EXPLOTECH

Specialists in Explosives, Blasting and Vibration
Consulting Engineers

Blast Impact Analysis
Strada Pit and Quarry Extension
Part of Lots 11 to 14, Concession 3
Geographic Township of Melancthon
Township of Melancthon
County of Dufferin

LICENSED PROFESSIONAL ENGINEER
A. M. CAMPBELL
100209604
PROVINCE OF ONTARIO

Submitted to:

Strada Aggregates
30 Floral Parkway
Concord, Ontario
L4K 4R1

Prepared by

Explotech Engineering Ltd.
58 Antares Drive, Unit 5
Ottawa, Ontario
K2E 7W6

January 27, 2025

EXPLOTECH

EXECUTIVE SUMMARY

Explotech Engineering Ltd. was retained in March 2023 to provide a Blast Impact Analysis for the proposed Strada Pit and Quarry located on Part of Lots 11 to 14, Concession 3, Geographic Township of Melancthon, Township of Melancthon, County of Dufferin.

Vibration levels assessed in this report are based on the Ministry of the Environment, Conservation and Parks Model Municipal Noise Control By-law (NPC119) with regard to Guidelines for Blasting in Mines and Quarries. We have assessed the area surrounding the proposed Aggregate Resources Act licence with regard to potential damage from blasting operations and compliance with the aforementioned by-law document.

We have inspected the property and reviewed the available site plans. Explotech is of the opinion that the planned aggregate extraction on the proposed property can be carried out safely and within MECP guidelines as set out in NPC 119 of the By-Law.

Recommendations are included in this report to ensure that blasting operations in all phases of this project are carried out in a safe and productive manner and to suitably manage and mitigate the possibility of damage to any buildings, structures or residences surrounding the property.

EXPLOTECH

TABLE OF CONTENTS

EXPLOTECH

INTRODUCTION

Strada Aggregates is applying for a Class A Licence for the property legally described as Part of Lots 11 to 14, Concession 3, Geographic Township of Melancthon, Township of Melancthon, County of Dufferin. The proposed name for the operation is the Strada Pit and Quarry. This Blast Impact Analysis assesses the ability of the proposed licence to operate within the prescribed blast guideline limits as required by the Ontario Ministry of the Environment, Conservation and Parks (MECP).

The proposed Strada Pit and Quarry operation is located within the footprint of Strada's existing licenced pit operation and is bound by agricultural farmland followed by Side Road 15 to the North, agricultural farmland followed by 3rd Line to the East, County Road 17 and agricultural farmland to the South, and 4th Line and agricultural farmland to the West. Existing licenced pits are located East and West of Strada's existing pit operation. The closest sensitive receptors, as currently defined by the MECP, lie along 4th Line approximately 150m to the West of the proposed extraction limit. A list of the closest sensitive receptors to the limits of the quarry's extraction limit is provided later in this report.

This Blast Impact Analysis has been prepared based on the Ministry of the Environment, Conservation and Parks (MECP) Model Municipal Noise Control By-law with regard to Guidelines for Blasting in Mines and Quarries (NPC 119). We have additionally assessed the area surrounding the proposed licence with regard to potential damage from blasting operations.

Given that quarrying and blasting operations have not been undertaken in the past on this property, site-specific blast monitoring data is not available. We have therefore applied data generated at a variety of quarries across Ontario which present similar material characteristics. It has been our experience that this data represents a conservative starting point for blasting operations. It is a recommendation of this report that a vibration monitoring program be initiated on-site upon the commencement of blasting operations and maintained for the duration of all blasting activities to permit timely adjustment to blast parameters as required. We note that blast monitoring is a prescribed condition to any licence issued for the proposed quarry under the Aggregate Resources Act.

Recommendations are included in this report to advocate for a safe and productive blasting operation and to suitably manage and mitigate the possibility of damage to any buildings, structures or residences surrounding the property.

EXISTING CONDITIONS

The licence area for the proposed Strada Pit and Quarry encompasses a total area of approximately 149.0HA with a net extraction area of 123.7HA. The proposed Strada Pit and Quarry operation is located within the footprint of Strada's existing licenced pit operation and is bound by agricultural farmland followed by Side Road 15 to the North, agricultural farmland followed by 3rd Line to the East, County Road 17 and agricultural farmland to the South, and 4th Line and agricultural farmland to the West. Existing licenced pits are located East and West of Strada's existing pit operation.

The bedrock within the subject lands is predominantly dolomite with existing surface bedrock elevations ranging from approximately 490masl located in the Northern portion of the quarry footprint to 480masl located in the Southern portion of the quarry footprint. The closest sensitive receptors located to the proposed Strada Pit and Quarry extraction boundaries are listed in Table 1 below as well as on the Sensitive Receptor Overviews contained in Appendix A:

Table 1: Closest Sensitive Receptors to Proposed Strada Pit and Quarry			
Sensitive Receptor	**Straight Line Distance from proposed Licence Boundary to Receptor (m)**	**Straight Line Distance from proposed Quarry Limit of Extraction to Receptor (m)**	**Receptor ID***
477084 3 Line	540	670	R15
477146 3 Line	590	610	R20
477274 3 Line	760	1025	R25
437028 4 Line	70	700	R06
437032 4 Line	90	630	R05
437044 4 Line	65	540	R04
437090 4 Line	55	195	R03
437134 4 Line	275	350	R02
437146 4 Line	100	160	R01
473274 4 Line	340	425	R29
437281 4 Line	395	460	R28
625173 Side Road 15	650	720	R27
625206 Side Road 15	580	730	R26
585166 County Road 17	45	960	R10
585189 Country Road 17	15	865	R11
585221 County Road 17	245	730	R12

* Receptor ID coordinated with Aercoustics Noise Impact Study

PROPOSED AGGREGATE EXTRACTION

The extraction will proceed in four phases defined as Phase 1, Phase 2, Phase 3, and Phase 4, with each phase being split into sub-phases. Extraction operations will be initiated in the Southeast portion of Phase 1A. The sinking cut will be located approximately 670m from the closest sensitive receptor, namely 477084 3 Line. Following execution of the sinking cut, Phase 1A and Phase 1B will be extracted concurrently. Phase 1A will be extracted in a general northern direction and Phase 1B will be extracted in a general western direction. Phase 1 is planned to be extracted in two (2) benches. Bench 1 starts at approximate maximum elevation 490masl and is to be extracted to a floor elevation of 472masl. Bench 2 is to be extracted to a floor elevation of 456.5masl.

The Phase 2 extraction area lies directly North of Phase 1. Phase 2 will leverage the existing face developed during blasting operations for Phase 1, eliminating the need for a sinking cut. Extraction will be initiated in the Southeast portion of Phase 2A and retreat towards the North. The extraction will then continue in Phase 2A and Phase 2B concurrently. Phase 2A will be extracted in a general Northern direction and Phase 2B will be extracted in a general Western direction. Once Phase 2A and Phase 2B are completed, Phase 2C will be extracted in a general Northern direction. Phase 2 is to be extracted in two (2) benches. Bench 1 starts at an approximate maximum elevation of 490masl and is to be extracted to a floor elevation of 472masl. Bench 2 is to be extracted to a floor elevation of 456.5masl.

The Phase 3 extraction area includes the removal of Bench 3 (to an elevation of 440masl) within the footprint area created through the excavation of Phases 1 and 2. Extraction operations will be initiated through the use of a sinking cut in the Northeast portion of Phase 3A. The sinking cut will be located approximately 500m from the closest sensitive receptor, namely 437281 4 Line. Utilizing this sinking cut, Phase 3A and 3B will be extracted concurrently. Both Phase 3A and 3B will be extracted in a general southern direction. Phase 3 is planned to be extracted in a single bench with an approximate initial elevation of 456.5masl and is to be extracted to a final floor elevation of 440masl.

The Phase 4 extraction area lies directly to the South of Phase 1 and Phase 3. Phase 4A will leverage the existing face developed during the excavation operations for Phase 1 and Phase 3, eliminating the need for a sinking cut. Extraction will be initiated in the Northeast portion of Phase 4A and will initially retreat towards the South to create a slot before pivoting towards a western retreat. Phase 4B will utilize the existing face developed during the blasting operations for Phase 4A and will retreat towards the West. Phase 4 initial elevation is approximately 490masl and is to be extracted to a final floor elevation of 440masl. Phase 4 will be extracted in three benches.

Quarries in Ontario normally employ 76 to 152mm diameter blast holes which, for a maximum 24m bench, would employ 117kg to 468kg of explosive load per hole. The choice of hole diameter and bench height will govern the maximum number of holes to be fired per period. As extraction progresses, it will be possible to vary operational aspects of the drilling and blasting program in response to monitoring program results and observed outcomes in order to maintain compliance.

