TOWN OF CALEDON

(CBM Caledon Quarry)

CAART COMMENT SUMMARY TABLE RESPONSE #1 – [BLASTING]

Please accept the following as feedback from the Caledon Aggregate Review Team (CAART). Fully addressing each comment will expedite the potential for resolution of the consolidated CAART comments and individual agency objections. **Additional comments may be provided once a response has been prepared to the comments raised below and additional information provided**.

Colour Code	Description
(dark blue)	Resolved
(light blue)	Resolved subject to additional information being provided to CAART Reviewers (e.g., Implementation Guide, Report Addendums)
(no colour)	Response provided, but no further action taken or required by Project Team

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1.	Consider adding the following information and references to the site plan: a. Discuss creating and implementing a planned approach for completing pre- and post-blast inspections of residential structures as the site develops.	Site Plans	CBM has reviewed the request and is prepared to conduct pre-blast inspections prior to the commencement of the blasting operations for each phase to a distance of500 m from the quarry perimeter for that phase, for any homeowner that is interested when contacted. Since there is a high potential for cracks to be induced by the local environment, in the absence of blasting (particularly over seasons), periodic inspections may be required to assess whether new cracks have developed. The results of the inspections will be related to the vibration monitoring. For long-term monitoring, it is often better to monitor existing cracks (with crack monitoring gauges) in parallel with the vibrations. Based on the above, the following note is proposed to be added to the Aggregate Resources Act (ARA) Site Plans: "Prior to the commencement of blasting within 500 m of a structure and subject to landowner authorization, the Licensee will conduct a pre-blast inspection, periodic inspections while extraction is within 500 m and a post-blast inspection when extraction is no longer within 500 m of the structure. The result of the inspection will be provided to the landowner and form the basis for assessing any potential impact to the structure from blasting operations within 500 m."	
1.	b. Include consideration of pre-blast processes (i.e. reviewing drill logs, checking hole deviation, and inspecting any open faces) to help ensure blasting is safe and effective.	Site Plans	A site-specific quality control plan will be developed by CBM, in collaboration with the drilling and blasting contractor, to help ensure blasting is safe and effective. Details of the plan would be made available to the regulators for their review upon request.	

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1.	c. The site plans mention an independent third-party will perform blast vibration monitoring services for the site. RESPEC recommends discussing the roles and responsibilities of the site reporting any potential exceedances.	Site Plans	The independent third-party party will remotely monitor the blast vibrations and overpressure at the closest residences in front of and behind the blast, similar to what occurs at other quarries operated by CBM in Ontario. The results will be provided to CBM via the remote server. A summary of the monitoring results for each blast will be forwarded to CBM on a monthly basis. In the unlikely occurrence of an exceedance the Ministry of the Environment, Conservation, and Parks (MECP will be notified, along with an explanation as to what happened, and the corrective action being taken prior to the next blast occurring on-site. The ARA Site Plans currently require the following: "If there are exceedances of the vibration limits, blast design parameters shall be altered to bring results back into compliance." This Site Plan note will be updated as follows: "If there are exceedances of the vibration limits, the Licensee will notify MECP and the blast design parameters shall be altered to bring results back into compliance prior to the next blast occurring on-site.	
2.	The paragraph references a tunnel under Regional Road 136 to access the north area from the main quarry after approximately 10 years of operation and another tunnel under Charleston Sideroad to access the south area after approximately 30 years of operation. The document does not note the required blasting for this tunnel. In both cases, the tunnel must go below the buried Enbridge natural gas pipeline. The tunnel excavations may result in some very restrictive blasting practices. RESPEC recommends noting this item in the report.	Blast Impact Assessment: Page 4, Paragraph 3	The current plan for the tunnel development includes excavation by either blasting or tunnel boring machine (TBM). The choice of the excavation method will depend on the required vertical offset, the vibrations likely to be induced during the excavation and discussions with Enbridge regarding the excavation below their pipelines. The recorded vibrations during the tunnel under Regional Road 136 will provide input for the tunnel under Charleston Sideroad.	
3.	The paragraphs are a duplicate of one another. One paragraph should be eliminated.	Blast Impact Assessment: Page 6, Paragraphs 1 and 2	Agreed and acknowledged. The second paragraph is a duplicate.	
4.	The section notes, "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." This comment requires clarification on whether blasting the final walls down to these slopes will be required after completion of operations in the area (i.e., completion of mining in a particular area) or if the final production blasts in these areas are to be angled to produce the required results.	Blast Impact Assessment: Page 7, Section 2.0, Paragraph 2	The final quarry walls above the water table will slope at 3:1 and the pit walls below the water table will slope at 2:1 configuration. These quarry slopes will be required after completion of operations in the area (i.e., completion of mining in a particular area). The angles will be achieved through backfill of overburden material. This is documented on the rehabilitation page of the Site Plan. In certain areas, vertical walls may be left in place below the water table to allow for greater flow of water through the rock face.	
5.	The drawing shows the best estimate of the area where the depth of rock excavation would exceed 25 meters. This should be clarified in the report text. RESPEC recommends splitting the bench into two benches of approximately equal height as the pit wall approaches 25 meters in height to allow recovery of all resources. Having a bench of 25 meters and a secondary bench of 3 meters where the final wall height is 28 meters would not be economical or practical. This proposed split would also reduce the explosive loading per delay for each blast, lowering potential vibration levels (see bullet on page 5 [Page 24, Table 2]).	Blast Impact Assessment: Page 9, Figure 5	As the quarry wall approaches 25 meters (m), the bench will be split into two benches of approximately equal height to allow recovery of all resources. This would result in a maximum bench height of approximately 25 m as shown in Table 2. The vibration monitoring records will inform when bench height should be split in order maintain compliance with the regulatory limits.	

