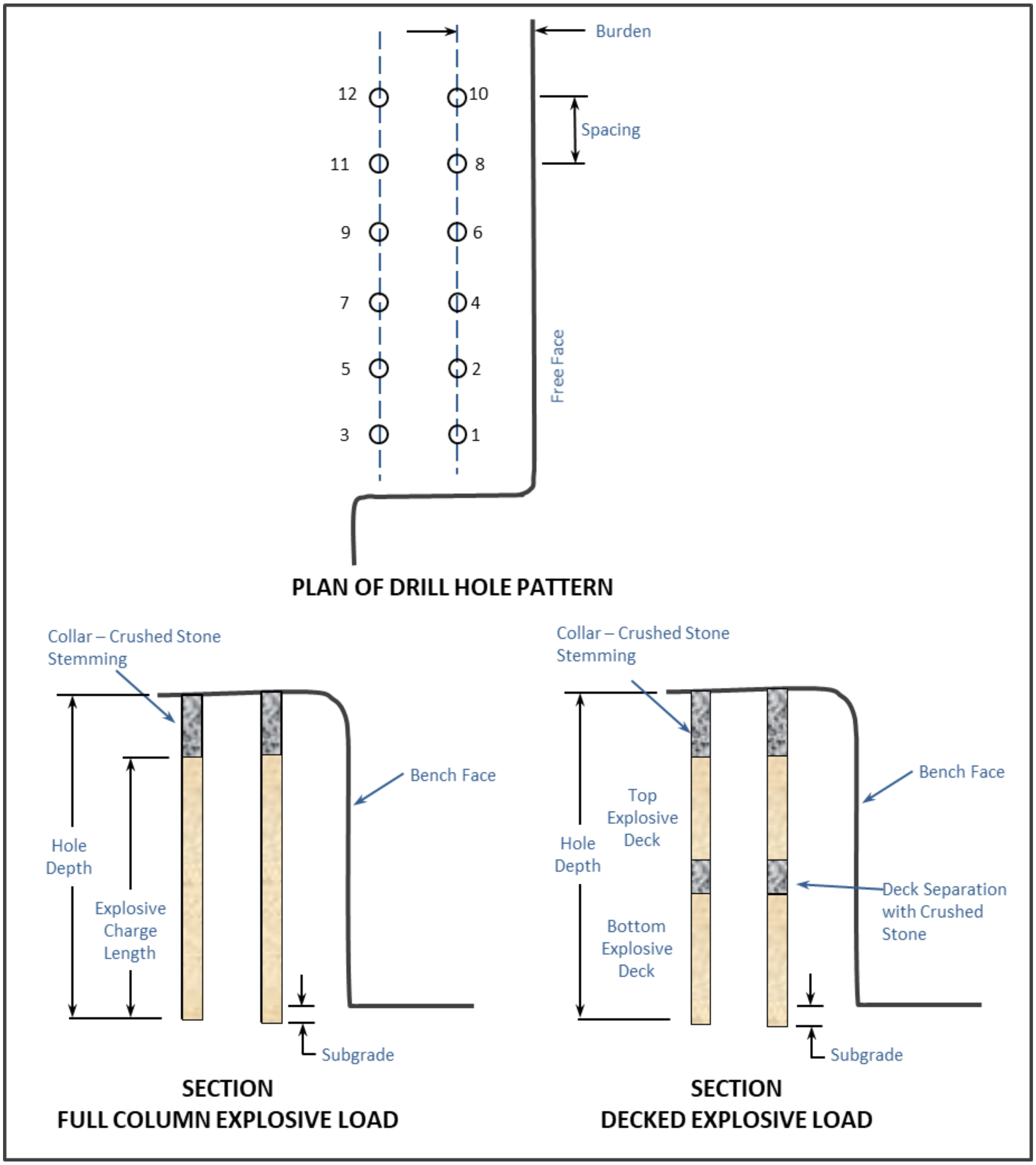


Figure A-1: Definition of Blasting Terms

GLOSSARY OF TERMS

The following is a glossary of blasting terms that were used in this report.

Bench Height - This is the vertical distance from the top of the bench to the floor or to the top of the next lower bench.

Blast - The operation of rending (breaking) rock by means of explosives.

Blast Area - The area of a blast within the influence of flying rock missiles, gases and concussion.

Blast Hole - A hole drilled in rock or other material for the placement of explosives.

Booster - This is an explosive unit containing a suitable firing device that is used for the initiation of an entire explosive charge.

Burden - Generally considered the distance from an explosive charge to the nearest free or open face.

Collar - This is the mouth or opening of a borehole.

Deck - In blasting a portion of a blast hole loaded with explosives that are separated from the main charge by stemming.

Detonation - This is an explosive reaction that moves through an explosive material at a velocity greater than the speed of sound in the material.

Detonator - This is any device containing any initiating or primary explosive that is used for initiating detonation. This includes blasting caps.

Electronic Detonator - This is a detonator that provides better precision for delays. They are that are variably and individually programmable.

Explosive - This is a chemical mixture that reacts at high speed to liberate gas and heat and thus cause development of tremendous pressures.

Flyrock - Rocks propelled from the blast area by the force of an explosion.

Free Face - The bench face to which the blast will move. It is also any rock surface exposed to air.

Highwall - Nearly vertical face at the edge of a bench, bluff or ledge on a surface excavation.

Initiation - The act of causing and explosive material to detonate or deflagrate.

ISEE - International Society of Explosives Engineers.

MIC - Maximum Instantaneous Charge is the maximum weight of explosive (kg) detonated at any instant in time.

Muckpile - The pile of broken material resulting from a blast.

Powder Factor - The weight of explosive per unit volume or weight of rock moved.

Spacing - This is the distance between boreholes or charges in a row.

Stemming - The inert material, such as drill cuttings or crushed stone, used in the uncharged portion (or elsewhere) of a blasthole so as to confine the gaseous products formed on explosion.

Subdrill - This is the portion of the blastholes beyond the planned grade lines or below floor level.

APPENDIX C

Publication NPC-119, Model Municipal Noise Control By-Law, Final Report, 1978

PUBLICATION NPC-119

Blasting

1. Scope

This Publication refers to limits on sound (concussion) and vibration due to blasting operations.

2. Technical Definitions

The technical terms used in this Publication are defined in Publication NPC-101 – Technical Definitions.

3. Measurement Procedures

All measurements of peak pressure level and vibration velocity shall be made in accordance with the "Procedure for Measurement of Sound and Vibration due to Blasting Operations" set out in Publication NPC-103 – Procedures, section 5.

4. Concussion – Cautionary Limit

Subject to section 5 the peak pressure level limit for concussion resulting from blasting operations in a mine or quarry is 120 dB.

5. Concussion – Peak Pressure Level Limit

If the person in charge of a blasting operation carries out routine monitoring of the peak pressure level, the peak pressure level limit for concussion resulting from blasting operations in a mine or quarry is 128 dB.

6. Vibration – Cautionary Limit

Subject to section 7, the peak particle velocity limit for vibration resulting from blasting operations in a mine or quarry is 1.00 cm/s.

7. Vibration – Peak Particle Velocity Limit

If the person in charge of a blasting operation carries out routine monitoring of the vibration the peak particle velocity limit for vibration resulting from blasting operations in a mine or quarry is 1.25 cm/s

APPENDIX D

Nearest Receptors to the Proposed Caledon Pit / Quarry

NEAREST RECEPTORS TO THE PROPOSED CALEDON PIT / QUARRY

Receptor ID	Receptor Name	Distance (m) [1)]
POR001	18147 Mississauga Rd.	280
POR002	18189 Mississauga Rd.	200
POR003	18205 Mississauga Rd.	180
POR004	18221 Mississauga Rd (Inside project boundary)	180
POR005	18234 Mississauga Rd	280
POR006	18309 Mississauga Rd.	190
POR007	833 Charleston Sideroad (Hwy 24)	490
POR008	18615 Mississauga Rd.	150
POR009	18627 Mississauga Rd.	160
POR010	18682 Mississauga Rd.	320
POR011	18785 Mississauga Rd.	220
POR012	18837 Mississauga Rd.	260
POR013	18906 Main St. (Hwy 136)	460
POR014	18942 Main St (Cultural Heritage)	580
POR015	18842 Main St.	240
POR016	18810 Main St.	240
POR017	18796 Main St.	200
POR018	18775 Main St.	320
POR019	18772 Main St. (Owned by CBM) [2)]	100
POR020	18719 Main St.	150
POR021	18659 Main St.	150
POR022	18473 Main St.	150
POR023	18471 Main St.	150
POR024	1700 Charleston Sideroad (Hwy 24)	150
POR025	Cultural Heritage (remaining silo)	310
POR026	1626 Charleston Sideroad (Hwy 24)	150
POR027	1540 Charleston Sideroad (Hwy 24)	220
POR028	1522 Charleston Sideroad (Hwy 24)	150
POR029	1531 Charleston Sideroad (Hwy 24)	180
POR030	1529 Charleston Sideroad (Hwy 24)	150
POR031	1521 Charleston Sideroad (Hwy 24) [3)] (gas station not sensitive)	100
POR032	18217 Cataract Rd.	150
POR033	18201 Cataract Rd.	170
POR034	18198 Cataract Rd.	150
POR035	18182 Cataract Rd.	160
POR036	18164 Cataract Rd.	160

Receptor ID	Receptor Name	Distance (m) [1)]
POR037	18148 Cataract Rd.	190
POR038	18140 Cataract Rd.	240
POR039	18130 Cataract Rd.	260
POR040	18137 Cataract Rd.	290
POR041	18120 Cataract Rd.	290
POR042	10 Deagle Lane	210
POR043	38 Williams St.	280
POR044	42 Williams St.	290
POR045	48 William St.	260
POR046	1498 Cataract Rd.	380
POR047	33 William St.	340
POR048	47 William St.	320
POR049	61 William St.	330
POR050	71 William St.	340
POR051	77 William St.	340
POR052	89 William St.	330
POR053	26 Albert St.	340
POR054	1392 Cataract Rd.	380
POR055	18051 Cataract Rd.	440
POR056	1501 Cataract Rd.	440
POR057	1460 Cataract Rd.	400
POR058	1446 Cataract Rd.	390
POR059	1463 Cataract Rd.	450
POR060	1453 Cataract Rd.	450
POR061	1437 Cataract Rd.	460
POR062	1434 Cataract Rd.	390
POR063	1432 Cataract Rd.	390
POR064	1404 Cataract Rd.	400
POR065	1425 Cataract Rd.	470
POR066	1411 Cataract Rd.	450
POR067	1391 Cataract Rd.	450
POR068	1375 Cataract Rd.	410
POR069	1369 Cataract Rd.	400
POR070	1357 Cataract Rd.	380
POR071	1341 Cataract Rd.	360
POR072	1327 Cataract Rd.	340
POR073	1342 Cataract Rd.	310

Receptor ID	Receptor Name	Distance (m) [1)]
POR074	1311 Cataract Rd.	320
POR075	1297 Cataract Rd.	310
POR076	1275 Cataract Rd.	300
POR077	1195 Cataract Rd.	350
POR078	18667 Mississauga Rd. (heritage structure proposed relocation)	135 [4)]
POR079	18501 Mississauga Rd. (heritage structure proposed relocation)	110 [4)]

1) *Separation distance to the nearest point of extraction.*
2) *POR019 is owned by CBM to used as an 'office and quality control lab' for the proposed CBM Caledon Pit / Quarry*
3) *POR031 is a retail structure and is not considered a sensitive receptor.*
4) *The distances from the designed extraction boundary to the heritage structure POR assumed location after is has been moved.*

APPENDIX E

Enbridge Third-Party Requirements in the Vicinity of Natural Gas Facilities Standard

Third-Party Requirements in the Vicinity of Natural Gas Facilities Standard

STANDARD

2021-09-29
ST-1E-30A8-8E30.V1.1.1
Enbridge Gas Inc.

Table of Contents

Third-Party Requirements in the Vicinity of Natural Gas Facilities Standard

1 Introduction

This document is intended for anyone involved in planning or carrying out work in the vicinity of Enbridge Gas Distribution and Storage's (GDS) network. It summarizes the requirements to be followed and specifies the technical requirements aimed at protecting GDS's facilities, and by extension, ensuring public and worker safety.

Within this document, "third party" refers to an individual or organization that is not employed by, or performing work under, contract to GDS. These requirements are applicable to work done by individuals such as homeowners, landowners, other utility companies, excavators, constructors, and contractors.

Third parties must follow the regulations and legislation applicable to their work in addition to these requirements. It is understood that all legal provisions applicable to work carried out around natural gas facilities take precedence over this document.

The terms "gas lines", "gas pipelines", and "mains" used throughout this document apply equally to natural gas mains and service lines, as well as any other component of GDS's natural gas systems found on public or private land.

All work in the vicinity of gas facilities must adhere to the requirements set forth in this document. Work includes, but is not limited to, any ground disturbance in the vicinity of facilities or equipment crossing. Ground disturbance includes, but is not limited to, activities associated with excavation, directional drilling, blasting, piling, compaction, boring, ploughing, grading, backfilling, and hand digging.

A locate of the facilities must be requested at least five business days prior to beginning any work. Locates are required before ground disturbance takes place.

2 Terms and Definitions

The following is a list of terms found in this document and their definitions.

applicant: The owner of the proposed work.

blaster: The person or persons responsible for setting the charges and performing the blast.

blasting, surface: An operation involving the excavation of rock foundations for various types of structures, grade construction for highways or railroads, or canals (trenches) for water supply or collection purposes.

blasting, tunnel: Operations involving the piercing of below-ground (generally horizontal) opening in rock.

compaction: Any vibration-generating operation that will result in a potential increase of the density of soils or controlled backfill materials. The means to increase the density may be static or dynamic.

constructor: A person who undertakes a project for an owner and includes an owner who undertakes all or part of a project by himself or by more than one employer (as defined by Occupational Health & Safety Act).

contractor or excavator: Any individual, partnership, corporation, public agency, or other entity that intends to dig, bore, trench, grade, excavate, hammer into, or break ground with mechanical equipment or explosives in the vicinity of a gas pipeline or related facility.

EGI: Enbridge Gas Inc.

facility: Any Enbridge Gas Distribution, Transmission, Storage pipeline, main, service, regulator station or storage facility and its related components.

Gas Distribution and Storage (GDS): Enbridge Gas Distribution and Storage, Gazifère Inc., Niagara Gas Transmissions Limited, 2193914 Canada Limited.

ground disturbance: Any work, operation, or activity on or under the existing surface resulting in a disturbance or displacement of the soil or ground cover. Ground disturbance can include, but is not limited to: activities associated with excavation, directional drilling, blasting, piling, compaction, boring, ploughing, grading, backfilling, and hand digging.

hand dig: To excavate using either a shovel with a wooden or fiberglass handle, or using hydro vacuum excavation equipment. The use of picks, bars, stakes, or other earth piercing devices are not considered hand digging.

independent engineering consultant: A professional engineer who is registered with the provincial or state professional engineering association and a holder of a certificate of authorization (C of A).

locate service provider: Any entity that performs locates under the terms of a locate service agreement.

pile: Any vertical or slightly slanted structural member introduced or constructed in the soil in order to transmit loads and forces from the superstructure to the subsoil; the structural member can also be used as a component of a retaining wall system.

pile driving: The placement of piles carried out by gravity hammer, vibratory hammer, auger, pressing, screwing, or any combinations of the above methods.

positive identification: Visually locating (daylighting, exposing, digging test holes to determine) the location, depth, and size of a below-grade facility by using either vacuum excavating or hand digging. This includes elevation or alignment changes that can alter the depth or direction of the pipe (e.g., 45° and 90° elbows, fittings, plugs, weldolets, flanges, branch piping, known abandoned facilities, etc.).

pre-Engineering review: A process by which third parties can request a pre-engineering review for any potential conflict analysis.

professional engineer: An engineer registered and licensed with the provincial professional engineering association in the jurisdiction in which the engineer is practicing.

rural: All areas outside urban areas.

temporary support: The support of gas pipelines before or during an excavation to protect the pipeline from its own weight and to minimize deflection stresses.

third party: An individual or organization that is not employed by or performing work under contract to GDS (e.g., homeowners, other utility companies, contractor, excavators, constructors, etc.).

urban: An area with a population of at least 1,000 and a density of 400 or more people per square kilometer.

vital pipeline: A subset of pipelines that are critical to the safe and reliable operation of the natural gas system. Damages to vital mains could result in significant negative impact to public and worker safety or significant customer outages. This subset of mains consists of CER-regulated (Canada Energy Regulator) pipelines, transmission pipelines, and select distribution pipelines.