It is a recommendation of this report that all blasts shall, at a minimum, be monitored at the nearest sensitive receptors, or closer, in front and behind any given blast in order to ensure constant compliance with MECP guideline limits and to permit timely adjustment to blast designs as required.

BLAST VIBRATION AND OVERPRESSURE LIMITS

The Ontario MECP guidelines for blasting in quarries are among the most stringent in North America.

Studies by the U.S. Bureau of Mines have shown that normal temperature and humidity changes can cause more damage to residences than blast vibrations and overpressure in the range permitted by the MECP. The limits suggested by the MECP are as follows:

Vibration___________12.5mm/sec Peak Particle Velocity (PPV)

Overpressure_______128 dB(L) Peak Sound Pressure Level (PSPL)

The above guidelines apply when blasts are being monitored. It is a recommendation of this report that all blasts at the operation be monitored to quantify and record ground vibration and overpressure levels employing a minimum of two (2) digital seismographs, one installed at the closest receptor behind the blast, or closer, and one installed at the closest receptor in front of the blast, or closer.

BLAST MECHANICS AND DERIVATIVES

The detonation of explosives within a borehole results in the development of very high gas and shock pressures. This energy is transmitted to the surrounding rock mass, crushing the rock immediately surrounding the borehole (approximately 1 borehole radius) and permanently distorts the rock to several borehole diameters (5-25, depending on the rock type, prevalence of joint sets, etc).

The intensity of this stress wave decays quickly so that there is no further permanent deformation of the rock mass. The remaining energy from the detonation travels through the unbroken material in the form of a pressure wave or shock front which, although it causes no plastic deformation of the rock mass, is transmitted in the form of vibrations.

Particle velocity is the descriptor of choice when dealing with vibrations because of its superior correlation with the appearance of cosmetic cracking. As such, for the purposes this report, ground vibration units have been listed in mm/s.

In addition to the ground vibrations, overpressure, or air vibrations are generated through the direct action of the explosive venting through cracks in the rock or through the indirect action of the rock movement. In either case, the result is a pressure wave which travels through the air, measured in decibels (or dB(L)) for the purposes of this report.

VIBRATION AND OVERPRESSURE THEORY

Transmission and decay of vibrations and overpressure 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.

In order to circumvent this scatter and improve confidence in forecast vibration levels, probabilistic and statistical modeling is employed to increase conservatism built into prediction models, usually by the application of 95% confidence lines to attenuation data.

The attenuation relations are not designed to conclusively predict vibrations levels at a specific location as a result of a specific blast design, application of this probabilistic model creates confidence that for any given scaled distance, 95% of the resultant velocities will fall below the calculated 95% regression line.

While the data still provides insight into probable vibration intensities, attenuation relations for overpressure tends to be less reliable and precise than results for ground vibrations. This is due primarily to wider variations in variables outside of the influence of the blast design which impact propagation of the vibrations. Atmospheric factors such as temperature gradients and prevailing winds (refer to Appendix B) as well as local topography can all serve to significantly alter overpressure attenuation characteristics.

Our experience and analysis demonstrates that blast overpressure is greatest when blasting toward receptors, and blast vibrations are greatest when retreating towards the receptor.

GROUND VIBRATION LEVELS AT THE NEAREST SENSITIVE RECEPTOR

The most commonly used formula for predicting PPV is known as Bureau of Mines (BOM) prediction formula or Propagation Law. We have used this formula to predict the PPV's at the closest house for the initial operations.

$$PPV = k\left(\frac{d}{\sqrt{w}}\right)^{e}$$

Where, PPV = the calculated peak particle velocity (mm/s)

K, e = site factors

d = distance from receptor (m)

w = maximum explosive charge per delay (kg)

The value of K and e are variable and is influenced by many factors (i.e. rock type, geology, thickness of overburden, etc.). As such, these site factors are developed empirically through the measurement of vibration characteristics at the specific operations of interested.

The portion of the BOM prediction formula contained within the parentheses is referred to as the *Scaled Distance* and represents another important PPV relation. It correlates the separation distance between a blast and receptor to the energy (usually expressed as explosive weight) released at any given instant in time. The two most popular approaches are square root scaling and cube root scaling:

$$(SDSR = \frac{R}{\sqrt{W}}) \qquad (SDCR = \frac{R}{\sqrt[3]{W}})$$

Where, SDSR = Scaled distance square root method
SDCR = Scaled distance cube root method
R = Separation distance between receptor site and blast (m)
W = Maximum explosive load per delay period (kg)

Historically, square root scaling is employed in situations whereby the explosive load is distributed in a long column (i.e. blasthole) while cube root scaling is employed for point charges. In accordance with industry standard, square root scaling was adopted for ground vibration analysis for the purposes of this report.

For a distance of 670m (i.e. the standoff distance to the closest sensitive receptor for the initial blasting, specifically 477084 3 Line) and a maximum explosives load per delay of 82.5kg (95mm diameter hole, 12m deep, 2.3m surface collar, single decked), we can calculate the theoretical maximum PPV at the closest building using the following formulae:

Imperial Equations:

Oriard 50% bound (2002) $$v = 160\left(\frac{D}{\sqrt{W}}\right)^{-1.6}$$

Oriard 90% Bound (2002) $$v = 242\left(\frac{D}{\sqrt{W}}\right)^{-1.6}$$

Oriard 99% Bound (2002) $$v = 605\left(\frac{D}{\sqrt{W}}\right)^{-1.6}$$

Quarry Production Blast*
(Bulletin 656 – 1971) $$v = 182\left(\frac{D}{\sqrt{W}}\right)^{-1.82}$$

Typical limestone Quarry*
(PADER report – 1995) $$v = 52.2\left(\frac{D}{\sqrt{W}}\right)^{-1.38}$$

Typical Coal Mine*
(RI8507 1980) $$v = 133\left(\frac{D}{\sqrt{W}}\right)^{-1.5}$$

Metric Equations:

General Blasting*
(Dupont) $$v = 1140\left(\frac{D}{\sqrt{W}}\right)^{-1.6}$$

Construction Blasting*
(Dowding 1998) $$v = 1326\left(\frac{D}{\sqrt{W}}\right)^{-1.38}$$

Agg. Quarry Blasting*
(Explotech 2005)

$$v = 5175\left(\frac{D}{\sqrt{W}}\right)^{-1.76}$$

Agg. Quarry Blasting*
(Explotech 2003)

$$v = 7025\left(\frac{D}{\sqrt{W}}\right)^{-1.85}$$

*95% Confidence Interval

The equations described above accommodate for a range of geological conditions. The proposed parameters were applied to the formulae to estimate a range of the potential vibrations to be imparted on the closest sensitive receptor behind the blast. As discussed in previous sections, the MECP guideline for blast-induced vibration is 12.5 mm/s (0.5 in/s). Appendix C demonstrates that the maximum calculated value for the vibration intensities imparted on the closest sensitive receptor based on all equations is 4.4mm/s for the initial blasting, below the MECP guideline limit. All blasts will be monitored for overpressure and ground vibrations with blast designs adjusted in response to readings on site in order to ensure consistent compliance with established limits.

Utilizing the formula providing the worst-case scenario for all geological conditions (Oriard 99% Bound), the table below states the maximum explosive loading based on MECP guideline limits. The following table will form a guideline for blasting operations until a site-specific equation is developed.

Table 2: Maximum Explosive Load at Set Offset Distances – 12.5 mm/sec

Distance to Receptor (m)	**Allowable Explosives Per Period** (kg)
100	6.7
200	26.8
300	60
400	107
500	168
600	242

Table 2: Maximum Explosive Load at Set Offset Distances – 12.5 mm/sec	
Distance to Receptor (m)	**Allowable Explosives Per Period** (kg)
700	329
800	429
900	543
1000	671

As the separation distance between the blast and closest receptor decreases, it will be necessary to adjust blast parameters to ensure continued compliance with the guideline limit. Fortunately, a variety of blast design alternatives are available to accomplish this including but not limited to reductions in blast hole diameter, change in explosives types, adjustment in bench heights and decking of holes. Given the planned phasing of the operation, vibration data will be continually collected and analyzed as the adjacent receptors are approached in order to confirm the requirement for any design modifications.

OVERPRESSURE LEVELS AT THE NEAREST SENSITIVE RECEPTOR

It is unusual for overpressure to reach damaging levels, and when it does, the evidence is immediate and obvious in the form of broken windows in the area. However, overpressure remains of interest due to its ability to travel further distances as well as cause audible sounds and excitation in windows and walls.