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6.	The blast pattern, hole size, stemming, subdrill depth, explosive weight per delay, and powder factor all appear to be very reasonable and equivalent to many operations in southern Ontario blasting in similar limestone rock formations. The explosive type is shown as a chemically sensitized, gassed bulk emulsion. RESPEC recommends showing this as an ammonium nitrate/fuel oil (ANFO) or gassed emulsion blend, which is most common in these types of operations. RESPEC recommends adding a 3-dimensional drawing or illustration of an example blast pattern.	Blast Impact Assessment: Page 10, Section 3.0	The current explosive type used at the CBM Osprey Quarry, which the blasts for the proposed Caledon Quarry were based on, is a chemically sensitized, gassed bulk emulsion. The explosive type to be implemented at the proposed quarry will be a chemically sensitized, gassed bulk emulsion or a gassed bulk emulsion blend. Many quarries avoid the use of ANFO due to its lack of water resistance and potential to increase nitrogen compounds (e.g., nitrates, nitrites and ammonia) to the groundwater.	
7.	The first bullet point describing the initiation of explosives in a borehole notes that “the bedrock behind the borehole is fractured.” As noted in Section 4.0, the rock immediately around the borehole is pulverized by the explosive, but outside the immediate area and behind the borehole (i.e., away from the open face), some cracking and micro fracturing extends for a very short distance into the final wall. The description of fracturing behind the borehole is very limited. RESPEC recommends expanding this explanation.	Blast Impact Assessment: Page 11, Bullet Point 1	The detonation of explosives within a borehole results in the development of very high gas and shock pressures. This causes crushing to occur around a blasthole wall when the pressure in the detonation front exceeds the dynamic compressive strength of the rock. The out-going strain pulse generated by the high-pressure detonation front disperses and loses energy rapidly. Crushing will cease when the strain level in the pulse drops below the elastic limit of the rock. This is usually very close to the blasthole wall (approximately 1 borehole radius). The rock that forms the wall of the blasthole outside the crushed zone is subjected to very sudden compression due to the dispersing strain pulse. This compression (i.e. relative radial motion) results in tangential stresses which can cause cracks to develop radially from the blasthole. A zone of very high pressure and temperature gases occupies the blasthole behind the detonation front. These gases penetrate the crushed zone around the blasthole and flow into the radial or naturally occurring cracks. The gas pressure tends to wedge open the cracks and cause them to extend. The radial cracks initially develop in all directions. permanently distorts the rock to several borehole diameters (5-25 hole diameters, 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. This energy attenuates rapidly from the blast site due to geometric spreading and natural damping and results in an attenuation of the vibrations with distance.	
8.	The term “Air vibrations or airblast” is used. RESPEC recommends defining and using the term “air overpressure” consistently throughout the report. Different terminology is used throughout the industry, causing a degree of confusion about the meaning of the terms.	Blast Impact Assessment: Page 11, Paragraph 2	A definition of air overpressure is provided in the response to comment number 28. The use of the terms “air vibrations” or “airblast” should be considered synonymous with air overpressure.	
9.	The cause of air overpressure is described as “the indirect action of a confining material subjected to explosive loading.” This description is unclear. One cause of air overpressure is the face	Blast Impact Assessment: Page 11, Paragraph 2	Air overpressure is a pressure wave generated by a blast. There are three main causes of air overpressure are 1) direct rock displacement at the blast when there is insufficient burden is in front of the face, 2) vibrating ground some distance from the	