3 General Requirements

3.1 CER-Regulated Pipelines and Vital Pipelines

The CER regulates natural gas, oil, and commodity pipelines that extend beyond provincial, territorial, or national boundaries. All work in the prescribed area (within 30 m [100 ft] from each side of the CER-regulated pipeline) must be reviewed by the applicable CER-regulated operating company prior to commencing. This review is a regulatory requirement of the CER.

Mains are designated as vital pipelines by GDS. These include, but are not limited to, any pipeline NPS 16 or larger, transmission pipelines, CER-regulated pipelines, all pipelines operated by Storage and Transmission Operations (STO), and select distribution pipelines. The designation of a vital pipeline may change at the discretion of GDS. Vital Pipelines will be identified through locates. In these requirements, special considerations for CER-regulated pipelines and vital pipelines will be highlighted.

All work within 5 m (16 ft) from either side of lines operated by STO must be approved by GDS prior to commencing. For all other vital pipelines, all ground disturbance work within 3 m (10 ft) from either side of the vital pipeline must be approved by GDS prior to commencing. Approval by GDS may include specific conditions that third parties must follow. GDS may require representation on site for any ground disturbance work within the vicinity of vital pipelines and CER-regulated pipelines.

3.2 When Observation Is Required

A GDS representative is required to be on site to ensure the excavation or third-party activity is being safely completed near a pipeline when:

- Excavation with mechanical equipment will occur within 5 m (16 ft) of CER-regulated pipelines and all lines operated by STO.
- Excavation with mechanical equipment may take place within 3 m (10 ft) of vital pipelines and pipeline segments.
  Once the pipeline is exposed, mechanical excavation is then permitted up to 1 m (3.3 ft) from the pipeline.
- It is anticipated that blasting will take place within 30 m (100 ft) of any pipeline.
- Any other situations which requires observation, as deemed necessary by EGI.

3.3 Safe Excavation

Mechanical excavation is not permitted within 5 m (16 ft) of CER-regulated pipelines and 3 m (10 ft) of vital pipelines, unless verified visually. After the exact location of the main is verified visually, mechanical excavation is allowed up to 1.0 m (3.3 ft) from the pipeline. Within 1 m (3.3 ft) of the CER-regulated or vital pipeline, only hand digging or hydro-excavation is allowed.

Mechanical excavation may not begin within 3 m (10 ft) of the pipe until:

- The pipe has been exposed by the excavator, under the supervision of GDS, by hand at the point of crossing, or the pipeline company has located the pipe and confirmed that it is at least 0.6 m deeper than the proposed excavation.
- The excavation is parallel, or the pipe has been exposed by handto confirm the location of the pipe.

For all non-vital pipelines, mechanical excavation is not allowed within 1 m (3.3 ft) of the locate marks of the pipeline, until the exact location of the pipeline has been visually verified. The excavator must expose the pipeline by hand digging or hydro-excavation. Once the pipeline is exposed, mechanical excavation is then permitted up to 0.3 m (1 ft) from the pipeline. Within 0.3 m (1 ft) of any pipeline, only hand digging or hydro-excavation is permitted.

Only handheld compaction equipment may be used within 1 m (3.3 ft) of the sides or top of all gas pipelines. When ground conditions make hand excavation impractical (e.g., frost), the pipeline company may permit excavation to within 1 m (3.3 ft) of the pipeline if the pipeline company considers it safe to do so and directly supervises the excavation.

Spoil from excavation must not be piled on the pipeline or its easement.

3.4 Minimum Cover Requirements

Table 3-1: Minimum Cover Requirements on page 8 defines mains and services cover requirements. In all cases where the depth of cover requirements cannot be met, contact GDS to review depth of the cover requirements.

Table 3-1: Minimum Cover Requirements

Pipeline	Location	Minum Cover m (ft)
Mains	Under traveled surfaces (roads), road crossings	1.2 m (4 ft)
	Right-of-ways	1 m (3.3 ft)
	Highways	1.5 m (5 ft)
	Water crossings, and below drainage and irrigation ditches	1.2 m (4 ft)
Services	Private property	0.5 m (1.6 ft)
	Road crossings	0.9 m (2.9 ft)

3.5 Points of Thrust

Additional precautions may need to be taken when working in the vicinity of points of thrust. Points of thrust occur at pipeline fittings such as elbows (45° or 90°), end caps, weld tees, reducers, closed valves, and reduced port valves. If a point of thrust is identified through the locate process, GDS may require additional time to review the proposed work area. In the event that the excavation involves exposing a point of thrust or exposing an area near a point of thrust, GDS may provide written specific instructions that are to be followed. Failure to follow these instructions can result in significant harm to persons, property, or the environment.

3.6 Repair of Damaged Pipe and Pipe Coating

In all cases where the pipeline or the pipeline coating is damaged by construction activities, GDS must be contacted immediately and the excavation left open until GDS personnel have made the necessary repairs.

3.7 Encroachment

Permanent awnings and roof structures are prohibited above GDS's facilities within public rights-of-way or GDS's rights-of-way. GDS will not accept responsibility for any damages resulting from maintenance or operation of its facilities to encroaching structures within the public or GDS rights-of-way. Examples of encroaching structures include: bus shelters, street benches, and garbage bins.

GDS requires approval for all permanent structures to be built within 7 m (22.9 ft) of GDS's vital pipelines. This requirement is in place to allow GDS sufficient access and working space should an inspection or repair be needed.

3.8 Tree Planting

When planting trees, the gas pipeline in and near the area of excavation must be located to ensure enough clearance is maintained between the pipeline and the tree.

For all vital pipelines (including CER and transmission pipelines), trees or large shrubs must maintain a horizontal clearance between the edge of the root ball or open bottom container to the adjacent edge of the existing pipelines of not less than 3.0 m (10 ft), or as specified in any applicable easement agreement.

For all other pipelines, a minimum horizontal clearance of 1.2 m (4 ft) is recommended between the edge of the root ball or open bottom container and adjacent edge of the existing gas pipeline.

In cases where the recommended clearance cannot be achieved, GDS may specify the installation of a root deflector.

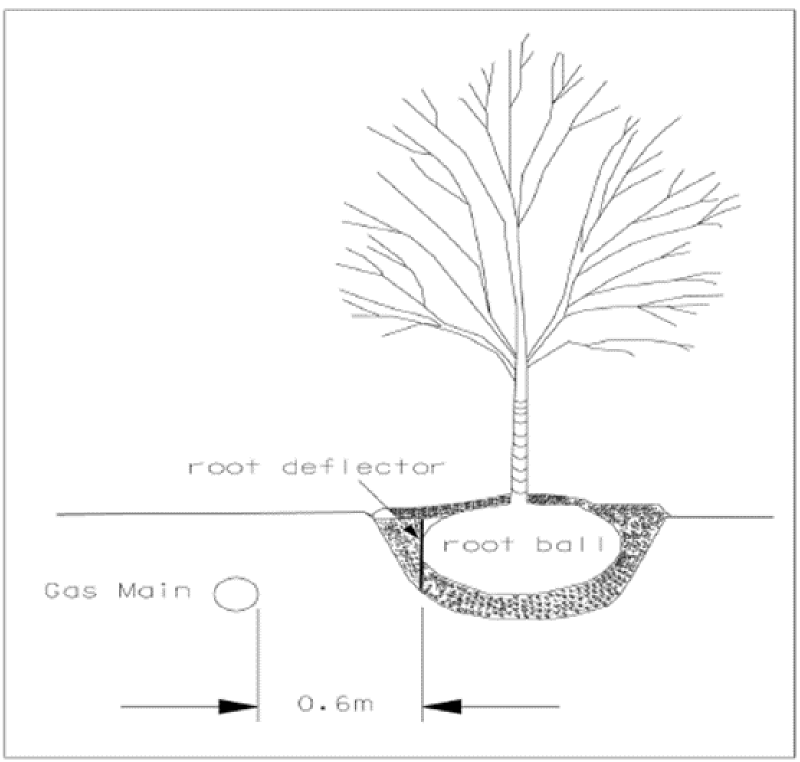
3.8.1 Root Deflectors

A root deflector is a physical barrier placed between tree roots and pipelines to prevent damage to the pipelines. A root deflector can be made from 1/4 in thick rigid plastic, fiberglass, or other non-degradable material. The root deflector is intended to prevent the root tips from attaching to the gas main.

Typically, root deflectors are straight barriers or encircle the tree. If installed as a straight barrier, the root deflector should be installed at a minimum 0.6 m (2 ft) from the pipeline on the tree-side of the pipeline. Also, it should extend parallel to the pipeline in both directions for 1.2 m (4 ft) measured from the centre of the tree trunk.

Root deflectors usually have a collar to keep the top of the deflector at ground level, and extend down to the bottom of the root-ball as shown in Figure 1: Example of a Root Deflector.

Figure 3-1: Example of a Root Deflector



3.9 Sewer and Drain Cleaning

Prior to sewer clearing activity using mechanical cutting or high pressure jetting equipment, the third party should call into Ontario One Call at 1-800-400-2255 for a cross bore sewer safety inspection. An EGI employee or contractor will attempt to attend the site within two hours to complete the inspection.

4 Minimum Clearance from Other Structures

The following clearances must be maintained between the circumference of the gas pipeline and other underground structures:

Table 4-1: Minimum Clearance Between Gas Pipelines (Less than NPS 16) and Other Underground Structures

Direction	Minimum Clearance m (ft)
Horizontal	0.6 m (2 ft)
Vertical	0.3 m (1 ft)

Table 4-2: Minimum Clearance Between CER-regulated Pipelines and Vital Pipelines and Other Underground Structures

Direction	Minimum Clearance m (ft)
Horizontal	1 m (3.3 ft)
Vertical	0.6 m (2 ft)

Additional clearance or mitigation may be required for installations (such as transit systems or power transformers) that will introduce DC stray current interference or AC fault hazards.

Note

For all pipelines (including vital pipelines), when drilling parallel to the pipeline, a minimum horizontal clearance measured from the edge of the pipeline to the edge of the final bore hole of 1 m (3.3 ft) is required.

5 Pipeline Location Verification

5.1 Surface Road Work

Surface road work applies to ground disturbance on travelled roadways related to the removal of hard-surfaces only. For any ground disturbance work, locates must be obtained prior to commencing and the excavator must ensure accuracy of the locate by reviewing the locate paperwork with the physical locate markings. Surface road work can be completed without the requirement to positively identify EGI pipelines, provided no mechanical equipment will be used within 1 m (3.3 ft) horizontally of the located pipelines. If mechanical excavation is required within 1 m (3.3 ft) of the locate during any surface road work or work that will take place deeper than removal of the hard surface, the excavator must follow rules outlined in 5.2 Subgrade Road Work on page 11 for positive identification requirements.

5.2 Subgrade Road Work

Subgrade road work is any road work exceeding the depth required for removal of the hard surface that enters the sub-surface. The boundary area for the pipeline is the distance that is identified off the locate marks of the pipeline and applicable boundary areas are highlighted in Table 5-1: Boundary Areas on page 11.

Table 5-1: Boundary Areas

Pipeline	Boundary Area
Vital pipelines (≥ NPS 24)	3 m (10 ft)
Vital pipelines (< NPS 24)	2 m (6 ft)
Non-vital pipelines (all sizes)	1 m (3 ft)

Note

Work within the boundary areas must comply with the positive identification requirements set in Table 8-2: Pipeline Location Verification Requirements for Vital Pipelines on page 22 and Table 8-3: Pipeline Location Verification Requirements for All Other Pipelines on page 22.

If these guidelines cannot be complied with, the excavator must submit a variance request work package. No variance will be provided for work within 1 m (3.3 ft) of any pipeline. The variance work package must include, at a minimum, the following information:

- Pre-Engineering design.
- Location of EGI facilities with respect to proposed excavation area (vertical and horizontal offsets).
- Location of proposed excavation area (vertical and horizontal offsets off permanent landmarks).
- Pipeline protection plan.

If a variance is requested, the excavator must also provide a physical barrier (e.g., silt fence), which would denote the boundary of the pipeline, where possible.

8.2 Drilling Parallel to Pipelines on page 21 and Table 8-3: Pipeline Location Verification Requirements for All Other Pipelines on page 22 indicate GDS's minimum requirements for the verification of the pipeline location based on the nature of the work. The frequency and location of test holes may change at the discretion of GDS. Additional test holes may be required to sufficiently confirm the location of the pipeline (e.g., regulator stations).

Note

Non-mechanical equipment must be used when working within 1 m (3.3 ft) of any pipeline. If mechanical equipment is required for use around non-vitals, the pipeline must be positively identified using hand tools or hydro-excavation. Once the non-vital pipeline location has been visually identified through positive identification requirements listed in the 8.2 Drilling Parallel to Pipelines on page 21 and Table 8-3: Pipeline Location Verification Requirements for All Other Pipelines on page 22, mechanical equipment can be used up to 0.3 m (1 ft) of the non-vital pipeline and 1 m (3.3 ft) of a vital pipeline.

When using hydro-vacuum excavation as an alternative to hand digging, see 9 Hydro-Excavation on page 25 for safe operating practices.

6 Operation of Heavy Equipment

6.1 General

Additional precautions are necessary when equipment in excess of the weights listed in Table 5: Vehicle Load Restrictions is operated in the vicinity of buried facilities where no pavement exists or where grading operations are taking place.

Table 6-1: Vehicle Load Restrictions

Pipe Material	Weight/Axle Maximum Allowable Load kg (lb)
Plastic	7,000 kg (15,400 lb)
Steel	10,000 kg (22,046 lb)

Prior to any crossing, the location of the gas main must first be staked out by a GDS representative.

The excavator is responsible for confirming the location and depth of the main. Test hole spacing must not exceed 50 m (160 ft).

6.2 Equipment Moving Across the Pipeline

Crossing locations for heavy equipment must be kept to a minimum.

The crossing locations must be determined by GDS after reviewing:

- The nature of the construction operation.
- The types and number of equipment involved.
- The line and depth of the existing gas main.

The use of equipment is contingent upon the review by GDS. Once the crossing locations have been established, heavy equipment is restricted to crossing at these locations only. It is the responsibility of the third party to inform their personnel of the crossing location restrictions.

Pipelines may require additional protection at crossing locations by constructing berms or installing steel plates over the pipeline.

Unless expressly allowed by the temporary crossing consent, equipment that crosses pipelines must be subject to the following conditions:

- The numbers of crossings back and forth must be kept to a minimum.
- Equipment must not remain stationary on top of a pipeline.
- Equipment must not cross with loaded side boom or other unbalanced loads.
- Equipment must cross perpendicular (not parallel) to the pipeline. The crossing angle for installations must be within 45° to 90° (with preference for as close to perpendicular as possible).
- Equipment must operate at slow speeds when crossing a pipeline in order to minimize loading impact.
- Existing cover over a pipeline must not be reduced; any loss of cover (e.g., due to rutting) must be promptly restored prior to crossing.
- Vibratory compaction equipment must not operate within 1.2 m (4 ft) of a pipeline.

6.3 Equipment Moving Along the Pipeline

Heavy equipment can be operated parallel to existing pipelines provided that a minimum offset of both:

- 1 m (3.3 ft) is maintained on pipeline sizes less than NPS 16.
- 2 m (6.6 ft) on pipeline sizes NPS 16 and larger, unless otherwise directed by GDS.

Only lightweight, rubber-tired equipment may be operated directly over the existing gas pipelines, unless a minimum pipe cover of twice the pipe diameter or 1 m (3.3 ft) (whichever is greater) can be verified. The use of all other equipment is contingent upon review and approval by GDS.

Unless expressly allowed by the temporary crossing consent, equipment moving along pipelines is subject to the following conditions:

- Equipment must operate at slow speeds when moving along a pipeline.
- Existing cover over a pipeline must not be reduced; any loss of cover (e.g., due to rutting) must be promptly restored prior to moving along the pipeline.

- Vibratory compaction equipment must not operate within 1.2 m (4 ft) of a pipeline.

Note
When crossing perpendicular to a pipeline that is smaller than NPS 16 (excluding vital pipelines), the vertical clearance outlined in Table 2: Minimum Clearance Between Gas Pipelines (Less than NPS 16) and Other Underground Structures may be used as long as all positive identification requirements are also followed.