Air overpressure decays in a known manner in a uniform atmosphere; however, a uniform atmosphere is not a normal condition. As such, air overpressure attenuation is far more variable due to its intimate relationship with environmental influences. Air vibrations decay slower than ground vibrations with an average decay rate of 6dB(L) for every doubling of distance.

Air overpressure levels are analyzed using cube root scaling based on the following equation:

$$P = k\left(\frac{d}{\sqrt[3]{w}}\right)^{e}$$

Where, P = the peak overpressure level (psi – imperial, Pa, dB(L) - metric)
K, e = site factors
d = distance from receptor (ft – imperial, m - metric)
w = maximum explosive charge per delay (lbs – imperial, kg - metric)

The value of K and e are variable and are influenced by many factors (i.e. rock type, geology, thickness of overburden, etc.). As such, these site factors are developed empirically through the measurement of overpressure characteristics at the specific operations of interested.

As discussed in previous sections, the MECP guideline for blast-induced overpressure is 128dB(L). For a distance of 670m (i.e. the standoff distance to the closest existing structure for the initial blasting, specifically 477084 3 Line) and a maximum explosive weight of 82.5kg (95mm diameter hole, 12m deep, 2.3m collar, single decked), we can calculate the overpressure at the nearest receptor in front of the blast using the following equations:

Imperial Equations:

USBM RI8485* $$P = 0.056(\frac{D}{\sqrt[3]{W}})^{-0.515}$$

USBM RI8485 (Front of Blast) $$P = 1.317(\frac{D}{\sqrt[3]{W}})^{-0.966}$$

USBM RI8485 (Full Confined) $$P = 0.061(\frac{D}{\sqrt[3]{W}})^{-0.96}$$

Construction Average*
(Oriard 2005) $$P = 1(\frac{D}{\sqrt[3]{W}})^{-1.1}$$

Metric Equations:

Ontario Quarry – dB(L)*
(Explotech) $$P = 159(\frac{D}{\sqrt[3]{W}})^{-0.0456}$$

Limestone – dB(L)*
(Explotech) $$P = 206(\frac{D}{\sqrt[3]{W}})^{-0.1}$$

Ontario Quarry – Pa*
(Explotech) $$P = 1222(\frac{D}{\sqrt[3]{W}})^{-0.669}$$

*Behind blast

Appendix C demonstrates that the maximum calculated value for the overpressure intensities imparted on the closest sensitive receptor based on all equations is 126.5 dB(L) for the initial blasting, below the MECP guideline limit.

Utilizing the formula providing the worst-case scenario for all geological conditions (Ontario Quarry– Pa (Explotech)), Table 3 below can be used as an initial guide showing maximum loads per delay based on various separation distances for receptors in front of the blast face. The following maximum loads per delay are derived from the air overpressure equation above and are based on a peak overpressure level of 128dB(L):

Table 3: Maximum Explosive Load at Set Offset Distances to Receptors <u>in Front of</u> the Blast – 128 dB(L)	
Distance to Receptor (m)	**Allowable Explosives Per Period** (kg)
100	0.6
200	4.8
300	16.4
400	39
500	76
600	131
700	209
800	312
900	445
1000	610

We note that the above values are typically conservative and are intended as a guideline only as the air overpressure attenuation equation is based on a calculated 95% regression line. Actual loads employed shall be based on the results of the monitoring program in place.

It is a recommendation of this report that all blasts be monitored for overpressure and ground vibrations with blast designs adjusted in response to readings on site in order to ensure consistent compliance with established limits.

We reiterate that air overpressure attenuation is far more variable due to its intimate relationship with environmental influences and as such, the equation employed is less reliable than that developed for ground vibration. Overpressure monitoring performed on site shall be used to guide blast design as it pertains to the control of blast overpressures.

ADDITIONAL CONSIDERATIONS OUTSIDE OF THE BLAST IMPACT ANALYSIS SCOPE

The following headings are addressed for general information purposes and are not strictly required as part of the scope of the Blast Impact Analysis as required under the ARA to ensure compliance with MECP NPC-119 guidelines.

RESIDENTIAL WATER WELLS

Possible impacts to the water quality and production capacity of groundwater supply wells is a common concern for residents near blasting operations. Complaints related to changes in water quality often include the appearance of turbidity, water discolouration and changes in water. Complaints regarding water production most often involve loss of quantity production, air in water and damage to well screens and casings. A review of research and common causes of these problems indicates that most of these concerns are not related to blasting and can be shown to be the direct impact of environmental factors and poor well construction and maintenance.

There is an intuitive belief that blasting operations have dramatic and disastrous impacts on residential water wells for large distances around such operations. However, there is no scientific basis for such claims. Outside of the immediate radius of approximately 20-25 blasthole diameters from a loaded hole, there is no permanent ground displacement. As such, barring blasting activity within several meters of an existing well, the probability of damage to residential wells is essentially non-existent.

Despite the scientific support for the above conclusion, numerous studies have been performed to verify the validity of this statement. These studies have investigated the effects of blasting on varied well configurations and in varied geological mediums to ensure results could be readily extrapolated to all blasting operations. The conclusion of these studies has confirmed that with the exception of possible temporary increases in turbidity, blasting operations did not result in any permanent impact on wells outside of the immediate blast zone of the blast until vibration levels reached exceedingly high intensities, far beyond the limits permitted for quarries. Applying universally accepted threshold levels for ground vibrations eliminates the possibility for any long-term adverse effects on wells in the vicinity of blasting operations.

In a study by Froedge (1983), blast vibration levels of up to 32.3mm/s were recorded at the bottom of a shallow well located at a distance of 60 meters (200 feet) from an open pit blast. There was no report of visible damage to the well nor was there any change in the water pumping flow rate. This study concluded that the commonly accepted limit of 50mm/s PPV level is adequate to protect wells from any damage. We reiterate, the current guideline limit for vibrations from quarry and mining operations is 12.5mm/s.

HYDRO TRANSMISSION TOWERS AND HYDRO LINES

Hydro transmission lines run parallel to 4th Line adjacent to the East side of the proposed extension limit boundary (refer to Appendix A). The MECP guideline for blast-induced vibration (12.5mm/s) does not apply to transmission towers and hydro lines as they are not classified as sensitive receptors. Typical facility owner policies employ a 50mm/s vibration limit for transmission structures.

The transmission towers shall not require monitoring as the sensitive receptors along 4th Line will govern the blasting operations with the more stringent 12.5mm/s vibration limit.

Applying the equation from Ground Vibration Levels at the Nearest Sensitive Receptor, for a distance of 470m (the conservative standoff distance to the closest transmission tower for the initial blasting) and a maximum explosive load per delay of 82.5kg (95mm diameter hole, 12m deep, 2.3m surface collar and 1 hole per delay), we can calculate the maximum PPV at the transmission tower for the initial blast as follows:

$$ppv = 1326\left(\frac{470}{\sqrt{82.5}}\right)^{-1.38} = 5.72mm/s$$

The calculated 95% predicted PPV (based on the proposed blasting data discussed above) would be 5.72mm/s, well below the limit of 50mm/s. Fortunately, given the planned phasing, vibration data will be continually collected and analyzed as the sensitive receptors and transmission towers are approached in order to confirm the requirement for any design modifications. An abundance of design modifications remain available which would readily keep vibration intensities to values below guideline limits.

BLAST IMPACT ON ADJACENT FISH HABITATS

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, ultimately resulting in the death of the organism. Additionally, ground vibrations imparted on active spawning beds have the ability to adversely impact the incubating eggs and spawning activity. In an effort to alleviate adverse impacts on fish populations as a result of blasting, the Department of Fisheries and Oceans (DFO) developed the Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters (1998). This publication establishes limits for water overpressure and ground vibrations which are intended to mitigate impacts on aquatic organisms while providing sufficient flexibility for blasting to proceed. Specifically, water overpressures are to be limited to 100kPa and, in the presence of active spawning beds, ground vibrations at the bed are to be limited to 13mm/s.

The Natural Environment study prepared for the application indicates that fish habitat lay outside the adjacent quarry property lands, and therefore water overpressure and ground vibration monitoring for fish or fish habitat will not be required as it relates to the proposed blasting operations.

FLYROCK

Flyrock is the term used to define rocks which are propelled from the blast area by the force of the explosion. This action is a predictable and necessary component of a blast and requires that every blast have an exclusion zone established within which no persons or property which may be harmed are permitted.

Government regulations strictly prohibit the ejection of flyrock off of a quarry property. The regulations regarding flyrock are enforced by the Ministries of Natural Resources, Environment and Labour. In the event of an incident where flyrock does leave a site, the punitive measures include suspension / revocation of licences and fines to both the blaster and quarry owner / operator. Fortunately, flyrock incidents are extremely rare due to the possible serious consequences of such an event. Through proper blast planning and design, it is possible to control and mitigate the possibility of flyrock.