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	movement of the rock when an insufficient burden is in front of the face or openings in the rock, insufficiently confining and allowing the escape of high-pressure gases. This gas release pulse is responsible for some of the air overpressure and should be explained in more detail.		blast., and 3) venting at the hole caused by blowout from the rock face or at the top of the hole where there is inadequate stemming (Dowding 1985). Where there is insufficient confinement from the rock mass, there can be a release of high-pressure gases and the development of a pressure pulse. The air overpressure consists of audible "sounds" (> 20 Hz) and inaudible frequencies (< 20Hz). The air overpressure can cause residential structures to vibrate and make internal items rattle.	
10.	The description of flyrock uses the term "wild flyrock." Although this does appear in some of the literature, RESPEC recommends not using this terminology as "wild flyrock" implies some sort of extreme event. In RESPEC's opinion, flyrock should be defined as rock that is outside the controlled blast area or blast zone.	Blast Impact Assessment: Page 13, Section 4.2, Paragraph 1	Flyrock refers to uncontrolled and unintended rock movement beyond the blast area. While RESPEC disagrees with the use of the term "wild flyrock", it does convey the idea of an unexpected violent projection of rock fragments (Richard and Moore 2004). Little (2007) describes wild flyrock as the unexpected propulsion of rock fragments, when there is some abnormality in a blast or a rock mass, which travels beyond the blast clearance (exclusion) zone. This is in contrast to the normal movement of rock fragments within the blast area. However, overall, we do not have an issue with using the simplified term 'flyrock' with the associated definition provided by RESPEC (i.e., rock that is outside the controlled bast area or blast zone). References: Little, T.N., 2007, "Flyrock Risk", in Proceedings of Explo 2007, Wollongong, New South Wales, Australia, p. 35 43. Richards, A.B. and Moore, A.J., 2004. "Flyrock Control – By Chance or Design", in Proceedings of the 30th Conference on Explosives and Blasting Technique, Vol. 1, ISEE, New Orleans.	
11.	The potential impacts on fisheries, pets, and livestock are well summarized and accurate. RESPEC agrees with the conclusions in these sections.	Blast Impact Assessment: Page 16, Section 4.3 and 4.4	Acknowledged. No action is required.	
12.	The summary is very comprehensive. RESPEC has reviewed all the blast reports and vibration monitoring information from CBM's Osprey Quarry near Collingwood (in a similar rock formation) for 3 years and produced a site attenuation forecast for ground vibrations. RESPEC's results are very similar to Golder's results. RESPEC believes the 95 percent confidence interval represents an excellent starting point to predict ground vibrations. As noted in the report, on-site monitoring at the proposed Caledon Quarry will be required to produce an attenuation relationship for the specific site. RESPEC is confident that the resulting site-specific equation will be similar to the prediction in Golder's report. RESPEC's data review and model are available upon request.	Blast Impact Assessment: Page 17, Section 5.2	Acknowledged. No action is required.	
13.	The data supplied from the Osprey Quarry consisted of air overpressure readings at different ranges insufficient to generate an air overpressure attenuation model. Air overpressure regression curves are difficult to generate with high accuracy as weather conditions make a significant difference in readings. However, Figure 9 presents industry standard equations to use as a starting point for quarry development. RESPEC verified these	Blast Impact Assessment: Page 18, Section 5.3	Acknowledged. No action is required.	