Note
When crossing perpendicular to a pipeline that is NPS 16 or larger, or crossing any CER-regulated pipelines or vital pipelines, a minimum vertical clearance of 1 m (3.3 ft) is required; 8 Horizontal Directional Drilling on page 20.

7 Support of Gas Pipelines

7.1 General

The support requirements specified in this section are the minimum requirements. GDS must be notified regarding the support of any gas main. GDS has complete discretion in the approval of any support system. Additionally, if a pipeline is to be exposed for longer than one month, approval must be sought from GDS and work must follow the requirements outlined in 3 General Requirements on page 6. Third parties must not depart from these support requirements unless a professional engineer working for or on behalf of the third party has designed an alternative method. Any alternative method must be comparable to these specifications and be, in the opinion of the professional engineer, consistent with good engineering practices. The alternative specification must be documented, approved by a professional engineer and provided to GDS for review prior to the commencement of work. The third party is responsible for the adequate support of the buried gas pipelines exposed during excavation according to this section.

Prior to any crossing, the location of the gas main must first be staked out by a GDS representative.

7.2 Support of Gas Pipelines Perpendicular to Excavation

Temporary support refers to the support of gas pipelines prior to or at the time of excavation to protect the pipeline from deflection due to its own weight while it is exposed. Temporary support must remain in place until the backfill material underneath the pipeline is compacted adequately to restore support of the pipeline.

Before trenching beneath a main or service, temporary support must be erected for pipelines if the unsupported span of pipe in the trench exceeds the length indicated in Table 7-1: Maximum Span without Support Beam on page 15.

Note

For pipelines larger than NPS 16, GDS must be contacted. Contact information can be found in the 12 Contact Information on page 32.

When temporary support is required, Table 7-2: Support Beam Sizes and Maximum Span Between Beam Supports on page 15 indicates the required beam for a given span. The beam must be a continuous length grade No. 1 Spruce-Pine-Fir (S-P-F) or equivalent. For spans exceeding 4.5 m (15 ft), a continuous length timber beam may not be available. In that case, steel I-beams (or equivalents) can be used as the support beam. Steel beam selection must be certified by a professional engineer and submitted to GDS for review.

Table 7-1: Maximum Span without Support Beam

Pipe Size (NPS)	Steel m (ft)	PE (polyethylene) m (ft)
1/2	2 m (6.6 ft)	1 m (3.3 ft)
3/4 to 1-1/4	2.5 m (8.2 ft)	1.25 m (4.1 ft)
2	3 m (10 ft)	1.5 m (5 ft)
3 to 4	4.5 m (15 ft)	1.75 m (6 ft)
6	6 m (20 ft)	2 m (7 ft)
8	7 m (23 ft)	2 m (7ft)
10	8.5 m (28 ft)	-
12	10 m (33 ft)	-
16	11.5 m (38 ft)	-

Table 7-2: Support Beam Sizes and Maximum Span Between Beam Supports

	Steel	Plastic	
Pipe Size (NPS)	≤ 4.5 m	≤ 2 m	≤ 4.5 m
1/2 to 2	4 × 6	4 × 6	6 × 8
3 to 6	-	6 × 6	8 × 8

Note

In all cases where the support beam size requirements cannot be met, GDS must be contacted to review support beam requirements.

The beam must be placed above the pipe with the ends of the beam resting on firm undisturbed soil. The beam must not bear directly on the gas pipeline. The pipe must be supported from the beam with rope, canvas sling, or equivalent in a manner that will prevent damage to the pipe and coating and eliminate sag. The spacing between the ropes must not exceed 1 m (3.3 ft); see Figure 7-1: Support of Gas Pipelines Crossing Excavations on page 18.

Backfill material underneath the exposed pipeline must be compacted to a minimum of 95% compaction. Sand padding must be placed to a level 150 mm (6 in) below and above the main. For additional details, see 10 Backfilling on page 26.

Perform compaction with the loose lift height not exceeding 200 mm (8 in) or one-quarter of the trench width, whichever is less. Injecting water into the backfill beneath the pipe is not an acceptable method of compaction.

All temporary support on pipelines must be removed before backfilling. Adequate support must remain in place until the backfill material has restored support.

7.3 Support of Pipelines Parallel to Excavation

Two cases exist for pipelines parallel to an excavation:

- Trench < 1.2 m deep
- Trench > 1.2 m deep

In either instance, the pipeline must not be exposed unless it is necessary to provide direct support.

Trench wall support may not be required for excavations provided the pipeline meets all of the following criteria:

- Depth is less than 1.2 m (4 ft).
- the pipeline is at least 0.6 m (2 ft) from the edge of the excavation or outside the 45° line projected upward from the trench bottom; see Figure 7-3: Influence Lines for Gas Pipelines Adjacent to Excavations on page 20.
- Soil is stable (type 1 or 2, see Table 15-1: Soil Types on page 34)

If the pipe does not meet these requirements and the soil is soft clay or sand (soil types 3 and 4), then the excavation must be suitably shored to prevent movement of the pipe. The shoring must remain in place until the backfill material has restored support.

Trench wall support is required for excavations if any one of the following conditions exist:

- Depth is ≥ 1.2 m (4 ft).
- The pipeline is closer to the edge of the excavation than the minimum allowed distance indicated Table 7-3: Minimum Allowed Distance from Main to Excavation on page 17.
- Depth is < 1.2 m (4 ft) and the soil is unstable (type 3 or 4, see Table 15-1: Soil Types on page 34).

Note
Adequate support must remain in place until the backfill material has restored support.

Minimum distances from the edge of the trench to the pipeline in which the excavation influences pipelines are shown in Table 7-3: Minimum Allowed Distance from Main to Excavation on page 17. The pipeline must be supported if these minimum distances cannot be met.

Table 7-3: Minimum Allowed Distance from Main to Excavation

Trench Depth (m)	Soil[a] Type 1 and 2	Soil[a] Type 3 and 4
1.2 m (3.9 ft)	0.9 m (3 ft)	0.9 m (3 ft)
1.5 m (4.9 ft)	0.9 m (3 ft)	0.9 m (3 ft)
1.8 m (5.9 ft)	0.9 m (3 ft)	0.9 m (3 ft)
2.1 m (6.9 ft)	0.9 m (3 ft)	0.9 m (3 ft)
2.4 m (7.9 ft)	0.9 m (3 ft)	0.9 m (3 ft)
2.7 m (8.9 ft)	0.9 m (3 ft)	1 m (3.3 ft)
3 m (9.8 ft)	0.9 m (3 ft)	1.5 m (4.9 ft)
3.3 m (10.8 ft)	0.9 m (3 ft)	1.8 m (5.9 ft)
3.6 m (11.8 ft)	0.9 m (3 ft)	2.2 m (7.2 ft)
3.9 m (12.8 ft)	0.9 m (3 ft)	2.5 m (8.2 ft)
4.2 m (13.8 ft)	0.9 m (3 ft)	3 m (9.8 ft)
4.5 m (14.8 ft)	1 m (3.3 ft)	3.4 m (11.2 ft)
4.8 m (15.7 ft)	1.5 m (4.9 ft)	3.8 m (12.5 ft)
5.1 m (16.7 ft)	2 m (6.6 ft)	4.1 m (13.5 ft)
5.4 m (17.7 ft)	2.5 m (8.2 ft)	4.6 m (15.1 ft)
5.7 m (18.7 ft)	3 m (9.8 ft)	5 m (16.4 ft)
6 m (19.7 ft)	3.4 m (11.2 ft)	5.5 m (18 ft)

a. As defined in the Occupational Health and Safety Act.

For pipelines where the trench bottom is below the water table, the trench must be suitably shored as per the trench wall support requirements.

Any pipeline that is exposed for a length greater than indicated in Table 7-1: Maximum Span without Support Beam on page 15 requires a field assessment.

For steel and polyethylene pipelines within the minimum distances given in Table 7-3: Minimum Allowed Distance from Main to Excavation on page 17, support must remain in place until backfill material restores support.

Figure 7-1: Support of Gas Pipelines Crossing Excavations

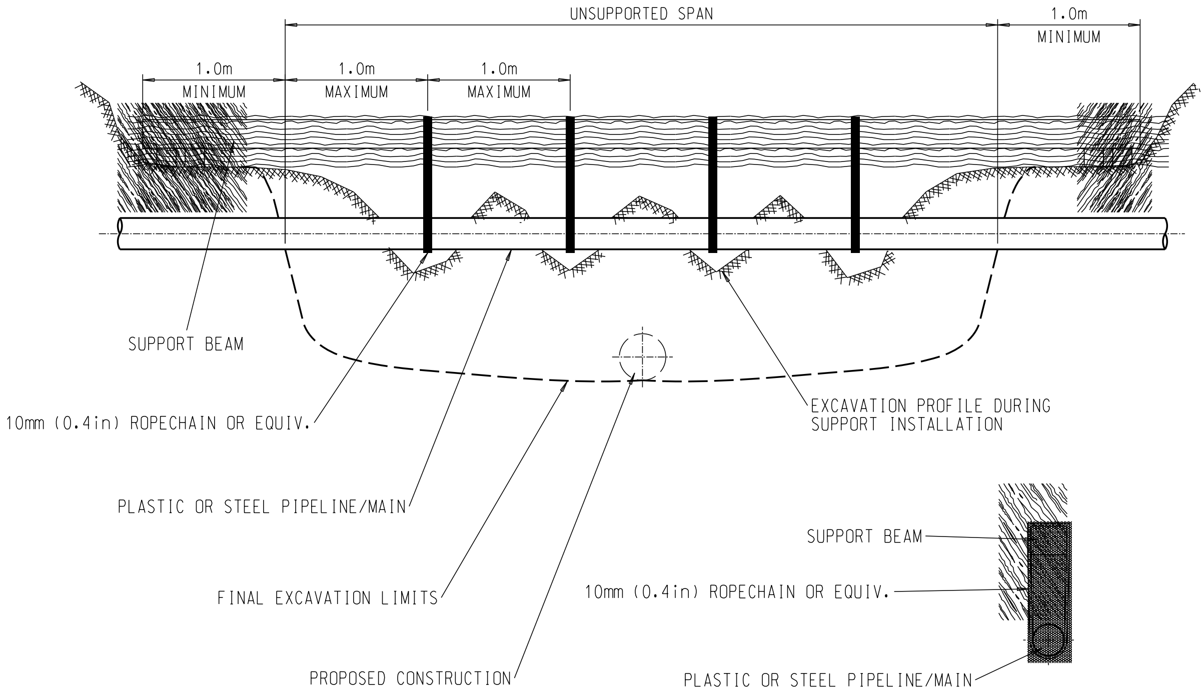
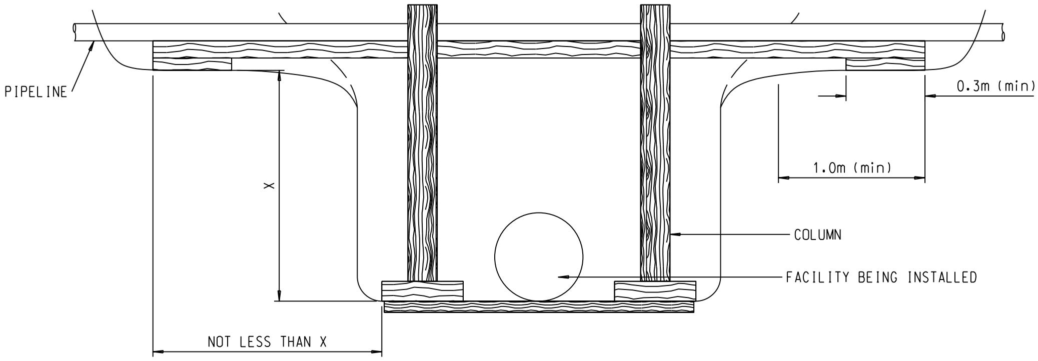


Figure 7-2: Typical Temporary Supports for Pipelines Crossing the Trench – Span Exceeds 4.5 m



NOTES:
1. LAMINATED 4X6 TIMBER BEAM REQUIRED BENEATH ALL NPS 1/2 - NPS 2.
2. LAMINATED 6X6 TIMBER BEAM REQUIRED BENEATH ALL NPS 3 - NPS 6.
3. LAMINATED 8X8 TIMBER BEAM REQUIRED BENEATH ALL NPS 8 - NPS 12.
4. COLUMN SIZE SHALL MATCH LAMINATED TIMBER BEAM REQUIREMENT.
5. COLUMN TO BE SPACED AS SPECIFIED BY PIPELINES AND STATIONS OPERATIONS ENGINEERING.
6. PLASTIC PIPE AND COATING ON STEEL PIPE TO BE PROTECTED FROM SUPPORTS AND STRAPPINGS WITH A PIECE OF RUBBER TIRE OR EQUIVALENT.
7. PLASTIC PIPE MUST BE SUITABLY STRAPPED O PREVENT MOVEMENT OFF THE BEAM.
8. ADDITIONAL SUPPORTS WILL BE REQUIRED AT MECHANICAL COUPLINGS OR VALVES.

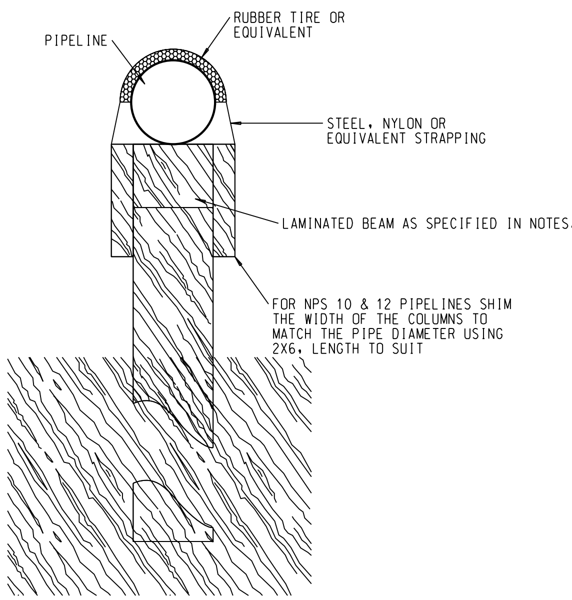
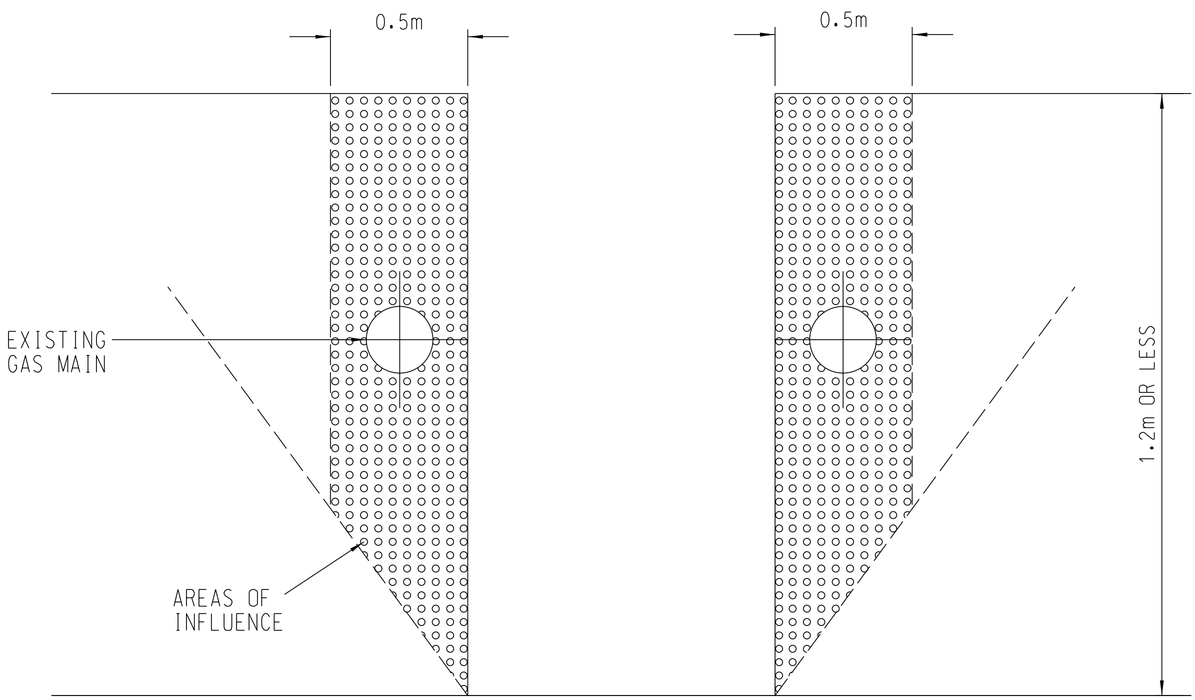


Figure 7-3: Influence Lines for Gas Pipelines Adjacent to Excavations



NOTE:
IF PIPE IS IN SHADED AREA AND SOIL IS TYPE 3 OR 4, THE TRENCH IS REQUIRED TO BE SHORED.