EXPLOTECH

THEORETICAL HORIZONTAL FLYROCK CALCULATIONS

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 primary sources of flyrock are as follows:

- **Face burst:** Lack of confinement by the rock mass in front of the blast hole results in flyrock in front of the face.
- **Cratering:** Insufficient stemming height or weakened collar rock results in a crater being formed around the hole collar with rock projected in any direction.
- **Stemming Ejection:** Poor stemming practice can result in a high angle throw of the stemming material and loose rocks in the blasthole wall and collar.

The horizontal distance flyrock can be thrown (L_H) from a blast hole is determined using the expression:

$$L_H = \frac{V_o^{\,2} Sin2\theta_0}{g} \qquad [1]$$

where: V_o = launch velocity (m/s)

θ_0 = launch angle (degrees)

g = gravitational constant (9.8 m/s^2)

The theoretical maximum horizontal distance flyrock will travel occurs when θ_0 = 45 degrees, thereby yielding the equation:

$$L_{H\max} = \frac{V_o^{\,2}}{g} \qquad [2]$$

The normal range of launch velocity for blasting is between 10m/s - 30m/s. To calculate the launch velocity of a blast the following formula is used:

$$V_o = k\left(\frac{\sqrt{m}}{B}\right)^{1.3} \quad [3]$$

where:
k = a constant
m = charge mass per meter (kg/m)
B = burden (m)

By combining equations 2 and 3 and taking into account the different sources of flyrock, the following equations can be used to calculate the maximum flyrock thrown from a blast:

Face burst: $$L_{H\max} = \frac{k^2}{g} * \left(\frac{\sqrt{m}}{B}\right)^{2.6}$$

Cratering: $$L_{H\max} = \frac{k^2}{g} * \left(\frac{\sqrt{m}}{SH}\right)^{2.6}$$

Stemming Ejection: $$L_{H\max} = \frac{k^2}{g} * \left(\frac{\sqrt{m}}{SH}\right)^{2.6} Sin2\theta$$

where:
θ = drill hole angle
L_{hmax} = maximum flyrock throw (m)
m = charge mass per meter (kg/m)
B = burden (m)
SH = stemming height (m)
g = gravitational constant
k = a constant

For calculation purposes, we have assumed 95mm (3.75”) diameter holes on a 2.4m x 2.4m (8’ x 8’) pattern, with total depths of up to 12m (39’) and a collar length of 1.8m (6’) to 3.0m (10’).

The range for the constant k is 13.5 for soft rocks and 27 for hard rocks. Given dolomite bedrock in the area, we have applied a k value of 20. The explosive density is assigned to be 1200 kg/m^3 for emulsion products and the drill hole angles are assumed to be 90 degrees (i.e. vertical).

The maximum horizontal throw for the flyrock using a varied collar is shown in Table 4 below.

Table 4 – Maximum Flyrock Horizontal

***Collar* Lengths** (m)	**Maximum Throw Face Burst** (m)	**Maximum Throw Cratering and Stemming Ejection** (m)
1.8	68	143
2.1	68	96
2.4	68	68
2.7	68	50
3.0	68	38

Different collar lengths are displayed in the table above to account for over or under loaded holes. As demonstrated with these various collar lengths, any deviation, no matter how slight, can greatly affect these maximum values.

Through proper blast design and diligence in inspecting the geology before every blast, flyrock can readily be maintained within the quarry limits. It may be necessary to increase collars and adjust designs accordingly when blasting along the perimeter to accommodate the reduced distance to receptors and to ensure flyrock remains within the property limit.

RECOMMENDATIONS

It is recommended that the following conditions be applied for all blasting operations at the proposed Strada Pit and Quarry:

1. An attenuation study shall be undertaken by an independent blasting consultant during the first 12 months of operation in order to obtain sufficient quarry data for the development of site specific attenuation relations. This study shall be used to confirm the applicability of the initial guideline parameters and assist in developing future blast designs.

2. Blasts shall be designed and loaded adhering to Table 2: Maximum Explosive Load at Set Offset Distances – 12.5 mm/sec as well as Table 3: Maximum Explosive Load at Set Offset Distances to Receptors in Front of the Blast – 128 dB(L) until the attenuation study is completed. Upon completion of the attenuation study, a site-specific attenuation relation shall be developed and shall be utilized to develop a new load chart to be utilized going forward.

3. All blasts shall be monitored for both ground vibration and overpressure at the closest privately owned sensitive receptors adjacent the site, or closer, with a minimum of two (2) digital seismographs – one installed in front of the blast and one installed behind the blast. Monitoring shall be performed by an independent third party engineering firm with specialization in blasting and monitoring.

4. The guideline limits for vibration and overpressure shall adhere to standards as outlined in the Model Municipal Noise Control By-law publication NPC 119 (1978) or any such document, regulation or guideline which supersedes this standard.

5. In the event of an exceedance of NPC 119 limits or any such document, regulation or guideline which supersedes this standard, blast designs and protocol shall be reviewed prior to any subsequent blasts and revised accordingly in order to return the operations to compliant levels.

6. Orientation of the aggregate extraction operation shall be designed and maintained so that the direction of the overpressure propagation and flyrock from the face shall be away from structures as much as possible.

7. Blast designs shall be continually reviewed with respect to fragmentation, ground vibration and overpressure. Blast designs shall be modified as required to ensure compliance with applicable guidelines and regulations.

Decking, reduced hole diameters and sequential blasting techniques shall be used to ensure minimal explosives per delay period initiated.

8. Blasting procedures such as drilling and loading shall be reviewed on a yearly basis and modified as required to ensure compliance with industry standards.

9. Detailed blast records shall be maintained in accordance with current industry best practices

10. The guideline for flyrock shall adhere to the standard as outlined in the Aggregate Resources Act O. Reg 244/97, specifically “A licensee or permittee shall take all reasonable measures to prevent flyrock from leaving the site during blasting if a sensitive receptor is located within 500 metres of the boundary of the site” or any such document, regulation or guideline which supersedes this standard.

The blast parameters described within this report are supported by the modeling in the attached appendices. As the quarry progresses and as site-specific data is collected from the on-going operation, the blast parameters can be refined, as necessary, to ensure continual compliance with MECP Guidelines.

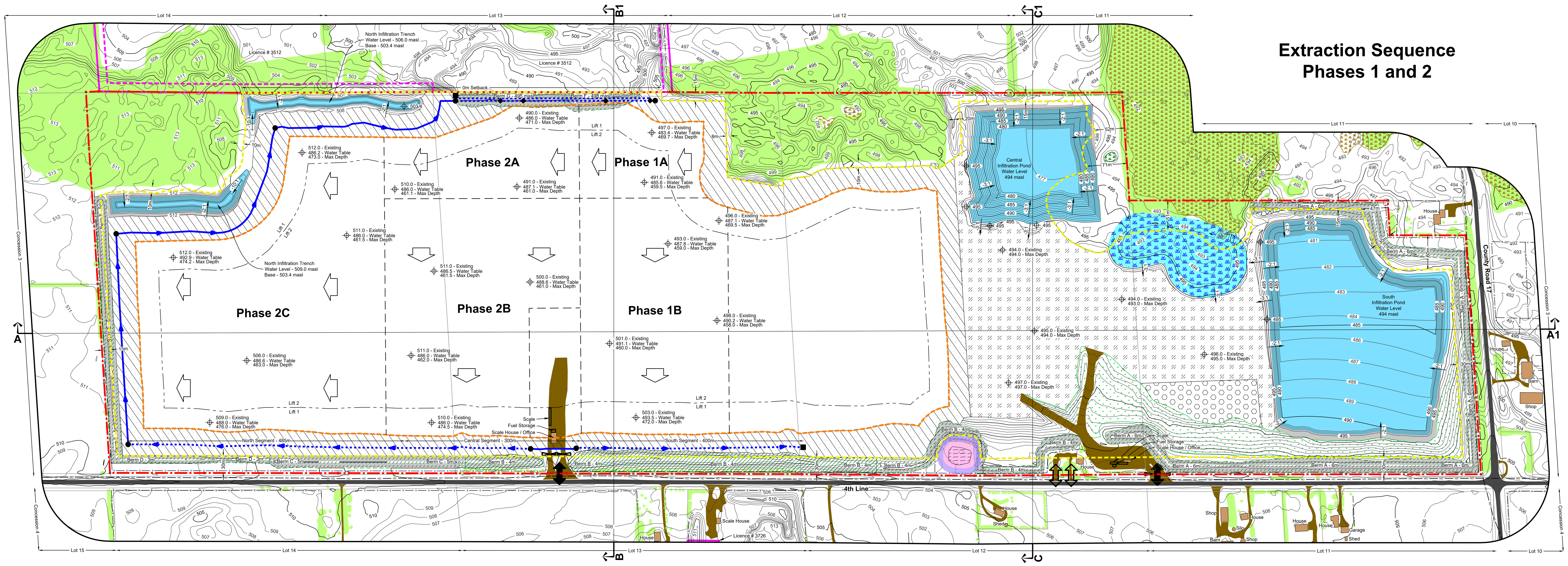
CONCLUSION

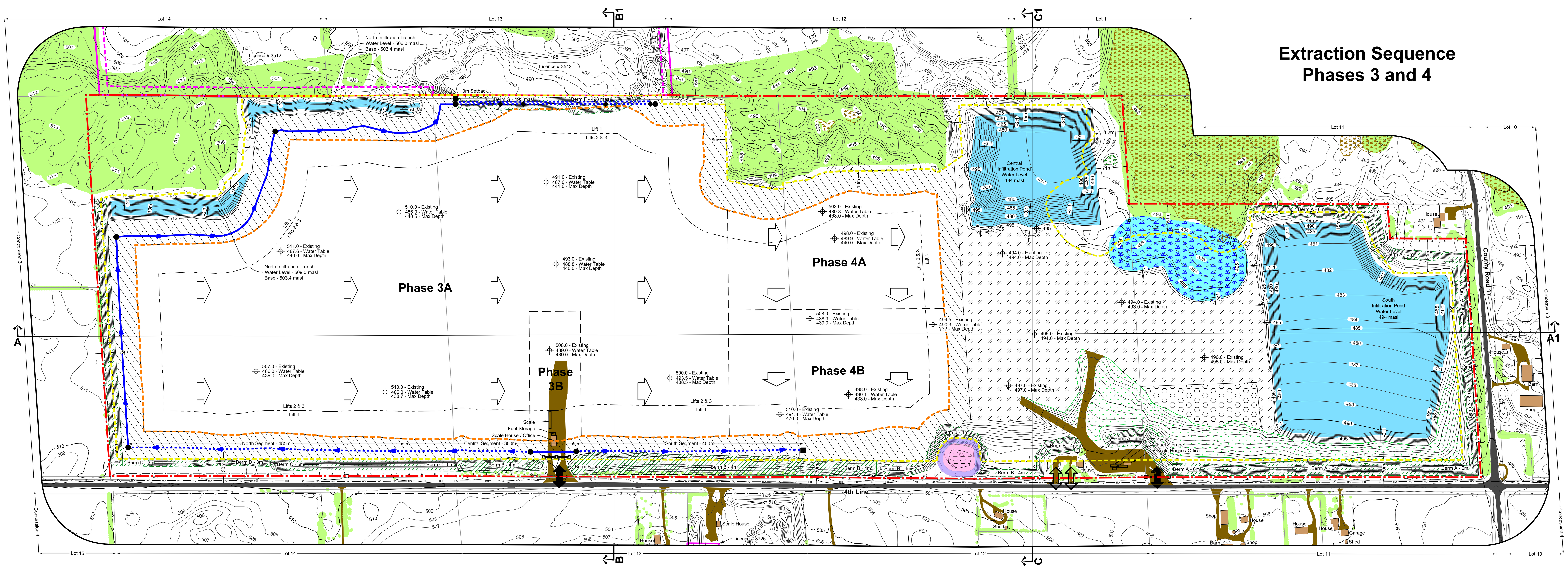
The blast parameters described within this report will provide a good basis for the initial blasting operations at this location. As site specific blast vibration and overpressure data becomes available, it will be possible to refine these parameters on an on-going basis.

Blasting operations required for operations at the proposed Strada Pit and Quarry site can be carried out safely and well within governing guidelines set by the Ministry of the Environment, Conservation and Parks.

Modern blasting techniques will permit blasting to take place with explosives charges below allowable charge weights ensuring that blast vibrations and overpressure will remain minimal at the nearest receptors and compliant with applicable guideline limits.

Appendix A





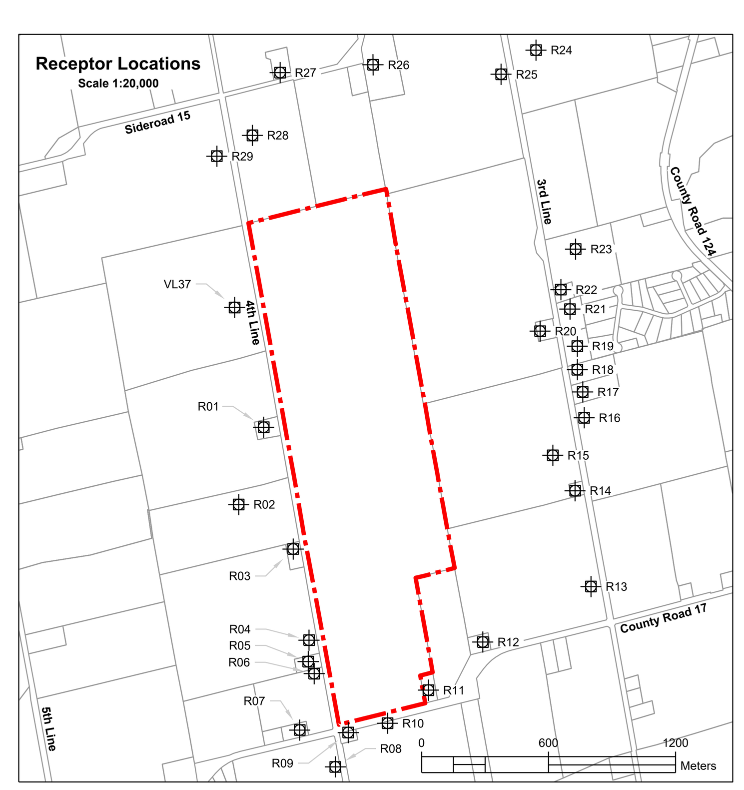


Table 1A: Closest Sensitive Receptors			
Sensitive Receptor	*Straight Line Distance From Licence Boundary to Receptor (m)*	*Straight Line Distance From Quarry Limit of Extraction to Receptor (m)*	*Receptor ID*
477084 3rd Line	540	670	R15
477146 3rd Line	590	610	R20
477274 3rd Line	760	1025	R25
437028 4th Line	70	700	R06
437032 4th Line	90	630	R05
437044 4th Line	65	540	R04
437090 4th Line	55	195	R03
437134 4th Line	275	350	R02
437146 4th Line	100	160	R01
437274 4th Line	340	425	R29
437281 4th Line	395	460	R28
625173 Side Road 15	650	720	R27
625206 Side Road 15	580	730	R26
585166 County Road 17	45	960	R10
585189 County Road 17	15	865	R11

Table 1B: Closest Sensitive Receptors			
Sensitive Receptor	*Straight Line Distance From Licence Boundary to Receptor (m)*	*Straight Line Distance From Quarry Limit of Extraction to Receptor (m)*	*Receptor ID*
585221 County Road 17	245	730	R12
585121 County Road 17	187	974	R07
436574 4th Line	200	1139	R08
585142 County Road 17	47	981	R09
477018 3rd Line	650	950	R13
477058 3rd Line	626	798	R14
477081 3rd Line	730	794	R16
477107 3rd Line	744	779	R17
477125 3rd Line	738	758	R18
477133 3rd Line	758	777	R19
477151 3rd Line	754	779	R21
477161 3rd Line	728	764	R22
477181 3rd Line	832	910	R23
477285 3rd Line	966	1235	R24
437202 4th Line	135	204	VL37

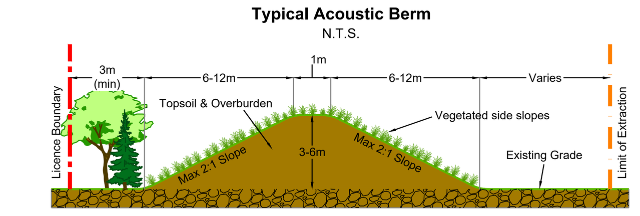
Legal Description

Part of West half of Lot 11, Concession 3
West Half of Lots 12, 13 and 14, Concession 3
(former geographic Township of Melancthon)
Township of Melancthon, County of Dufferin

Legend

- Licence Boundary
- Existing Licence Boundary
- Pit Limit of Extraction
- Existing Limit of Extraction
- Quarry Limit of Extraction
- 120m Offset From Licence Boundary
- Contours with Elevation — Metres above sea level (MASL)
- Parcel Fabric
- Public Road
- Overhead Hydro
- Driveway
- Fence — 1.2m post & wire fence unless otherwise noted
- Water Feature
- Entrance / Exit — Operational - Solid; Farmhouse - Hollow
- Wooded Area
- Gate
- Wetland
- General Direction of Excavation & Boundary
- Unevaluated Wetland
- Berm — Existing - Solid; Proposed - Dashed
- Processing and Stockpiling Area
- Building/Structure
- Recycling and Scrap Area
- Spot Elevation — Top - Existing (MASL) / Middle - Water Table (MASL); Bottom - Maximum Depth of Extraction (MASL)
- 2:1 Side Slopes to Top of Bedrock
- Pond Side Slope — (Horizontal : Vertical)
- Arch. Site BaHb-17 Stage 2 Limit
- Buried Tile Drain — Continuous - Solid Tile Drain; Dashed - Perforated Tile Drain Wrapped in Filter Sock
- Arch. Site BaHb-17 Stage 3 Limit
- Injection Well
- Arch. Site BaHb-17 10m Offset from Stage 3 Limit
- Inspection Port
- Pump Station
- Cross Sections

Typical Acoustic Berm
N.T.S.