8 Horizontal Directional Drilling

8.1 General

Horizontal directional drilling (HDD) or directional boring is a steerable trenchless method of installing underground facilities. Trenchless technology is used where utilities being crossed are positively identified to confirm location.

For installations using any other type of drilling or augering equipment in the vicinity of gas facilities, GDS must be contacted.

In all cases, positive identification holes are required to visually verify the drill head's location (including depth) relative to the measurement of the tracking equipment. For positive identification hole requirements, see Figure 8-2: Pipeline

Location Verification and Clearance Requirements for HDD for crossing all pipelines (including Vital Pipelines) on page 25. For pipeline location verification and clearance requirements for all horizontal directional drilling see Table 8-1: Pipeline Location Verification and Clearance Requirements for HDD for all Pipelines (including Vital Pipelines) on page 21.

If these guidelines cannot be complied with, a variance request work package must be submitted. No variance will be provided for work within 1 m (3.3 ft) of any pipeline. The variance work package must include, at a minimum, the following information:

- Pre-Engineering design.
- Location of EGI facilities with respect to proposed installation area (vertical and horizontal offsets).
- Location of proposed installation area (vertical and horizontal offsets off permanent landmarks).
- Pipeline protection plan.

If a variance is requested, a physical barrier (e.g., silt fence) must also be provided, which would denote the boundary of the pipeline, where possible.

Table 8-1: Pipeline Location Verification and Clearance Requirements for HDD for all Pipelines (including Vital Pipelines)

Location of Work Relative to Pipeline[a]	Required Verification of Pipe Location by Hand Digging or Hydro-Excavation
Crossing below pipeline (HDD)	All sides of pipeline (including below pipeline) exposed to 1.0 m (3.3 ft) from the pipeline's sidewalls. Additional positive identification hole at 2.0 m to 4.0 m (6.6 ft to 13.1 ft) prior to the daylight hole at the crossing, to verify depth and trajectory of drill head and backreamer.
Crossing above pipeline (HDD)	Top of pipeline and all sides exposed to 1.0 m (3.3 ft) or 1.0 m (3.3 ft) below the proposed installation. Additional positive identification hole at 2.0 m to 4.0 m (6.6 ft to 13.1 ft) prior to the positive identification hole at the crossing, to verify depth and trajectory of drill head and backreamer.

a. See Figure 8-2: Pipeline Location Verification and Clearance Requirements for HDD for crossing all pipelines (including Vital Pipelines) on page 25.

8.2 Drilling Parallel to Pipelines

When the proposed route is parallel to a natural gas pipeline at a perpendicular distance of 3 m (10 ft) or less, positive identification must be performed at intervals of no more than 10 m (33 ft) along the drilling path so that the precise location of the drilling head and backreamers (if any) can be verified visually. These excavations must be sufficiently wide to see the entire width of the drilling head, backreamers, and structures from entry point to exit point.

Note

The location of the pipeline must be visually confirmed as per the requirements set out in Table 8-2: Pipeline Location Verification Requirements for Vital Pipelines on page 22 and Table 8-3: Pipeline Location Verification Requirements for All Other Pipelines on page 22.

Note

For all pipelines (including vital pipelines), when drilling parallel to the pipeline, a minimum horizontal clearance of 1 m (3.3 ft) is required.

Table 8-2: Pipeline Location Verification Requirements for Vital Pipelines

	Required Verification of Pipe Location by Hand Digging or Hydro-excavation
Work parallel to pipe, within 1 m (3.3 ft)	Spacing of test holes must not exceed 4.5 m (15 ft)
Work parallel to pipe, between 1 m (3.3 ft) and boundary area of pipeline based on size	Spacing of test holes must not exceed 4.5 m (15 ft)[b]
Crossing below pipeline (open excavation)	Top and sides of pipeline, and 0.6 m (2 ft) below the pipeline
Crossing above pipeline (open excavation)	Top and sides of pipeline, or 0.6 m (2 ft) below the proposed installation

a. Test holes must expose top and sides of pipeline

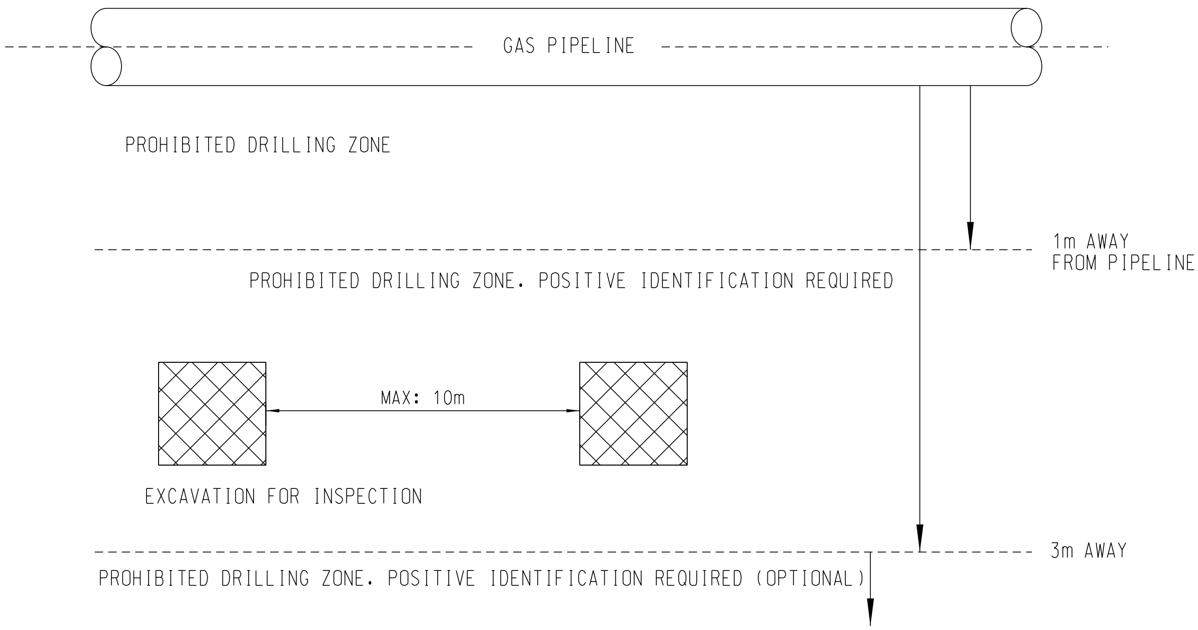
b. For work parallel to pipe, between 1 m (3.3 ft) and boundary area of pipeline based on size, for rural applications, test holes must be completed for any change in direction of the pipeline every 23 m (75 ft).

Table 8-3: Pipeline Location Verification Requirements for All Other Pipelines

Location of Work Relative to Pipeline	Required Verification of Pipe location by hand digging or hydro-excavation
Work parallel to pipe, inside of boundary area (1 m [3.3 ft])	Spacing of test holes must not exceed 4.5 m (15 ft)
Crossing below pipeline (open excavation)	For less than NPS 12: Top of pipeline and all sides of the pipeline, or 0.3 m (1 ft) below the pipeline For NPS 12 and larger: Top of pipeline and all sides of the pipeline, or 0.6 m (2 ft) below the pipeline
Crossing above pipeline (open excavation)	For less than NPS 12: Top of pipeline and all sides of the pipeline,or 0.3 m (1 ft) below the proposed installation For NPS 12 and larger: Top of pipeline and all sides of the pipeline, or 0.6 m (2 ft) below the proposed installation

No drilling installation may be performed within a distance of 1 m (3.3 ft) or less from either side of the pipeline. This buffer zone must be clearly designated and marked off around the work area. This prohibited zone may be widened in some cases.

Figure 8-1: Drilling Parallel to Pipelines



8.3 Drilling Across Pipelines

When the proposed drill path crosses a GDS pipeline, the pipeline must be exposed to the desired depth of the crossing to ensure that the natural gas pipeline is not affected and that the required clearance is maintained during all drilling operations. All minimum clearances must be measured from the outer edge of the drill, including backreamers (if any), to the outer circumference of the pipeline.

To ensure that the directional drilling operation will not result in damage to the pipeline, the following positive identification hole requirements must be followed:

- A positive identification hole must be created that is sufficiently wide enough to see the drill head and backreamer entering the excavation at a minimum of 1 m (3.3 ft) before crossing the pipeline. See Figure 8-2: Pipeline Location Verification and Clearance Requirements for HDD for crossing all pipelines (including Vital Pipelines) on page 25 positive identification hole 1.

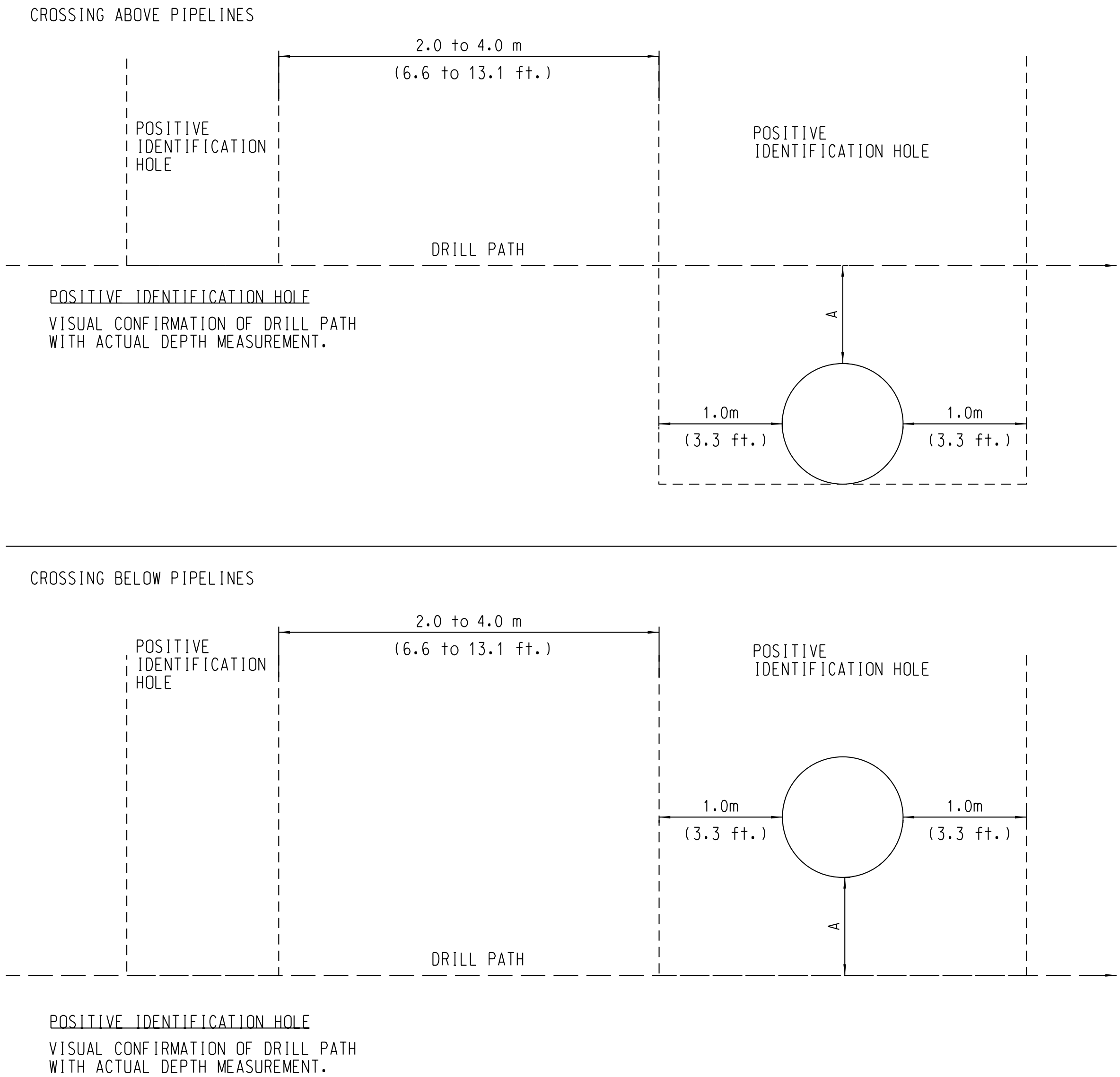
- A second positive identification hole must be created prior to reaching the pipeline such that the precise location of the drill head and backreamer (if any) can be verified visually. The positive identification hole must be sufficiently wide to measure the depth and trajectory of the drill head and backreamer. See Figure 8-2: Pipeline Location Verification and Clearance Requirements for HDD for crossing all pipelines (including Vital Pipelines) on page 25 positive identification hole 2.

When drilling across pipelines that are smaller than NPS 16 (excluding vital pipelines), the vertical clearance, measured from the edge of the pipeline to the edge of the final bore hole, may follow the vertical clearance outlined in Table 4-1: Minimum Clearance Between Gas Pipelines (Less than NPS 16) and Other Underground Structures on page 10 as long as all positive identification requirements are also followed.

When drilling across pipelines that are NPS 16 or larger, or crossing any CER-regulated pipelines or vital pipelines, a minimum vertical clearance, measured from the edge of the pipeline to the edge of the final bore hole, of 1 m (3.3 ft.) is required.

Note
The location of the pipeline must be visually confirmed as per the requirements set out in Table 8-2: Pipeline Location Verification Requirements for Vital Pipelines on page 22 and Table 8-3: Pipeline Location Verification Requirements for All Other Pipelines on page 22. For specified minimum clearances, see 4 Minimum Clearance from Other Structures on page 10.

Figure 8-2: Pipeline Location Verification and Clearance Requirements for HDD for crossing all pipelines (including Vital Pipelines)



9 Hydro-Excavation

9.1 General

Hydro-excavation, also known as hydrovac, is the non-destructive process in which pressurized water is utilized as a method of excavation through loosening and suction of soil, rocks, and other earth materials. Hydro-excavation machines are an alternative to hand digging to locate and expose pipelines.

9.2 Hydro-Excavation Requirements

The following requirements must be met at all times when excavating with hydro-excavation technology:

- Spinning tip nozzles must be used for hydrovac excavations with water pressures that must not exceed the maximum water pressure of 17,236 kPa (2,500 psi) during excavation. Pressure measures must be permanently monitored using a calibrated device mounted on either the hydro-excavation machine (truck and pump), or the wand when using a spinning tip nozzle.
- The wand must never remain motionless during excavation. The wand must never point to the plant at any time.
- A distance of 20 cm (8 in) between the end of the pressure wand nozzle and the plant or subsoil must be maintained. The nozzle must never be inserted into the subsoil while excavating above the plant.
- Hydro-excavation equipment and nozzles must have been specifically designed for use above buried gas lines or other reasonably expected underground gas plants.
- A device capable of stopping the excavation on demand must be installed, such as an approved automatic electronic shut-off or valve on the wand.
- If heated water is used during excavation, the temperature and pressure of the water must not exceed 100 °F (38 °C) and 17,250 kPa (2,500 psi), respectively.
- The excavator must contact the gas utility if any damage to a gas plant occurs while using hydro-excavation technology or any other method of excavation.

10 Backfilling

The gas pipeline must be inspected by GDS for damages before backfilling the excavation. It is the third party's responsibility to ensure that the gas pipeline is not undermined or endangered in any way. If any damage occurs, GDS must be contacted immediately.

The following principles must be followed:

- The backfill does not harm the pipe or coating throughout the installation process and while in service.
- The use of native material (especially with respect to anode installation) and minimize haul out must be maximized.
- A reliable and stable installation must be created and the use of dams included when appropriate.