Site Plan Acronyms

1. ARA - Aggregate Resources Act
2. MASL - Metres Above Sea Level
3. MNR - Ministry of Natural Resources
4. MCM - Ministry of Citizenship and Multiculturalism
5. MGCS - Ministry of Government and Consumer Services
6. MECP - Ministry of Environment, Conservation and Parks
7. PTTW - Permit to Take Water
8. ECA - Environmental Compliance Approval

Site Plan Amendments

No.	Date	Description	By

Site Plan Revisions (Pre-Licencing)

No.	Date	Description	By

MHBC PLANNING URBAN DESIGN & LANDSCAPE ARCHITECTURE
113 COLLIER STREET, BARRIE, ON, L4M 1H2 | P: 705.728.0045 | WWW.MHBCPLAN.COM

MNR Approval Stamp

MHBC Stamp

Christopher [illegible]
Is authorized by the Ministry of Natural Resources pursuant to Subsection [illegible] of Ontario Regulation [illegible] to prepare and certify site plans.

Draft

Applicant

Strada Aggregates Inc.
30 Floral Parkway
Concord, Ontario
L4K 4R1

Project *Strada Pit & Quarry*
437159 4th Line, Melancthon, Ontario, L0N 1S9

MNR Licence Reference No.

Applicant's Signature

Plan Scale: 1:3000 (Arch E)
0 90 180 Meters

Date January 2025

Drawn By C.P.

Checked By B.Z.

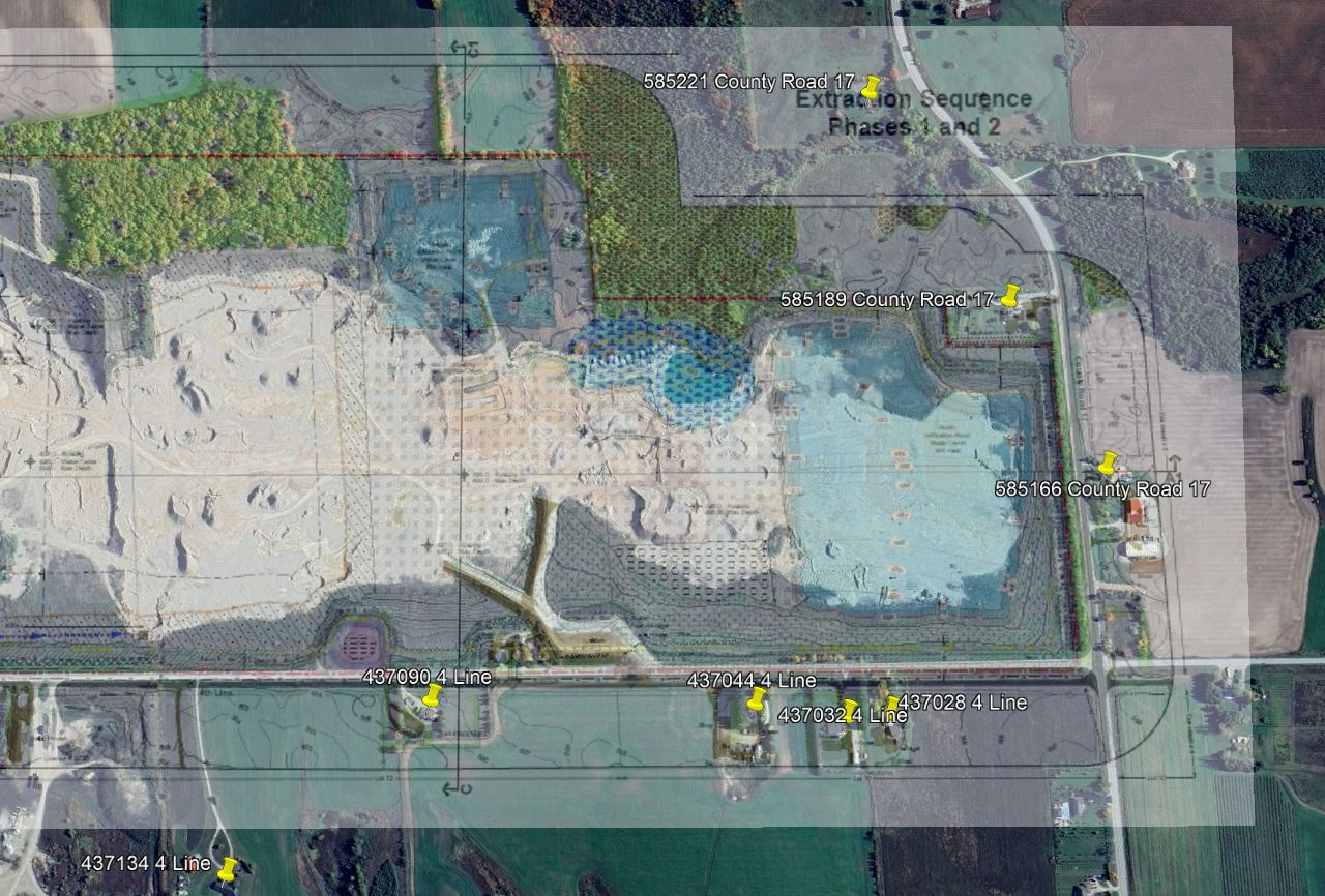
File No. Y349I

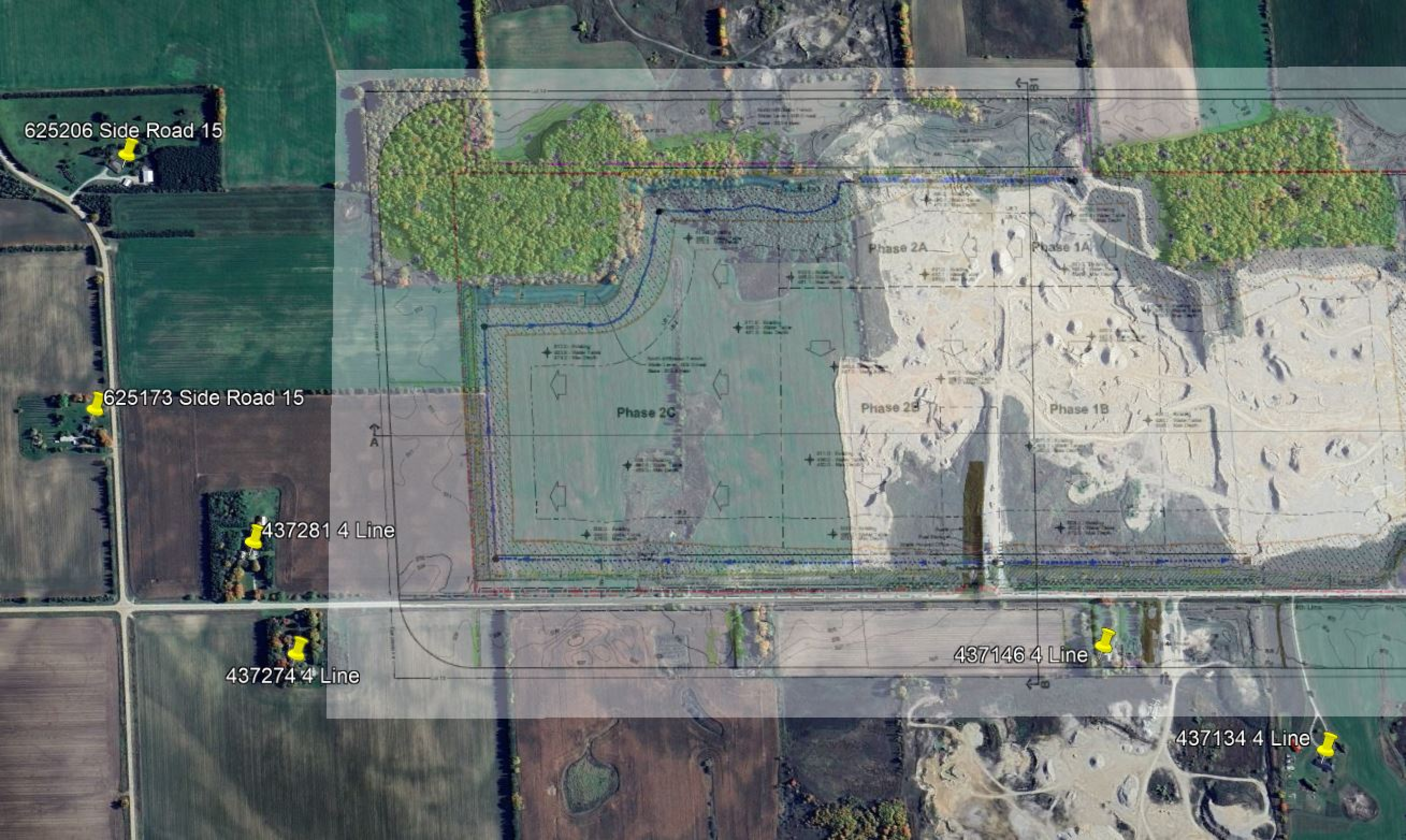
Drawing Name Operational Plan

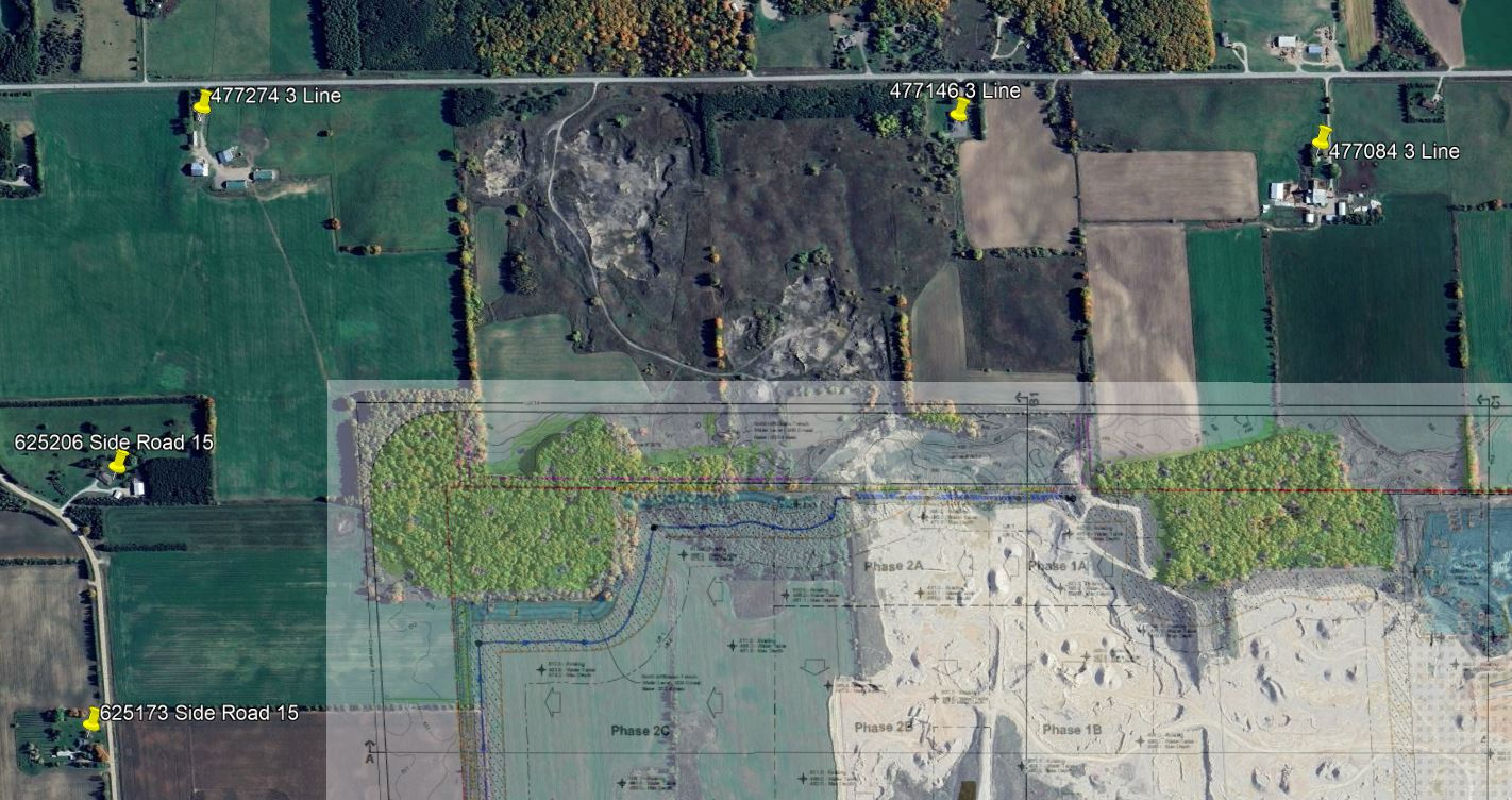
Drawing No. 2 of 5

File Path N:\Brian\Y349I Strada- Melancthon KW File\Drawings\Site Plan\CAD\Y349I - Site Plan.dwg


477274 3 Line
477146 3 Line
477084 3 Line
625206 Side Road 15
585221 County Road 17
Extraction Sequence
Phases 1 and 2
585189 County Road 17
625173 Side Road 15
585166 County Road 17
437281 4 Line
437090 4 Line
437044 4 Line
437032 4 Line
437274 4 Line
437146 4 Line
437134 4 Line


585221 County Road 17
Extraction Sequence
Phases 1 and 2
585189 County Road 17
585166 County Road 17
437090 4 Line
437044 4 Line
437032 4 Line
437028 4 Line
437134 4 Line


625206 Side Road 15
625173 Side Road 15
437281 4 Line
437274 4 Line
437146 4 Line
437134 4 Line
Phase 2A
Phase 1A
Phase 2B
Phase 1B
Phase 2C
A


477274 3 Line
477146 3 Line
477084 3 Line
625206 Side Road 15
625173 Side Road 15
Phase 2A
Phase 1A
Phase 2C
Phase 2B
Phase 1B

Appendix B

EXPLOTECH

Strada Pit and Quarry

PREVAILING METEOROLOGICAL CONDITIONS

Canadian Climate Normals 1991-2020
Egbert, Ontario

Date	Wind Direction	Max Hourly Wind Velocity Km/h	Temperature (Deg Celsius)
January	S	12.4	-7.2
February	NW	12.6	-6.4
March	NW	12.7	-1.3
April	NW	13.3	5.6
May	NW	11.5	12.3
June	NW	10.0	17.5
July	NW	9.1	20.1
August	S	8.9	19.2
September	S	9.5	15.3
October	S	11.1	8.9
November	S	11.9	2.7
December	S	12.2	-3.2

Appendix C

Ground Vibrations

Imperial Equations					
Equation 1	Equation 2	Equation 3	Equation 4	Equation 5	Equation 6
Oriard 50% Bound (2002)	Oriard 90% Bound (2002)	Oriard 99% Bound (2002)	Typical Production Blast (Bulletin 656 – 1971)	Typical limestone Quarry (Pader report – 1995)	Typical Coal Mine (RI8507 1980)
$v = 160\left(\frac{D}{\sqrt{W}}\right)^{-1.6}$	$v = 242\left(\frac{D}{\sqrt{W}}\right)^{-1.6}$	$v = 605\left(\frac{D}{\sqrt{W}}\right)^{-1.6}$	$v = 182\left(\frac{D}{\sqrt{W}}\right)^{-1.82}$	$v = 52.2\left(\frac{D}{\sqrt{W}}\right)^{-1.38}$	$v = 133\left(\frac{D}{\sqrt{W}}\right)^{-1.5}$

Metric Equations			
Equation 1	Equation 2	Equation 3	Equation 4
DuPont General (1968)	Construction Blasting (Dowding 1998)	Agg. Quarry Blasting (Explotech 2005)	Agg. Quarry blasting (Explotech 2003)
$v = 1140\left(\frac{D}{\sqrt{W}}\right)^{-1.6}$	$v = 1326\left(\frac{D}{\sqrt{W}}\right)^{-1.38}$	$v = 5175\left(\frac{D}{\sqrt{W}}\right)^{-1.76}$	$v = 7025\left(\frac{D}{\sqrt{W}}\right)^{-1.85}$