The Company permits the use of any compacting device that:

- Will compact backfill sufficiently to eliminate any settlement of the pipe or ground surface.
- Will not cause any deformation or damage to the pipe or coating.
- Will not cause any damage to any adjacent building, structure or utility.
- Will not cause any damage to any tree, shrub, tended lawn, or ground cover.

When backfilling where the finished grade has not been established, sufficient soil must be placed over the trench to allow for settlement.

Backfilling must be done in such a manner as to prevent any rocks from being placed at or near the surface of the pipe. Native excavated material must be used as backfill unless otherwise directed by GDS. Where native material is unsuitable, 150 mm (6 in) of approved earth or sand padding must be placed over the pipe for protection, to a minimum depth of 300 mm (12 in). Each layer must be compacted thoroughly by manual tamping. Topsoil must not be used for backfilling.

Aggregate backfill must be replaced in 200 mm (8 in) layers. Each layer must be thoroughly compacted by pneumatic tampers or an equivalent method acceptable to GDS to ensure no settlement. The final layer must be smoothed down with a grader (or a rake for small scale projects) and must be tamped flush or slightly higher than the surrounding ground surface in order to prevent ponding of water and accommodate any future soil subsidence over the trench line.

Backfilling a flooded trench is not allowed. The third party is responsible for the removal of water from the trench, before backfilling. If backfilling on a slope, the backfill must first be placed from the bottom of the slope, then the filling should continue by building upwards. This prevents large voids in the backfill that can occur when the backfill is dumped from the top of a slope.

Backfill and compaction within road allowances must be completed in accordance with the local governing authority.

Unshrinkable fill or other engineered backfill material must be installed only when requested by the municipalities, local governing authority, or as directed by GDS. The approved unshrinkable fill must be batched at a ready-mix plant with a specified maximum compressive strength of 0.7 MPa at 28 days and minimum slump of 150 mm (6 in). After curing, it must be excavatable using hand tools and must meet any governing agency requirements. The pipe and valve assemblies must be sand padded before placement of unshrinkable fill. The third party must ensure that placement of the unshrinkable fill does not displace sand padding or directly contact the pipeline.

If the bulk backfill material contains rocks, stones, or frozen material, pipelines must be padded with padding material to a minimum depth of 150 mm (6 in) over the pipe and fittings. If the location requires the backfill material to be tamped, the padding material must also be tamped.

The final covering of gas pipelines must adhere to municipal requirements.

11 Blasting and Pile Driving

11.1 General

Blasting and pile driving activities in the vicinity of GDS facilities require prior approval by GDS. The Blasting and Pile Driving Form, provided by GDS, must be submitted by the owner of the proposed work for all blasting and pile-driving operations. The request must be submitted a minimum of four weeks prior to the beginning work to allow sufficient time for review.

11.2 Blasting

Before any blasting operation in the vicinity of a gas pipeline can occur, the hazards to the GDS facility must be evaluated. Responsibility for the design of the blast and any resultant damage is borne entirely by the party using the explosives.

A recognized independent blasting consultant must be retained at the applicant's expense to perform an evaluation of the blast design. The independent blasting consultant must be an independent engineering consultant specialized in blasting. A copy of the stamped consultant's validation report must be submitted to GDS for review if blasting is to occur within 30 m (100 ft) of GDS facilities.

If in the opinion of GDS or an independent blasting consultant, blasting cannot be carried out without affecting the facility's integrity, alternatives must be considered, including the replacement or relocation of the affected facility at the applicant's expense. In these situations, additional time must be allowed to obtain the necessary permits and to complete the necessary construction work. In the event a third party is affected as a result of the blasting operations, all expenses associated therewith incurred by GDS must also be at the applicant's expense.

Ontario: The third party must comply with the Ontario Provincial Standard Specification (OPSS 120 – General Specification for the Use of Explosives) in addition to GDS's blasting requirements.

Quebec: The third party must comply with Quebec's Acts regarding explosives (CQLR c E-22 and CQLR c E-22, r 1) and Safety Code (CQLR c S-2.1, r 4), in addition to GDS's blasting requirements.

11.2.1 Surface and Tunnel Blasting Application Process

For subsurface blasting application requirements, refer to the Surface Blasting section of the Blasting and Pile Driving Form.

For tunnel blasting application requirements, refer to the Surface Blasting section of the Blasting and Pile Driving Form in addition to the Tunnel Blasting section.

To assist with the preparation of the form, locates must be requested to determine the location of the facilities.

11.2.2 Guidelines for Blasting

The information provided in this section is not to be construed as an exhaustive list of performance specifications, but rather a guide for conducting blasting in the vicinity of GDS's facilities. The third party is responsible for ensuring that all blasting work is performed in a good and workmanlike manner in accordance with all applicable laws, codes, by-laws, and regulations.

The third party will be held liable for and indemnify GDS in relation to any and all damage directly or indirectly caused or arising as a result of blasting operations carried out by the applicant, its employees, contractors, or those for whom the applicant is responsible by law. Prior to blasting operations, a site meeting must be arranged with an authorized representative of the applicant and a GDS representative to confirm the location of GDS's facilities and details of the proposed blast.

GDS’s pipelines must not be excavated prior to blasting. If excavation is unavoidable, then the pipeline must be properly supported according to GDS’s requirements as stated in 7 Support of Gas Pipelines on page 14.

The third party must take suitable precautions to protect the exposed pipeline from fly-rock .

Explosives must be of a type that cannot propagate between holes or be desensitized due to compression pressures. Explosives must not be left in the drill hole overnight.

If a surface blast islocated less than 10 m (33 ft) from pipeline; creates its first blast hole at a depth equal to the top of the pipeline; andthe depth of subsequent blast holes exceeds one half of the horizontal distance to the closest portion of the pipeline, then the required independent blasting consultant's report must specifically address the impact of these conditions. This is not applicable for tunnel blasting operations. The blasting consultant is responsible for the monitoring of blasting vibrations with a portable seismograph capable of transmitting data instantaneously (e.g., via email or cellular) to the required reviewer in the vicinity of GDS's facilities is mandatory to confirm that predicted vibration levels are respected. On a daily basis, a copy of the seismographic report must be provided to GDS.

Peak particle velocity (PPV) must be limited to 50 mm/s (2 in/s) and maximum amplitude must be limited to 0.15 mm (0.006 in).

11.2.3 Post Blasting

A leak survey must be completed at the end of each day of blasting. Upon completion of daily blasting operations and within 30 days after the final blasting, GDS will conduct a leak survey of the pipeline at the third party’s expense. Leak surveys will also be completed at the end of each day of blasting. Damage that has resulted from the blasting will be repaired at the third party’s expense. A summary of all blasting operations including blasting logs, vibration control, seismograph reports, and other pertinent information must be provided to GDS by the third party daily and at the completion of blasting operations.

11.3 Pile Driving

General pile installation or compaction activities in the vicinity of GDS’s facilities must be evaluated by GDS prior to beginning. Any resultant damage as a result of these activities will be borne entirely by the third party undertaking the proposed work.

If in the opinion of GDS, the particular pile installation or compaction operation cannot be carried out without affecting the pipeline or facility integrity, the following must be considered:

- Risk analysis or mitigation program for the proposed operation.
- Alternative construction methods.
- Relocation or replacement of the facility.

All costs incurred will be covered by the third party undertaking the proposed work and final approval for the work will be granted by GDS.

Piles installed using an auger must satisfy the locating and clearance requirements listed in 5 Pipeline Location Verification on page 10 and 4 Minimum Clearance from Other Structures on page 10, respectively. GDS must provide approval for the installation of piles within 3 m (10 ft) of a vital pipeline.

The third party is responsible for all costs related to customer interruption as well as costs incurred because of work delays. In the event a third party is affected as a result of the pile installation or compaction operations, all expenses associated therewith incurred by GDS will be passed to the third party.

11.3.1 Pile Driving Application Process

The application to pile drive or do compaction work must be sent to GDS via the Blasting and Pile Driving Form.

This work must be completed under the supervisor of qualified personnel. Vibration results must be provided to GDS on a daily basis.

11.3.2 Pile Installation and Compaction Work

The information provided in this section is not to be construed as an exhaustive list of performance specifications, but rather a guide for conducting pile installation and compaction work in the vicinity of GDS's facilities. The third party is responsible for ensuring that all pile installation and compaction work is performed in accordance with all applicable laws, codes, by-laws, and regulations.

Operations must not be permitted within a standoff distance of 3.0 m (10 ft) from the pipeline or other natural gas facility, unless approved by GDS.

Prior to pile installation or compaction work, a site meeting with an authorized representative of the third party and a GDS representative (for the Damage Prevention contact, see 12 Contact Information on page 32) must be arranged by the third party, to confirm the location of GDS's facilities and the details of the proposed work.

It is recommended that during the design phase, pile installation or compaction work drawings be sent to Markups for review (see 12 Contact Information on page 32).

The pipeline should not be excavated prior to the piling or compaction operation. If excavation of the pipeline is necessary, then it must be properly supported in accordance with 7 Support of Gas Pipelines on page 14.

The following situations require the opinion of an independent professional engineer:

- Compaction of soils or backfill rated at 10,000 ft-lbs (13,600 Nm) or higher at a stand-off distance of 6 m (20 ft) or less from the pipeline.
- Pile driving at a stand-off distance of 10 m (33 ft) or less from the pipeline facility.
- High-energy dynamic compaction for the rehabilitation of soils at a stand-off distance of 30 m (100 ft) or less from the pipeline.

- Type 4 soil as defined in Article 226 of the Occupational Health and Safety Act and Regulations for Construction Projects (see Table 15-1: Soil Types on page 34).

For these situations, the appropriate number of seismographs to monitor vibrations is mandatory. The seismographs must be portable with the capability of transmitting data instantaneously (e.g., via email or cellular). This control will confirm the intensity of the vibrations generated by the pile installation or compaction work as projected. Furthermore, reports of recorded intensities must be provided on a regular basis or at the request of GDS.

The peak particle velocity (PPV) measured on the pipeline, or at the closest point of the related structure with respect to the work, must not exceed 50 mm/s (2 in/s). Furthermore, the maximum displacement for the vertical or horizontal component corresponding to the above stated vibration intensity must not exceed 50 mm (2 in) at any given length of the pipeline in question.

If the PPV or displacement limit is surpassed, all operations must stop notwithstanding any delays or costs incurred by the third party or owner of the proposed work. GDS requires that the cause of these higher vibrations or displacements be investigated. GDS may arrange for a leak survey to be conducted. GDS Engineering must approve resumption of operations. Should a situation with low energy compaction operations with a soil cover of less than 1.5 m (5 ft) above the pipeline at a stand-off distance of 3 m (10 ft) or less from a pipeline be encountered, GDS may require the opinion of an independent engineering consultant.

In addition, if a Type 3 soil (see Table 15-1: Soil Types on page 34) is present on site, GDS may require the opinion of an independent engineering consultant.

The use of an auger may be required in order to avoid the use of piles.

All operations must comply with the Provincial Occupational Health and Safety Act and Regulations for Construction Projects, other applicable laws and regulations, as well as all applicable GDS specifications, standards, and guidelines.

11.3.3 Post Pile Driving Process

The third party must send GDS the items that follow within five business days of the completion of the pile installation via pile driving or compaction operations:

- A summary of all operations.
- Pile driving and compaction logs.
- Vibration control records.
- Seismograph records.

On completion of each day's work, and approximately 30 days after all work is completed, GDS will arrange to conduct a leak survey of the facility. If damage to GDS's facilities is found, it will be repaired by the third party. An invoice will be sent to the third party responsible for the work.

12 Contact Information

Location	Contact
Enbridge Gas Inc 500 Consumers Road North York, ON M2J 1P8	Markups: Mark-Ups@enbridge.com Ontario One Call Locates: 1-800-400-2255 Damage Prevention: 1-866-922-3622 Emergency: 1-866-763-5427 and 1-877-969-0999
Enbridge Gas Inc Storage and Transmission Operations Locates (Dawn) 3332 Bentpath Line P.O. Box 1180 Dresden, ON N0P 1M0	Ontario One Call Locates: 1 (800) 400-2255 Locates: 1-800-265-5260 ext 5102236 Stacey.Smith@enbridge.com Locates: 1-800-265-5260 ext 5102184 Janice.Langstaff@enbridge.com
Enbridge Gas Inc Storage and Transmission Operations Locates (Tecumseh) 3501 Tecumseh Road, Mooretown, Ontario N0N 1M0	Field Operations: 519-312-0176 jay.moore@enbridge.com Field Operations: 519-862- 6004 jason.japp@enbridge.com Tecumseh Control Room: 519-862-6012 Emergency: 1-800-255-1431
Gazifère 706 Boulevard Greber Gatineau, QC J8V 3P8	Locates: 1-800-663-9228 Planning Dept.: 1-819-776-8804 Emergency: 1-819-771- 8321, press 1

Note

The website www.clickbeforeyoudig.com gives access to the damage prevention centres in Canada, and allows locate requests to be made for each province.

13 References

- IS_F_172 Blasting and Pile Driving Form

14 Document Governance

For document control and maintenance purposes, the following tables capture important information related to this document.

Control and Maintenance

Category	Value
Owned By	Pipeline Engineering
Review Interval	Every three years
MOC-Related	No

Revision History

Table 14-1: September 29, 2021 Release

Release Date	Version	Project Number	RFC Number	Prepared By	Approved By
2021-09-29	1.1.1	n/a	4983	Hooman Zahedi, Supervisor, Pipeline Engineering	Todd Piercey, Manager, Pipeline Engineering

Doc ID	Scope	Document & Section	Summary of Changes
ST-1E-30A8-8E30	GDS	Third-Party Requirements in the Vicinity of Natural Gas Facilities Standard	Corrected tyop in 11.2 Blasting

Table 14-2: June 30, 2021 Release

Release Date	Version	Project Number	RFC Number	Prepared By	Approved By
2021-06-30	1.1	n/a	4922	Hooman Zahedi, Supervisor, Pipeline Engineering	Todd Piercey, Manager, Pipeline Engineering

Doc ID	Scope	Document & Section	Summary of Changes
ST-1E-30A8-8E30	GDS	Third-Party Requirements in the Vicinity of Natural Gas Facilities Standard	Revise tree clearance restrictions in section 3.8.

Table 14-3: April 28, 2021 Release

Release Date	Version	Project Number	RFC Number	Prepared By	Approved By
April 28, 2021	1.0	6513-20	None	Emily Varga, EIT I, Pipeline Engineering	Todd Piercey, Manager Pipeline Engineering

Doc ID	Scope	Document & Section	Summary of Changes
ST-1E-30A8-8E30	GDS	Third-Party Requirements in the Vicinity of Natural Gas Facilities Standard	Initial version.

15 Soil Types

Table 15-1: Soil Types

Type	Definition
Type 1	• Hard, very dense, and only able to be penetrated with difficulty by a small sharp object. • Low natural moisture content and a high degree of internal strength. • No signs of water seepage. • Can be excavated only by mechanical equipment.
Type 2	• Very stiff, dense, and can be penetrated with moderate difficulty by a small sharp object. • Low to medium natural moisture content and a medium degree of internal strength. • Damp appearance after it is excavated.
Type 3	• Stiff-to-firm and compact-to-loose in consistency or is previously-excavated soil. • Exhibits signs of surface cracking. • Exhibits signs of water seepage. • If dry, may run easily into a well-defined conical pile. • Low degree of internal strength.
Type 4	• Soft to very soft and very loose in consistency, very sensitive, and upon disturbance is significantly reduced in natural strength. • Runs easily or flows, unless it is completely supported before excavating procedures. • Almost no internal strength. • Wet or muddy. • Exerts substantial fluid pressure on its supporting system.

APPENDIX F

Curriculum Vitae

St. Catharines

Senior Hydrogeologist and Principal

As a Senior Hydrogeologist with Golder, Dr. McFarland has more than 30 years of professional experience and a broad background in conducting, managing and directing aggregate waste management, mining, power, oil and gas, and ground management and protection projects. He served as the project director for work programs for proposed mines, aggregate operations and industrial facilities.

He has a broad background in licensing and permitting of pits and quarries. This includes the licensing for the expansion of the Lafarge Dundas Quarry, the expansion of the Lafarge Woodstock Quarry, the expansion of the Nelson Aggregate Quarry, the RW Tomlinson license application, the St. Mary's cement Bonis Quarry, the ongoing expansion of the Port Colborne Quarry, and the Lafarge Goodwood Pit and other sites. He is also involved in numerous PPTW applications for pits and quarries. In addition, he has extensive experience in site selection studies and resource evaluations for aggregate sites.

Sean acted as the Project Director and Senior Hydrogeologist for the 2014 and 2015 annual landfill monitoring reports for the Vale Port Colborne site and for 8 landfill monitoring programs in Niagara Region. He was the Project Manager and Senior Hydrogeologist for the extensive Adams Mine landfill project, which involved the successful permitting of a 20 million tonne hydraulic containment engineered landfill facility, within a 200 m deep former open pit mine, following hydrogeological investigations collected over an 8-year period that involved extensive monitoring well installation, electronic instrumentation and testing, pump test analyses and groundwater flow modelling. He has also been an expert witness for hydrogeology at Environmental Assessment (EA) and Ontario Municipal board (OMB) hearings and has been involved in extensive contaminated site investigations including legal disputes.

Additional project experience includes hydrogeological assessments for the low level radioactive (LLRWM) facility concepts of waste management for the Canadian federal government Siting Task Force Secretariat (STFS) in limestone bedrock beneath the Great Lakes, and fractured and faulted Precambrian granitic gneiss at the Chalk River Nuclear Reactor site in northern Ontario, Canada. Further project experience in fractured rock includes the proposed Steetley Landfill, in limestone bedrock of the Niagara escarpment, including an extensive EA level hydrogeological investigation, over a 5-year period, and the existing Brow Landfill including an EPA level investigation, a long-term monitoring program and remediation.

Education

PhD Osgoode Hall Law School, York University, 2013

LLM Osgoode Hall Law School, York University, 2005

MBA Centre for Innovative Management, Athabasca University, 2001

M.Sc. Earth Sciences, Brock University, 1997

B.Sc. Geological Sciences (Honours), University of Toronto, 1985

Certifications

Professional Geoscientist, P.Geo., Ontario

Certified Professional Accountant, CPA, Ontario

Certified Management Consultant, CMC

Project Management Professional, PMP

Languages

English – Fluent

Employment History

Golder Associates Ltd. – Mississauga, Ontario

Senior Geoscientist and Principal (1987 to Present)

Hydrogeologist then Senior Hydrogeologist (1987-present)
Managing Principal, Vice President, Canada (2005-2014)
Associate - 1997 appointment
Principal - 2003 appointment
Geologist and Hydrogeologist (1985 to 1987)

Characterization of proposed and existing metal and industrial mineral facilities and impact assessments for industrial facilities.

Regina Associates Ltd. – Kingston, Ontario
Geoscientist (1983 to 1987)

Characterization of proposed and existing metal and industrial mineral facilities in Ontario, Nova Scotia, Newfoundland, British Columbia and the Northwest Territories; and hydrogeological impact assessments for industrial facilities.

SELECTED PROJECT EXPERIENCE – AGGREGATE INDUSTRY

Aggregate Resource Evaluation Regional Municipality of Peel, ON	Project Manager and geologist for evaluation of sand and gravel and bedrock resources in the Regional Municipality of Peel, Ontario for the provincial Ministry of Municipal Affairs and Housing (MMAH). The project was carried out as part of the development of the official plan for the Region.
Region of Peel Regional Municipality of Peel, ON	Technical advisor for ARIP (Aggregate Resource Inventory Paper) report for the Regional Municipality of Peel. The project involves and evaluation of shale and gravel, limestone and shale resources in the Region and was submitted to the Ontario Geological Survey for publication as a government document ARIP Paper.
Navan Quarry Navan, ON	Project Manager and geologist for evaluation of sand and gravel and bedrock resources in the Regional Municipality of Peel, Ontario for the provincial Ministry of Municipal Affairs and Housing (MMAH). The project was carried out as part of the development of the official plan for the Region.
Brockville Quarry Brockville, ON	Project Manager and hydrogeologist for hydrogeological evaluation of the Permanent Lafarge Brockville Quarry. The results of the evaluation were used to negotiate the liability of the quarry to alleged water well interference associated with quarry expansion with the Ontario Ministry of the Environment.
Dufferin Aggregates ON	Project Director and senior hydrogeologist for numerous aggregate projects at quarries and sand and gravel pits within Ontario including resource evaluations, hydrogeological investigations and environmental assessments.
Due Diligence Studies Southern Ontario	Project Manager and senior hydrogeologist for due diligence studies as part of the potential purchase of aggregate companies and operating pits and quarries in Ontario.
Site Selection Studies Southern Ontario	Project Director for site selection studies for development of quarries and sand and gravel operations in Ontario.
Lafarge - North Quarry Flamborough, ON	Project Director for hydrogeological program at the Lafarge (formerly Redland) Quarry Operations in Flamborough, Ontario, to meet the regulatory requirements of the Ontario Ministry of the Environment.
Proposed Halminen Quarry Buckhorn, ON	Project Manager for a private application for a license for a proposed limestone quarry near Buckhorn, Ontario. The project involved management of multi-disciplinary project team public meetings, and application for a Class A licence under the Aggregate Resources Act.
Votorantim Cimentos Bowmanville, ON	Project Director for the development of a limestone/dolostone mine under Lake Ontario. The work programs involve drilling and testing of a 275m deep borehole under the lake, development of an underground mine plan, preparation of an EA document for regulatory approvals and public participation programs.

Milton Limestone Quarry Peer Review
Milton, ON

Project Director for the peer review of the hydrogeological and adaptive management plan report for the proposed Dufferin Aggregates Milton Quarry expansion. The work program involved meetings with the hydrogeological consultant and legal counsel and attendance at Ontario Municipal Board hearings.

SAROS Study
Greater Golder Horseshoe, ON

Evaluation of supply and demand of aggregate resources in the Greater Golden Horseshoe for the MMNR (Ministry of Natural Resources and Forestry). The project includes resource estimates for 25 quarries and 120 pits and unlicensed sand and gravel resources in the study area.

Nelson Quarry Expansion
Burlington, ON

Project Director for the proposed Nelson Quarry extension including extensive borehole drilling and monitoring well installations, water quality sampling, a surface water program, groundwater flow modeling, impact assessments, preparation of an Adaptive Management Plan (AMP), reporting and acting as an expert witness at an Ontario Municipal Board hearing.

Lafarge South Quarry Expansion
Dundas, ON

Project Director for a hydrogeological and hydrological work programs in support of a license application for the expansion of the Lafarge South Quarry near Dundas, Ontario (ongoing). The work program involves borehole drilling and monitoring well installations, geophysical borehole logging, water quality sampling and analyses, hydrological analyses of streams and wetlands, a karst assessment, a water well survey, geological and hydrogeological interpretation, groundwater flow modeling, agency interaction and attendance at public meetings.

Lafarge Fonthill Pit PTTW Renewal
Fonthill, ON

Project Director for a hydrogeological work program in support of a Permit to Take Water (PTTW) application for the Lafarge, The work program included interpretation of pumping wells records, evaluation of drawdown in water wells related to pumping, water quality analyses and preparation and submission of a report in support of the permit application.

Lafarge North Quarry Expansion
Dundas, ON

Project Director for a hydrogeological work program conducted in support of a license application for the expansion of the Lafarge North Quarry. The work program involved borehole drilling and monitoring well installations, pumping tests, groundwater flow modelling, a water well survey, an impact assessment of potential effects on water wells and an adjacent provincially significant wetland, agency interaction and preparation of a report submitted in support of the license application. The application was approved with an Ontario Municipal Board hearing.

Lafarge PTTW Monitoring Programs
ON

Project Director for hydrogeological monitoring programs for a portfolio of more than 50 pits and quarries in Ontario. The programs involved water level and water quality monitoring, evaluation of pumping records, effects assessments and preparation and submission of monitoring reports for compliance with the permits.

RW Tomlinson Quarry License Application
Brechin, ON

Project Co-director for the hydrogeological work program for a hydrogeological work program performed in support of a license application for a dolostone quarry in the Carden Plain. The work program involved borehole drilling and monitoring well installation, geophysical borehole logging, packer testing, well response testing, pump testing, water quality sampling, groundwater flow monitoring, an impact assessment including potential effects on surrounding water wells and an adjacent wetland, development of a monitoring program preparation of a report in support of the application and agency interaction.

Proposed Lafarge Glen Morris Pit
ON

Project Director and senior hydrogeologist for the hydrogeological work program in support of a license application for the proposed Glen Morris Pit. The work program included borehole drilling, monitoring well installations, groundwater level monitoring and the provision of data and preparation of a hydrogeological report.

Lafarge Wellington Quarry PTTW and ECA Renewal
ON

Project Director and senior hydrogeologist for the Lafarge Wellington Quarry Renewal. The field program involved borehole drilling, packer testing, monitoring well installations, groundwater level monitoring, a field pumping test, development of a water budget and groundwater quality sampling. A hydrogeological impact assessment was developed to assess the potential impacts of quarry groundwater level drawdown related to quarry dewatering activities on surrounding private water wells and municipal wells. The work program included the modification of the regional source water protection to incorporate site data to assess the potential affects on the Guelph municipal wells.

Lafarge Regan Resource Drilling
ON

Project Manager and senior geoscientist for resource drilling at the Lafarge Regan site using some drilling techniques. The results of the work program were provided to Lafarge for their resource assessment.

Lafarge Hagersville Quarry
Hagersville, ON

Senior Hydrogeologist for the assessment of quarry dewatering and pumping for the Lafarge Hagersville Quarry as part of the PTTW monitoring program.

Arbour Farms License Application
ON

Senior Hydrogeologist for the Arbour Farms license application for a pit below water. The work program included borehole drilling, installation of monitoring wells, groundwater level monitoring and assessment of potential affects on an adjacent water course. Three-dimensional groundwater flow and heat transport modeling was completed to assess the potential thermal impacts on the surrounding surface water courses.

Rankin Construction Port Colborne Quarry Extension
Port Colborne, ON

Project Director for a multi-disciplinary work program for a license application for an extension of the Port Colborne Quarry. The work program involved hydrogeological, hydrological, blasting, noise, air, natural environment, planning, agricultural and archaeological studies and a resource estimate. Senior Hydrogeologist for the hydrogeological work program that involved borehole drilling, monitoring well installations, groundwater quality sampling and analysis, an impact assessment and a monitoring and response program for potential impacts on surrounding water wells.

Lafarge Goodwood Pit Extension
Goodwood, ON

Project Director and senior hydrogeologist for a license application for the Lafarge Goodwood Pit extension, for a Category 1 Class EA pit below water. The objective of the work program was to characterize the existing hydrogeological and hydrological conditions in the vicinity of the site, including the depth and elevation of the water table and assess potential affects of the operational and rehabilitation scenarios. The work program involved borehole drilling, monitoring well installations, groundwater level monitoring, development of a water budget and a hydrogeological impact assessment.

Lafarge Woodstock Quarry Expansion
Woodstock, ON

Project Director and senior hydrogeologist for the hydrogeological investigation of the Woodstock quarry for support of a license amendment. The field program involved borehole drilling, packer testing, monitoring well installations, groundwater quality sampling and analysis, a field water well survey and development of a water budget. An impact assessment was conducted to assess the potential affect of quarry related groundwater level drawdown on surrounding water wells and surface water courses.

CRH Resource Evaluation and Due Diligence
ON

Project Manager and senior geoscientist for a resource evaluation of a property near Orangeville, Ontario for potential acquisition for quarry development. The work program included borehole drilling, geological logging of the rock core, monitoring well installations to determine the depth of the water table, aggregate quality testing and reporting.

Limestone and Sandstone Resource Evaluation and Due Diligence
Regional Municipality of Peel, ON

Project Director and senior hydrogeologist for a resource evaluation for a property developer for potential acquisition of an existing quarry near Mississauga. The work program involved borehole drilling, core logging, aggregate quality testing and reporting.

Stouffville Resource Drilling
Stouffville, ON

Project Manager and senior hydrogeologist for the resource drilling at Lafarge Stouffville Quarry. The drilling was conducted using a sonic drill rig with continuous core sampling. The results were provided to the Lafarge geologist for the resource assessment.

Lakeridge Resource Drilling
ON

Project Manager and senior geoscientist for the resource drilling at the Lafarge Lakeridge site. The drilling was conducted using sonic coring and the results provided to the Lafarge geologist for development of a resource assessment.

Votorantim Thomas Quarry License Application
ON

Senior hydrogeologist for the hydrogeological component of the Votorantim Thomas Quarry Extension license application. The work program involved borehole drilling, packer testing, geophysical borehole logging monitoring well installations and groundwater quality sampling and analysis. Three-dimensional groundwater flow monitoring was conducted to assessment the potential hydrogeological impacts of the quarry.

Lafarge Pinkney Pit #3
ON

Senior Hydrogeologist for the hydrogeological work program for the Lafarge Pinkney Pit #3 license application. The work program involved borehole drilling, monitoring well installations and a hydrogeological impact assessment.

Lafarge Mosport Resource Drilling
ON

Project Manager and senior geoscientist for the sonic borehole drilling at the Lafarge Mosport Pit. The results of the resource drilling were provided to the Lafarge geologist as part of the site resource assessment.

Lafarge Goodwood Resource Drilling
ON

Project Manager and senior geoscientist for sonic borehole drilling of the resource near the Lafarge Goodwood Pit. The results of the drilling were provided to the Lafarge geologist for a resource assessment.

APAO (Aggregate Producers Association of Ontario) Water Consumption Study
ON

Project Director for a study for the APAO to determine the consumption of water associated with pits and quarries.

Lafarge Sunningdale Pit Monitoring Program
ON

Senior Hydrogeologist for the Lafarge Sunningdale Pit Monitoring Program. The work program includes hydrogeological monitoring, an assessment of potential impacts and preparation of an annual monitoring report.

Votorantim Resource Assessment
ON

Project Manager and senior geoscientist for a resource assessment at a Votorantim Quarry in central Ontario. The work program involved borehole drilling and borehole geophysics were used to identify and correlate the geological formations and members at the site.

Cox Construction Monitoring Well Network
Wellington County, ON

Project Manager and senior hydrogeologist for borehole drilling and monitoring well installations at a property in Wellington County to provide baseline date for potential future licensing as a quarry. The wells were installed in the thick sequence of Amabel Formation at this locates. Groundwater level monitoring was performed to determine the depth to water table.

Cox Construction Resource Evaluation and Due Diligence
ON

Project Director for a drilling program to evaluate to the limestone resource for potential acquisition of a property for development. The work program involved borehole drilling, geological logging of the rock core, monitoring well installations, aggregate quality testing and reporting.

SELECTED PROJECT EXPERIENCE – WASTE MANAGEMENT

Adams Mine
Kirkland Lake, ON

Project Hydrogeologist and Project Manager for the hydrogeological assessment of the Adams Mine near Kirkland Lake, Ontario over a five-year period as part of the proposed development of 20 million tonne engineered landfill facility for solid non-hazardous waste. The facility will receive waste from the Greater Toronto Area (GTA) via a rail line system. The landfill facility incorporates a hydraulic containment design, which prevents outward migration of contaminants from the landfill, which reduces environmental impacts and long-term operating costs. Provided expert witness testimony in an environmental assessment (EA) hearing.