D (m)	W (Kg)	PPV1 (mm/s)	PPV2 (mm/s)	PPV3 (mm/s)	PPV4 (mm/s)	PPV5 (mm/s)	PPV6 (mm/s)	PPV1 (mm/s)	PPV2 (mm/s)	PPV3 (mm/s)	PPV4 (mm/s)
670	83	**1.2**	**1.8**	**4.4**	**0.4**	**1.2**	**1.6**	**1.2**	**3.5**	**2.7**	**2.5**

Air Overpressure

Imperial Equations			
Equation 1	Equation 2	Equation 3	Equation 4
USBM RI8485 (Behind Blast)	USBM RI8485 (Front of Blast)	USBM RI8485 (Full Confined)	Construction Average
$P = 0.056\left(\frac{D}{\sqrt[3]{W}}\right)^{-0.515}$	$P = 1.317\left(\frac{D}{\sqrt[3]{W}}\right)^{-0.966}$	$P = 0.061\left(\frac{D}{\sqrt[3]{W}}\right)^{-0.96}$	$P = 1\left(\frac{D}{\sqrt[3]{W}}\right)^{-1.1}$

Metric Equations		
Equation 1	Equation 2	Equation 3
Ontario Quarry (Explotech 2013)	Limestone (Explotech 2011)	Ontario Quarry (Explotech 2012)
$P = 159\left(\frac{D}{\sqrt[3]{W}}\right)^{-0.0456}$	$P = 206\left(\frac{D}{\sqrt[3]{W}}\right)^{-0.1}$	$P = 1222\left(\frac{D}{\sqrt[3]{W}}\right)^{-0.669}$

D (m)	W (Kg)	OP1 (dB)	OP2 (dB)	OP3 (dB)	OP4 (dB)	OP1 (dB)	OP2 (dB)	OP3 (dB)
670	83	**119.1**	**123.1**	**96.8**	**113.8**	**126.4**	**124.5**	**126.5**

Appendix D

Andrew Campbell, P.Eng.

Explotech Engineering Ltd.

EDUCATION & QUALIFICATIONS

Bachelor of Engineering,
Mechanical Engineering, Carleton University

Advanced and Expert (Industry) CadnaA Modelling
DataKustik, Mississauga, Ontario

PROFESSIONAL AFFILIATIONS

Professional Engineers of Ontario (PEO)
Engineers and Geoscientists British Columbia (EGBC)
International Society of Explosive Engineers (ISEE)

SUMMARY OF EXPERIENCE

An engineer working for Explotech Engineering Ltd., Andrew holds a Bachelor of Engineering degree in Mechanical Engineering and has strong analytical, technical, and interpersonal skills. A proven leader in collaborative environments, Andrew is comfortable managing projects, specifying details, and communicating internally and externally. With a focus on blast designs, blast impact analyses, noise monitoring and modelling, damage complaint investigations, vibration analysis, and blast monitoring, Andrew has applied these skills across Canada.

PROFESSIONAL RECORD

2018 – Present	- Engineer, Explotech Engineering Ltd.
2013 – 2018	- Technician / EIT, Explotech Engineering Ltd.
2012 – 2012	- Ride Technician, Canada's Wonderland

Appendix E

EXPLOTECH

Blasting Terminology

ANFO:	Ammonium Nitrate and Fuel Oil – explosive product
ANFO WR:	Water resistant ANFO
Blast Pattern:	Array of blast holes
Body hole:	Those blast holes behind the first row of holes (Face Holes)
Burden:	Distance between the blast hole and a free face
Column:	That portion of the blast hole above the required grade
Column Load:	The portion of the explosive loaded above grade
Collar:	That portion of the blast hole above the explosive column, filled with inert material, preferably clean crushed stone
Face Hole:	The blast holes nearest the free face
Overpressure:	A compressional wave in air caused by the direct action of the unconfined explosive or the direct action of confining material subjected to explosive loading.
Peak Particle Velocity:	The rate of change of amplitude, usually measured in mm/s or in/s. This is the velocity or excitation of the particles in the ground resulting from vibratory motion.
Scaled distance:	An equation relating separation distance between a blast and receptor to the energy (usually expressed as explosive weight) released at any given instant in time.
Sensitive Receptor:	Sensitive land use may include recreational uses which are deemed by the municipality or provincial agency to be sensitive; and/or any building or associated amenity area (i.e. may be indoor or outdoor space) which is not directly associated with the industrial use, where humans or the natural environment may be adversely affected by emissions generated by the operation of a nearby industrial facility. For example, the building or amenity area may be associated with residences, senior citizen homes, schools,

EXPLOTECH

day care facilities, hospitals, churches and other similar institutional uses, or campgrounds.

Spacing: Distance between blast holes

Stemming: Inert material, preferably clean crushed stone applied into the blast hole from the surface of the rock to the surface of the explosive in the blast hole.

Sub-grade: That portion of the blast hole drilled band loaded below the required grade

Toe Load: The portion of explosive loaded below grade

EXPLOTECH

References

Building Research Establishment, (1990), *"Damage to Structures From Ground-Borne Vibration",* BRE Digest 353, Gaston, Watford, U.K.

Crum S. V., Siskind D. E., Pierce W. E., Radcliffe K. S., (1995) *"Ground Vibrations and Airblasts Monitored in Swedesburg, Pennsylvania, From Blasting at McCoy Quarry",* Contract Research Rept. By the United States Bureau of Mines for the Pennsylvania Department of Environmental Resources, 120 pp.

Dowding C.H., (1985), *"Blast Vibration, Monitoring and Control"*, Prentice-Hall Canada Inc., 297 pp.

Dowding C.H., (1996), *"Construction Vibrations"*, Prentice-Hall, Upper Saddle, N.J., USA, 610 pp.

Du Pont Company, (1980), *"Blaster's Handbook"* Wilmington, Delaware, United States of America

Fletcher L.R., D'Andrea D.V., (1986) *"Control of Flyrock in Blasting"*, Proceedings of the Twelfth Annual Conference on Explosives and Blasting Technique, International Society of Explosives Engineers

Froedge D. T., (1983) *"Blasting Effects on Water Wells",* Proceedings of the Ninth Annual Conference on Explosives and Blasting Technique, International Society of Explosives Engineers

Kopp J.W., (1994) *"Observation of Flyrock at Several Mines and Quarries"*, Proceedings of the Twentieth Annual Conference on Explosives and Blasting Technique, International Society of Explosives Engineers

Matheson G. M., Miller D. K., (1997) *"Blasting Vibration Damage to Water Supply, Well Water Quality and Quantity",* Proceedings of the Twenty-Third Conference on Explosives and Blasting Technique, International Society of Explosive Engineers

Moore A.J., Richards A.B., (2005), *"Golden Pike Cut-Back Flyrock Control and Calibration of a Predictive Model"*, Terrock Consulting Engineers, Eltham, Victoria, Australia.

Nicholls H., Johnson C., Duvall W., (1970), "*Blasting Vibrations and their Effects on Structures",* United States Department of the Interior, Bureau of Mines, Bulletin 656

Oriard L.L., (1989) *"The Scale of Effects in Evaluating Vibration Damage Potential"* Fifteenth Conference on Explosives and Blasting Technique, International Society of Explosive Engineers

Oriard L.L., (2002) *"Explosives Engineering, Construction Vibrations and Geology"* International Society of Explosive Engineers, Clevland, Ohio, United States of America

Robertson D. A., Gould J. A., Straw J. A., Dayton M. A., (1980) *"Survey of Blasting Effects on Ground Water Supplies in Appalachia",* United States Department of the Interior, Bureau of Mines, Contract No. J-0285029

Rose R., Bowles B., Bender W. L., (1991) *"Results of Blasting in Close Proximity to Water Wells at the Sleeper Mine",* Proceedings of the Seventeenth Annual Conference on Explosives and Blasting Technique, International Society of Explosive Engineers

Roth J., (1979) *"A Model for Determination of Flyrock Range as a Function of Shot Conditions"*, United States Department of the Interior, Bureau of Mines, Report OFR 77-81

Siskind D.E., Stagg M.S., Kopp J.W., Dowding C.H., (1980), *"Structural Response and Damage Produced by Ground Vibration from Surface Mine Blasting",* United States Bureau of Mines RI 8507.

White,T.J., Farnfield,R.A., Kelly,M., (1993), "*The Effect of Low Level Blast Vibrations and the Environment on a Domestic Building*", Proceedings of the Ninth Annual Symposium on Explosives and Blasting Research, International Society of Explosives Engineers.

Wright D.G., Hopky G. E., (1998) *"Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters",* Canadian Technical Report of Fisheries and Aquatic Sciences 2107