Brow Landfill Dundas, ON	Project Hydrogeologist then Project Manager for hydrogeological assessment for landfill expansion of the existing Redland Quarries Inc. (formerly Steetley Quarry Products Ltd.) solid industrial waste Brow Landfill in Flamborough, Ontario. Subsequent work included ongoing groundwater and surface water quality monitoring and preparation monitoring reports submitted to the MOE, followed by development of a closure plan and an ongoing compliance monitoring program.
South Quarry Landfill Flamborough, ON	Project Hydrogeologist for hydrogeological assessment of the proposed Redland Quarries Inc. (formerly Steetley Quarry Products Ltd.) South Quarry in Flamborough, Ontario for the proposed development of an engineered landfill facility. Participated in environmental assessment (EA) hearings and assisted with the preparation of final arguments with legal counsel.
Siting Task Force Secretariat Chalk River, ON	Project Hydrogeologist, then Project Manager for geological and hydrogeological characterizations of the Chalk River Nuclear laboratories property, near Chalk River, Ontario for siting of a proposed facility for the disposal of low-level nuclear waste for the federal Siting Task Force Secretariat (STFS).
Siting Task Force Secretariat Port Hope, ON	Project Hydrogeologist then Project Manager for geological and hydrogeological characterization of the Lakeshore site in Port Hope, Ontario, for the federal Siting Task Force Secretariat (STFS). The work was carried out as part of the feasibility level I study for dispose of low-level waste in engineered caverns beneath Lake Ontario and the Cameco Uranium fuel processing facility in Port Hope.
Interim Waste Authority Regional Municipality of Peel, ON	Project Hydrogeologist for geological and hydrogeological characterization comparative evaluation of five short-listed sites for siting of an engineered landfill facility as part of the provincial Interim Waste Authority (IWA) landfill site selection process for the Region of Peel.
Guelph-Wellington County WMMP Wellington County, ON	Project Hydrogeologist for geological and hydrogeological characterization of five candidate sites and identification of a preferred site in Wellington County for siting of an engineered municipal landfill facility, as part of the joint City of Guelph - County of Wellington Waste Management Master Plan (WMMP).
Model City Landfill Lewiston, NY	Project Hydrogeologist for hydrogeological investigation of the Model City hazardous waste landfill, near Lewiston, New York, carried out as part of landfill expansion.
Welland-Wainfleet WWMP Townships of Welland and Wainfleet, ON	Project Hydrogeologist for the identification of preferred sites for development of a municipal landfill facility, as part of the Welland-Wainfleet Waste Management Master Plan (WMMP).
Brock South Landfill Pickering, ON	Project Hydrogeologist for assessment of the proposed Brock South Landfill near Pickering, Ontario, to assess the suitability of the site for development of an engineered municipal landfill facility for Metropolitan Toronto.
Redland Queenston Quarry Queenston, ON	Project Hydrogeologist for hydrogeological assessment of the Redland Quarries Inc., Queenston Quarry to determine the suitability of the site for disposal of waste rock saline shale, from the construction of the proposed diversion tunnels of the Sir Adam Beck III hydroelectric generating facility in Niagara Falls, Ontario.

Fly Ash Disposal Facility
ON

Project Hydrogeologist for hydrogeological investigations at four quarries located near Hagersville, Cayuga, Smithville and Milton to determine their suitability for development an engineered landfill for disposal of fly ash from the Ontario Hydro Lakeview Power Generating Station.

Mohawk Street Landfill
Brantford, ON

Project Hydrogeologist for assessment of groundwater and surface water quality impacts at the municipal Mohawk Street Landfill in Brantford, Ontario.

Vale Industrial Landfill
Port Colborne, ON

Project director for the preparation of an annual report for the groundwater monitoring program for an industrial waste landfill at a former nickel refinery. The work program included interpretation of groundwater flow directions and water quality trends, evaluation of the extent of the leachate plume, and an impact assessment.

Vale Industrial Refinery Landfill Monitoring
Port Colborne, ON

Project Director and senior hydrogeologist for an evaluation of the effectiveness of the purge well system at a former nickel refinery and the development of mitigation and rehabilitation measures for well clogging. The work program involved step drawdown pumping tests, longer term pumping tests, hydraulic analysis of pumping test data, assessment of the decline of well efficiency due to scaling and bio fouling and the development of a work program for well rehabilitation and maintenance including acidification.

Municipal Landfill Annual Monitoring Programs
Niagara Region, ON

Project Director for the annual monitoring program for 8 landfills in bedrock and escarpment settings in Niagara Region. The work program involves field water quality sampling, groundwater level monitoring, and provision of progress and annual reports.

Proposed Walker Ingersoll Landfill
ON

Senior Hydrogeologist for the hydrogeological investigation for the proposed Walker Landfill near Ingersoll, Ontario. The field program involved borehole drilling, monitoring well installations, packer testing, geophysical borehole logging, downhole flow profiling, groundwater quality sampling and analysis, a karst study and a water well survey. Three-dimensional groundwater flow modeling was conducted to assess the potential impacts of the landfill.

SELECTED PROJECT EXPERIENCE – SHALE INDUSTRY

Canada Brick
Mississauga, ON

Specialist for assessment of geological controls upon shale quality at the Canada Brick Britannia Road quarry site. The work was carried out in conjunction with quality control estimate of shale reservoir on the property.

Canada Brick
Halton Region, ON

Project Manager for a hydrogeological work program in support on an application for a license for the Hanson Brick Tremaine Quarry in Halton Region, Ontario.

Brampton Brick Limited
Halton and Peel Region, ON

Project Director for a hydrogeological and surface water program in support of a license application for a proposed shale quarry for a brick manufacturer. The work programs involved borehole drilling and monitoring well installations, surface water flow monitoring, water quality sampling, groundwater flow modelling and preparation of an Adaptive Management Plan (AMP).

Hanson Brick Limited
Halton Region, ON

Project Director for the assessment of the potential gas migration from a landfill to an adjacent brick manufacturing facility containing a brick kiln. The program identified potential risks and a monitoring and response program.

SELECTED PROJECT EXPERIENCE – MINING

Stanleigh Mine
Elliot Lake, ON

Project Hydrogeologist for assessment of the Rio Algom Stanleigh Mine near Elliot Lake, Ontario. The project included development of a three-dimensional flow model of a low-level radioactive waste tailings facility in Precambrian bedrock of the Canadian Shield. The model was used to develop estimates of seepage rates from the facility and was submitted to the Atomic Energy Control Board (AECB) as part of the regulatory approvals process.

Voisey's Bay Mine
Labrador

Technical specialist for hydrogeological modelling at the Voisey's Bay Mine site involving development of three-dimensional groundwater flow models of a proposed tailings basin, mine waste rock disposal facility, and an open pit mine at the Voisey's Bay Mine Site in Labrador. The modelling was carried out for the Voisey's Bay Nickel Company (VBNC) as part of the hydrogeological assessment of the mine. The work was subject to regulatory review and presented as evidence at an environmental assessment hearing.

Baley Gold Mine
Baley, Russia

Project Hydrogeologist for an Environmental Impact Assessment (EIA) as part of a feasibility study for mine expansion. The hydrogeological component included evaluation of potential for water quality impacts for an open pit mine and tailings basin, reduction of flow in stream and interference with the municipal water well supply.

Asacha Gold Mine
Kamchatka, Russia

Project Hydrogeologist of the proposed Asacha Gold Mine in northeastern Russia. The assessment focused upon chemical water quality and streamflow impacts associated dewatering of an underground mine and construction of a tailings basin. The results of the assessment formed part of the mine feasibility study.

Timmins Mine Water Study
Timmins, ON

Project Hydrogeologist for assessment of flooding of an extensive array of underground mine working beneath the City of Timmins. The assessment included evaluation of the potential impacts arising from the discharge of water from the flooded mine workings at surface within the city.

Cigar Lake Mine
Saskatchewan

Project Hydrogeologist for assessment of potential groundwater inflows into proposed shaft in northern Saskatchewan for the Cigar Lake Mining Corporation (CLMC). The results of the assessment were used as the basis for the engineering design at the shaft.

Denison Mines
Elliot Lake, ON

Project Hydrogeologist for an assessment of low-level nuclear waste tailings basin at the Denison Mines near Elliot Lake, Ontario. The hydrogeology study included assessment of seepage of uranium-impacted groundwater from the basin.

MaCassa Mines
Kirkland Lake, ON

Project Hydrogeologist for hydrogeological assessment at the Lac Minerals MaCassa Mine tailing basins in Precambrian bedrock near Kirkland Lake, Ontario. The work was carried out to evaluate the potential impacts during operation and following decommissioning of the facility.

SELECTED PROJECT EXPERIENCE – CONTAMINATED INDUSTRIAL SITES

ICI
Nobel, ON

Hydrogeological assessment of groundwater and surface water quality at the former ICI explosives and war productions plant near Parry Sound, Ontario for ICI Canada. The program included assessment of groundwater and surface water quality impacts and removal of buried underground fuel storage tanks. The results of the investigations were submitted to the Ontario Ministry of the Environment as part of the site decommissioning.

Ford Motor Company
North York, ON

Dewatering of a groundwater collection gallery and discharge of the contaminated (chlorinated solvent) wastewater to the municipal sewer system (under special conditions), at the Ford Motor Company Plant in North York, Ontario.

Shell Oil
North York, ON

Dewatering of a groundwater collection gallery and discharge of the contaminated (chlorinated solvent) wastewater to the municipal sewer system (under special conditions), at the Ford Motor Company Plant in North York, Ontario.

Beaver Lumber
Cole Harbour, NS

Excavation of underground storage tank (fuel oil) at the Beaver Lumber store at Cole Harbour, Nova Scotia. The results of the investigation favoured Beaver Lumber, by indicating that damage to the store was due to lack of delivery of the fuel supplier rather than leakage from the site fuel storage tank.

ICI Surfactants
Oakville, ON

Hydrogeological impact assessment of cadmium concentrations in groundwater at the ICI Surfactants (formerly Atkemix) site in Oakville, Ontario. The results of the monitoring were submitted to the Ministry of Environment and Energy for regulatory purposes.

Bata Footwear
Batawa, ON

Participation in the hydrogeological investigation of chlorinated solvent contamination of a bedrock limestone aquifer at the Bata Footwear plant site in Batawa, Ontario. The results of the hydrogeological impact assessment were submitted to the Ministry of Environment and Energy and used during subsequent legal proceedings to determine financial liability of Bata Footwear for the groundwater contamination.

Niagara Recycling Centre
Niagara Falls, ON

Project Director and senior hydrogeologist for the annual operational and monitoring programs for a hydrogeological work program involving groundwater contaminated with chlorinated solvents at the Niagara Recycling Centre related to prior industrial land use. The work program involved operation of the groundwater injection remediation system, assessment of subsurface contamination and preparation of annual monitoring reports.

Rankin Construction Fill Management Plan
Port Colborne, ON

Project Director and senior geoscientist for the development of a fill management plan for Pit 1 at the Rankin Construction Port Colborne Quarry. The program included a plan to take excess fill from the area to fill Pit 1. This included a sampling and reporting program to meet MECP requirements.

SELECTED PROJECT EXPERIENCE – OIL & GAS

Assessment of Natural Gas Storage Potential
Lake Erie, ON

Project Manager for an assessment of the potential for natural gas storage on Crown Lands beneath Lake Erie. The study involved the assessment of natural gas reservoirs to evaluate their suitability for use as gas storage facilities. Estimated available storage volumes were provided for each of the reservoirs.

Assessment of Natural Gas Storage Potential
Southwestern Ontario

Project Manager for an evaluation of the hydrocarbon resources in Southwestern Ontario for the Petroleum Resources Centre of the Ministry of Natural Resources. The study included the interpretation and mapping of pool boundaries for major pools, calculations of in place and recoverable reserves, tabulation of reservoir characteristics, and estimation of potential hydrocarbon resources in the Ordovician strata of southern Ontario.

SELECTED PROJECT EXPERIENCE – MUNICIPAL GROUNDWATER STUDIES

Groundwater Study for the County of Victoria
ON

Project Director and senior hydrogeologist for a large-scale groundwater study for the County of Victoria with funding from the Provincial Water Protection Plan (PWPP). The work program involved a groundwater resource assessment, evaluation of existing groundwater usage, contamination assessment, development of management options and protection strategies, and an economic evaluation.

Groundwater Study for the City of Stratford
ON

Project Director and senior hydrogeologist for a Groundwater Study for the City of Stratford involving an assessment of groundwater resources, source of contamination, pump testing of deep wells in limestone bedrock, and development of groundwater management options and protection strategies.

Simcoe and South Simcoe Groundwater Studies
ON

Provided specialist hydrogeological services for both the North Simcoe Groundwater Study and South Simcoe Groundwater Study. The work program involved a characterization of the hydrogeology of the study areas and numerical groundwater modelling of Well Head Protection Areas for municipal wells (WHPAs).

SELECTED PROJECT EXPERIENCE – KARST

Nelson Quarry Extension
ON

Project Director and Senior Hydrogeologist for karst assessment of the proposed Nelson Quarry extension that involved mapping of the Amabel Formation along the exposed cliff faces of the Mount Nemo outlier, identification of karstic springs in the Medad Valley and associated water courses, mapping of karst features along more than 1 km of exposed quarry faces. Examination of surface karst features including sinkholes and internal drainage were mapped in the area of the quarry. An ERI (Electrical Resistivity Imaging) survey was conducted over a linear distance to identify potential anomalies that could represent karstic features. Boreholes were drilled into the karstic features to evaluate karstic conditions. The boreholes were video logged along the length of the hole to evaluate karstic features such as solution enlarged fractures and voids. The flow in the boreholes were pumped and logged during an impeller flow meter to assess inflow into boreholes from potential karstic features. An array of 8 wells and a pumping well were drilled to conduct a tracer test using fluorescein dye. The dye was injected into the wells and the travel time and dye concentrations were recorded to evaluate karstic flow paths and velocities. The results were incorporated in a report submitted as part of the regulatory approvals process and presented and defended at an Ontario Municipal Board hearing.

Proposed Redland Quarries Landfill
ON

Project Hydrogeologist for a karst study as part of a geological and hydrogeological evaluations of a proposed hydraulic containment engineered landfill facility in a quarry near Dundas, Ontario. The karst study involved examination and evaluation of karstic features in the vicinity of the quarry including solution-enhanced weathering and extensive network of surficial dolostone plain, and examination of epi-karst on more than 1 km of quarry faces including solution enlarged and materialized vertical joints. The results of groundwater level monitoring results were evaluated for patterns indicative of presence of karst including rapid rises in groundwater levels (‘spiking’). Pump tests were analysed to evaluate the drawdown and recovery responses characteristic of karst.

Proposed Dundas Quarry Extension
ON

Project Director and Senior Hydrogeologist for a karst assessment as part of a hydrogeological work program for the approval of an application for a large dolostone quarry near Dundas, Ontario. The work program involved an ERI surface geophysical survey along more than 500 m of line to test for potential karstic anomalies. Boreholes were drilled in the areas of identified anomalies to evaluate the potential presence of karst. The faces of the quarries were also examined for layers of karstic groundwater inflow. The results of the karst study have been peer reviewed and are currently being used in support of the license application for quarry expansion.

Karst Remediation
Hamilton, ON

Senior Hydrogeologist for a karst assessment of a remediated industry site in the area of the Eramosa Karst Conservation Area in Hamilton, Ontario. The work program involved a review of literature on karst in the area. An inspection of the karstic features includes sinkholes, internal drainage and inferred subsurface karstic flow pathways was undertaken in areas around the site. A report in support of a property transaction was provided to regulatory authorities and agencies.

Brow Landfill Monitoring Program
ON

Project Hydrogeologist for an assessment of leachate seepage from an industrial solid waste landfill along karstic flow pathways including epi-karst, solution weathered vertical joints and horizontal fracture networks. The assessment involved monitoring of the flow rates from leachate springs and water quality of springs.

Hydrocarbon Reserve Evaluation
Southwestern Ontario

Project Director and Senior Geologist/Hydrogeologist for the estimation of hydrocarbon reserves in Southern Ontario for the Petroleum Resource Centre of Ontario Ministry of Natural Resources. The work program involved extensive analysis of karstic reservoirs formed and dolomitization from solution weathering and collapse along vertical joints and horizontal sub horizontal fracture networks. Prepared a report summarizing the study and provided to the MNR as a commercial publication.

SELECTED PROJECT EXPERIENCE – LAND DEVELOPMENT AND INFRASTRUCTURE

Peer Review, Town of Caledon
Caledon, ON

Peer review of the hydrogeological work program for a proposed residential development in Palgrave for the Town of Caledon planning department. The work program involved review of hydrogeological reports, discussions with the Town and preparation of a peer review reports with recommendations.

Peer Review, Town of Caledon
Caledon, ON

Peer review of the hydrogeological and geotechnical work program for a proposed residential development in Beaverhall for the Town of Caledon planning department. The work program involved review of hydrogeological reports, discussions with the Town and preparation of a peer review reports with recommendations.

Niacon Construction
Niagara-on-the-Lake, ON

Hydrogeological assessment of the potential impacts associated with the development of an infrastructure for a zipline facility along the Niagara river at Thompsons Point. The work program involved an evaluation of the potential for reduction of groundwater seepage along the Niagara Gorge and related environmental effects. A report was prepared that was submitted to agencies as part of the regulatory approvals process.

Time Developments
Niagara Falls, ON

Senior hydrogeologist for the hydrogeological assessment of the existing conditions and potential impacts associated with the development of a condominium adjacent to the Niagara River in Niagara Falls. The work program involved borehole drilling, monitoring wells installation, groundwater level monitoring and assessment of groundwater levels and flow directions. The results of the work program were incorporated into a geotechnical and hydrogeological report.

Time Developments
Niagara Falls, ON

Phase 1 and Phase 2 Environmental Site Assessments (ESA) for regulatory approval for condominium development on River Road in Niagara Falls, Ontario. The work program involved test pitting and surface sampling as well as collection and analysis of soil and water samples and evaluation of potential soil and water contamination.

AECOM
Oakville, ON

Hydrogeological assessment of the excavation and construction of a water pumping station in till and bedrock adjacent to a surface water course. The work program involved borehole drilling, monitoring well installations, hydraulic conductivity testing and a hydrogeological assessment of impacts on surrounding private wells associated with construction dewatering.

Geranium Homes Woodview Development
ON

Hydrogeological assessment in support of approval for a proposed residential development involving borehole drilling, monitoring well installations, hydraulic conductivity testing, groundwater level monitoring, determination of groundwater levels and flow directions and a hydrogeological impact assessment involving a water balance to evaluate reduction in infiltration and potential interference with surrounding water wells and effects on an adjacent provincially significant wetland. Participated in meetings with the TRCA as part of the approvals process. A report was prepared in support of the approvals process.

Geranium Homes Altona Development
ON

Hydrogeological assessment in support of approval for a proposed residential development. The work program involved borehole drilling, monitoring well installations, groundwater level monitoring, development of a water balance and a hydrogeological impact assessment. A report was prepared in support of the application.

Education

B.Sc. (Hons) Geological Sciences and Chemistry (Hon.), Brock University, Canada, 1983

Languages

English – Fluent

Golder Associates Ltd. – Mississauga

Senior Mining / Vibration Consultant

Daniel Corkery is an Associate and Senior / Vibration Blasting Consultant with Golder Associates.

Daniel has been involved in blasting and vibration assessment since 1989. His experience includes work in quarry, open pit, underground, construction, demolition and marine blasting.

Daniel has conducted several comprehensive studies for open pit blasting operations which involved modelling the vibration, air and water overpressure, flyrock, wall control and fragmentation. He has prepared Blast Impact Assessment for proposed operations as well as extensions to existing quarries and open pit mines across Canada and internationally.

Daniel has provided testimony before an arbitration hearing assessing the blasting techniques to produce armour stone at an existing rock quarry. He provided expert testimony regarding potential impact of blasting operations during permitting hearing for a proposed expansion of an aggregate quarry in Southern Ontario. He provided expert opinion on the blasting practices of a contractor and the potential for nitrate impact on the local groundwater. Daniel provided expert opinion on the potential cause of flyrock at an aggregate quarry near Halifax, Nova Scotia.

Employment History

Golder Associates Ltd. – Mississauga, Ontario

Associate, Senior Blasting / Vibration Consultant (2014 to Present)

Responsible for the blast consulting projects in various sectors of the blasting industry. These include blast impact assessments, blast design, compliance and near-field vibration monitoring, fragmentation analyses, pre-construction surveys and environmental control. Responsible for design, oversight and senior review of vibration monitoring control projects for construction operations across Canada.

Golder Associates Ltd. – Sudbury, Ontario

Senior Mining Consultant / Geologist (2003 to 2014)

Responsible for blast impact assessments, blast design, compliance and near-field vibration monitoring, fragmentation analyses, pre-construction surveys, data collection and analysis and report preparation for projects in various sectors of the blasting industry. Responsible for geological and mineral assessment compilations, geological mapping as well as site supervision, logging and data analysis for geological and geotechnical drilling programs.

Explotech Engineering Ltd. – Sudbury, Ontario

Senior Blasting Consultant / Geologist (1989 to 2003)

Involved in underground, quarry, construction, demolition and marine blasting, as well as blasting operations for pipeline and hydroelectric power plant operations. Handled blast monitoring, blast performance, vibration analysis, and investigations of blast damage complaints. Conducted near-field underground blast vibration monitoring for optimization of development and stope blasts as well as timing assessments of prototype detonators. Conducted VOD measurements for blasting at quarries and mining operations. Provided geological interpretations for blasting in complex terrain.

Geocanex Ltd. – Toronto, Ontario

Project Geologist (1985 to 1989)

Responsible for the coordination and execution of exploration projects, predominantly in Northwestern Ontario, Canada. Responsible for crew of up to 10 geologists, engineers and technicians. Projects typically involved the integration of geophysical and geochemical surveys with geological mapping and subsequent diamond drilling projects. Managed diamond drilling projects and prepared summary reports.

PROJECT EXPERIENCE – CONSTRUCTION VIBRATION MONITORING

Urban Infrastructure Construction Monitoring
Ontario, Canada

Designed and oversaw vibration monitoring projects for a range of construction operation types and assessment of the potential impact of the vibrations. This included operations adjacent infrastructure as well as heritage and historic structures.

Traffic Vibration Impact Studies
Ontario, Canada

Implementation, analysis of traffic vibration impact studies in the Sudbury and Cochrane regions, Ontario.

PROJECT EXPERIENCE – OPEN PIT AND QUARRY BLASTING

Expert Opinion and Testimony
Canada

Provided expert testimony at an Ontario Municipal Board hearing regarding the potential impact of blasting operations at a proposed expansion of an aggregate quarry in Southern Ontario.

Provided expert opinion to the Ontario government on blast practices for a road construction project related to the potential for release of nitrates to the local groundwater. The work included a review of documents including blasting design reports and logs.

Provided expert opinion on the potential cause of flyrock at an aggregate quarry near Halifax, Nova Scotia. The work included a site visit, a review of documents (including drilling and blasting logs and as-built reports) and preparation of a summary report of findings.

United States

Provided testimony before an arbitration hearing assessing the blasting techniques to produce armour stone at an existing rock quarry. The work included a site visit, review of extensive documentation (including drilling and blasting logs and as-built reports), preparation of a summary report on finding.

Drilling and Blasting Audit
Northwest Territories, Canada

Carried out a drill and blast audit of the surface and underground operations at a diamond mine in Northwest Territories, Canada. The work entailed a review of the drilling and blasting practises. Recommendations were provided for blasting optimization and mitigation of nitrate losses to the environment.

Nunavut, Canada	Carried out a drill and blast audit including data review, site observations, discussions of the conceptual blast designs for the various types of blasts at the mine and recommendations regarding optimization of the blast designs.
Quebec, Canada	Conducted a study to assess the wall control practices and the resulting final wall at an open pit gold mine in western Quebec.
General Blasting Requirements Minnesota, United States	Carried out a review of the blasting requirements, ROM fragmentation distribution prediction and drillability assessment an open pit project in north-eastern Minnesota.
Quebec, Canada	Carried out a study to assess the practicality of mining an open deposit overlooking existing infrastructure at an operating open pit mine. The study included assessments of the potential impact from flyrock, vibrations and the estimated fragmentation size distribution of possible blast designs. A follow-up study provided a calibration of the flyrock, vibrations and the estimated fragmentation size distribution models for current nearby pit. Recommendations regarding blast design were provided.
Armenia	Provided ongoing blast consultation services for the construction operation prior to the open pit development at a gold mine in Armenia.
Fragmentation Assessments Mexico	Preparation of a fragmentation prediction report for Wheaton Mineral's Los Filos Project, Guerrero, Mexico.
	Analysis and report preparation for a blast fragmentation prediction at the Peñasquito Silver Project in Zacatecas State, Mexico.
Riprap Assessments Quebec, Canada	Assessment of blast fragmentation and size distribution for riprap at a) the CA-606 Quarry and b) the Canal D'Amenée, Rupert Diversion Project, James Bay, Quebec.
	Assessment of blast fragmentation and size distribution for riprap at the CF4 Quarry, Eastmain-1 Hydroelectric Project, Quebec.
Explosive Performance Ontario, Canada	Conducted VOD measurements and analysis for an explosive's distributor at an Oakville quarry as part of an explosive assessment/troubleshooting study.
	Provided explosive VOD measurement and analysis for production blasts at a graphite near Kearney, Ontario.

Blast Vibration Monitoring and Analysis
Canada

Blast vibration monitoring and analysis for an investigation of blast induced pore pressure beneath the dike at Diavik Diamond Mines Inc.'s open pit diamond operation in Northwest Territories.

Blast monitoring and the development of a blast vibration regression analysis for the open pit operation in Timmins.

Blast and vibration monitoring and analysis for Rainbow Concrete Industries' quarries in North Bay and Maley Drive in Sudbury, Ontario.

Prepared a blast vibration attenuation analysis for a quarry operator in Bruce Mines.

Established vibration and overpressure attenuation curves in preparation of the expansion of a large open pit in Timmins, Ontario.

PROJECT EXPERIENCE – BLAST IMPACT ASSESSMENTS

Blast Impact on Heritage Structures
Nova Scotia

Provided a review of proposed blasting near a heritage structure in Halifax, Nova Scotia. The work included a site visit, a review of documents (including proposed blast design) and a provision of a summary report (including best practises and recommended blast vibration limits for heritage structures).

NWT and Nunavut, Canada

Identification and quantification of nitrate sources related to the blasting at the surface and underground operations at a diamond mine in Northwest Territories, Canada.

In support of a feasibility study, carried out a study to assess the potential impact of mining an open deposit. The study included assessments of the potential impact from vibrations, flyrock, water overpressure on fish, the estimated fragmentation size distribution of possible blast designs as well as the relative costs for drilling and blasting the proposed designs.

Open Pit Environmental Impact
Ontario, Canada

Carried out a study to assess the potential impact of mining a proposed open pit deposit adjacent residential and industrial areas in Timmins, Ontario. The study included assessments of the potential impact from vibrations, flyrock, air and water overpressure, and the estimated fragmentation size distribution of possible blast designs.

Prepared a blast vibration impact assessment as a part of a larger Environmental Impact Assessment for a proposed open pit operation near the town of Atikokan.

Prepared a blast vibration impact assessment as a part of a larger Environmental Impact Assessment for a proposed operation in the "Ring of Fire" in Northern Ontario.

Prepared a blast vibration impact assessment as a part of a larger Environmental Impact Assessment for a proposed open pit operation near the town of Dubreuilville.

British Columbia, Canada

Carried out a study to assess the potential impact of mining a proposed open pit coal deposit adjacent an existing natural gas coal mine in Southeastern British Columbia. Recommendations for blast designs and mitigation strategies were provided.

Provided an assessment of the potential impact of open pit coal blasting on nearby tailings embankment. Recommendations for vibration limits, mitigation strategies and response frameworks were provided.

Northwest Territories, Canada

Assessed the potential impact of construction blasting on a tailings embankment at an existing mining operation. Provided analysis and guidance regarding recorded blast vibrations at the embankment and adjacent grout curtain.

Blast Impact on Tailings Embankments
Australia

Prepared a blast impact assessment for the blasting operations to be carried out adjacent an active mine tailings storage facility for the Solomon Hub Iron mine in Western Australia.

Prepared a blast impact assessment for the blasting operations to be carried out adjacent a mine tailings embankment for Rio Tinto's Yandicoogina mine in Western Australia. The project entailed the development of a mitigation strategy, blast design review and assistance with the development of a site-specific attenuation model.

Ireland

Prepared a stability review and assessment of the potential impact of blasting on the embankments and raises associated nearby residue disposal area at the Aughinish Alumina refinery, Ireland.

Nitrate Mitigation Studies
Canada

Identification and quantification of nitrate sources related to the blasting at the surface and underground operations at a diamond mine in Northwest Territories, Canada.

Data collection, analysis and report preparation for an investigation of ammonium nitrate loss to the mine discharge water at Diavik Diamond Mines. Identification and quantification of nitrate sources related to the blasting at the open pit operations at an iron mine in Labrador, Canada. The study also included recommendations for measures to mitigate the nitrate losses from blasting.

Conducted an audit of current blasting practices and explosives handling procedures at diamond mine in the Northwest Territories, Canada that identify the nature and potential magnitude of nitrogen compound sources and developed an implementation plan to address the recommendations from the audit.

Quarry Environmental Impact
Ontario, Canada

Prepared Blast Impact Analysis reports for quarry operations across Ontario in support of the permitting of new quarries or extension of existing quarries. This included reporting and technical representation for blasting issues at a public information session.

Participated in Public Information Session for a number of operations Ontario to discuss the blasting impact related to a proposed quarry expansion.

Attended a "Community Advisory Panel" for a number of quarries in Ontario as a blasting consultant to discuss the blasting impact related to ongoing quarry blasting operations.

PROJECT EXPERIENCE – CIVIL BLASTING

Urban Blasting
Ontario, Canada

Provided vibration monitoring and consulting services for numerous blasting operations in urban settings and in close proximity to existing infrastructure. This included blast design and recommendations for risk mitigation.

Blast Monitoring and Consulting
Ontario, Canada

Blast monitoring and consulting for blasting contractor during the expansion of the sewage treatment facility in Fort Francis, Ontario.

Blast monitoring and consulting to TransCanada Pipelines Limited for the construction and upgrading of natural gas pipelines across Ontario. This included both mainline and station blasting operations.

Blast monitoring and consulting to CentraGas (now Union Gas) for operations associated with the installation of main natural gas service lines in Sudbury, Ontario.

Blast monitoring and consulting for installation or upgrading of several hydro generating stations in Ontario, Canada. These include the following projects: Great Lakes Power's High Falls Rehabilitation Project, Wawa; Ontario Hydro's Matabitchuan Power Station Rehabilitation, North Cobalt; Ontario Hydro's Big Chute Generating Station Redevelopment, Port Severn; Ontario Hydro's Sluiceway Safety Upgrading at the South Falls GS, Bracebridge; E.B. Eddy's Paper Plant Power Plant Installation, Espanola; and Conwest Ltd.'s Black River Power Plant Generating Station Installation, Heron Bay.

Highway Construction
British Columbia, Canada

Provided support for the slope reprofiling blasting operations for the highway through Yoho National Park. The work included a drill and blast audit and ongoing support of the blasting operations regarding safety, blast designs, submissions and wall control strategies.

Ontario, Canada

Blast consulting to the Ontario Ministry of Transportation during road construction blasting operation on Highway 69, south of Sudbury. Responsibilities included the assessment of results of wall control blasting and quality assurance report on the vibration monitoring program conducted by the blasting contractor's blasting consultant.

Assessment and recommendations for wall control blasting operations conducted for the twinning of Highway 69 near Parry Sound, Ontario.

Blast Specifications and Audits
Ontario, Canada

Carried out a study to evaluate the potential effects of blasting, a vibration audit of the site preparation blasting operations and preparation of a performance specification for the pre-split blasting conducted for the installation of the No. 4 Air Separation Unit, Inco/Vale Smelter Complex, Copper Cliff, Ontario.

Assisted in the preparation of blasting specifications for the surface site preparations required during the mine infrastructure development at a project near Falconbridge, Ontario.

Geotechnical mapping (surface and underground), logging, analysis blast damage assessment for the Sudbury Sewer Tunnel Project, Sudbury, Ontario.

Saskatchewan, Canada

Assisted in the preparation of blasting specifications for the blasting operations required during the installation of a natural gas pipeline in La Ronge, Saskatchewan.

PROFESSIONAL AFFILIATIONS

Member, International Society of Explosives Engineers (ISEE)

Member, Canadian Institute of Mining and Metallurgy

PUBLICATIONS

Conference Proceedings

Corkery, D., N. Lauzon and D. Sprott. 2010. *Reducing Ammonium Nitrate Loss to Mine Discharge Water.* CIM Mine Operators Conference. Sudbury, Ontario, Canada.

Corkery, D. and R. Wing. 1993. *Controlled Study of the Effects of Temperature and Humidity Versus Blasting Vibrations on Homes*. Nineteenth Annual Conference on Explosives and Blasting Technique, International Society of Explosive Engineers., Canada.

Cameron, A., D. Corkery, B. Forsyth, T. Gong and G. MacDonald. 2007. *An Investigation of Ammonium Nitrate Loss to Mine Discharge Water at Diavik Diamond Mines*. Explo 2007, Blasting: Techniques and Technology, Australian Institute of Mining and Metallurgy., Australia.

Journal Articles

Corkery, D.J., E.G. Lorek and H.R. Williams. A study of Joints and Stress Release Buckles in Palaeozoic Rock of the Niagara Peninsula, Southern Ontario. *Canadian Journal of Earth Sciences*, 25 (1985)

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