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	equations by reviewing supporting documentation and performing validation checks. A more accurate site-specific model will be developed as ongoing monitoring occurs throughout the quarry development.			
14.	The paragraph notes that cloud ceilings and temperature inversions can contribute to the air overpressure propagating further than expected. RESPEC's experience is that this is a common occurrence with air overpressure when a temperature inversion or low cloud cover causes the shock wave to be reflected back to ground and creates a higher level of air overpressure in an area that normally experiences little or no air overpressure. This only occurs in a very local area and is not likely repeated in subsequent blasts. The result of these incidents are that people who typically have limited or no knowledge of the blasting occurring may be startled and complain; however, the levels will be well below that which could cause any potential damage. RESPEC recommends expanding the explanation of the air overpressure in this section.	Blast Impact Assessment: Page 18, Section 5.3, Paragraph 2	Since the levels will be well below that which could cause any potential impact, WSP does not believe that additional explanation is required in this section.	
15.	RESPEC recommends emphasizing that proper control of face burdens and inspection of the face before shot loading should be done to minimize the potential for face bursting and higher air overpressure levels.	Blast Impact Assessment: Page 19	Proper control of face burdens (with controlled drilling and/or use of face mapping tools such as laser contouring) and inspection of the face before shot loading can be included to minimize the potential for face bursting and higher air overpressure levels. This will be completed as part of the third-party quality control plan implemented at the site prior to operations commencing.	
16.	RESPEC recommends explaining that air over pressure may be noticeable, but far below damage thresholds and that the effect of significant air overpressure on nearby residences will result in potential vibrations in the mid-wall sections of the house, potentially causing dishes to rattle or wall hangings to shift. Such air overpressure levels are far below what would cause any damage. Air overpressure would have to be as high as 148 to 150 dBL to have the potential to crack windows (which is the first damage noted from air overpressure).	Blast Impact Assessment: General Comment	[Section 4.1] Humans can perceive air overpressure well below damage thresholds. While people can perceive air overpressure levels below 90 dBL (0.63 pa), levels would have to be as high as 148 dBL (500 pa) to have the potential to crack windows (which is the first damage noted from air overpressure).	
17.	The paragraph notes that "the blasting operation will progress toward the extraction perimeter with the nearest sensitive receptors located behind the face." This is generally true, but as the quarry is developed, there will be many situations where quarry faces will not be oriented this way (e.g., open corners). RESPEC recommends adding text to address these alternate situations.	Blast Impact Assessment: Page 20, Paragraph 2	The blasting operation will progress toward the extraction perimeter with the nearest sensitive receptors located behind the blast face. While this is intended to reduce the overpressure level, there may be situations where quarry faces will not be oriented this way (e.g., open corners). In such cases, there may be an increase in overpressure and measures may be required to maintain compliance with the MECP guidelines. Measures include a reduction in maximum explosives charge weight per delay and appropriate changes in blast design parameters such as the burden and the stemming height.	
18.	The section on flyrock is very thorough and covers this subject clearly; however, RESPEC recommends two changes related to flyrock.	Blast Impact Assessment: Page 20, Section 6.0	The equation	

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	a. The equation for rifling shows sin2θDH with no reference to what DH represents, though it may be the launch angle noted in the list of terms. This should be updated or corrected in the report.		$$R_1 = \frac{k^2}{g}\left(\frac{\sqrt{m}}{SH}\right)^{2.6} \sin 2\theta_{DH}$$ should be replaced with $$R_1 = \frac{k^2}{g}\left(\frac{\sqrt{m}}{SH}\right)^{2.6} \sin 2\theta_{LA}$$ where θ_{LA}= launch angle from horizontal	
18.	b. (Starting with McKenzie [2009]) RESPEC suggests Golder add a paragraph recommending specifically what should be done with respect to flyrock control and blast area size.	Blast Impact Assessment: Page 20, Section 6.0	Within Section 7.8, flyrock estimates are presented in Table 7 for a range of blast design parameters. Following Table 7 general recommendations are presented, however the specific fly rock control and blast area size cannot be determined until such time as a detailed blast design, taking into account detailed on-site conditions that are inspected. Regulation 244/97 under the ARA requires CBM to implement the following: “28. A licensee or permittee shall take all reasonable measures to prevent fly rock from leaving the site during blasting if a sensitive receptor is located within 500 metres of the boundary of the site.” For clarity, the following note will be added to the ARA Site Plans: “The Licensee shall take all reasonable measures to prevent fly rock from leaving the site during blasting if a sensitive receptor is located within 500 metres of the boundary of the site.”	
18.	c. RESPEC has reviewed the flyrock prediction equations and supporting documents and completed validation checks, and supports the conclusions in the report.	Blast Impact Assessment: Page 20, Section 6.0	Acknowledged. No action is required.	
19.	Three distances are noted for different bench heights indicating the estimated standoff distances to adjacent receptor residences based on estimated air overpressure levels. These calculations are correct. RESPEC recommends adding a note stating that these readings will depend on weather conditions.	Blast Impact Assessment: Page 27	Acknowledged. As a note below Table 3 and Table 4: 3) Recorded levels will be dependant on the weather conditions. Following the bullets: The estimated standoff distances will be dependent on the weather conditions at the time of the blast.	
20.	Three points provide suggestions for techniques to reduce vibration levels. RESPEC recommends adding a fourth point that suggests considering the use of electronic detonators to improve timing accuracy. Numerous studies have shown that improved timing accuracies can reduce ground vibration levels in sensitive areas.	Blast Impact Assessment: Page 29, Section 7.2	Acknowledged. Please see below: 4) Implement the use of electronic detonators to improve timing accuracy and maintain hole timing as designed. This requirement will be added to the ARA Site Plans.	
21.	Enbridge’s specification notes that they may require a daily leak test when blasting occurs near a pipeline. Providing the notifications and approvals are completed correctly, it is up to Enbridge to determine the need for testing while CBM would be financially responsible for the testing.	Blast Impact Assessment: Page 30, Section 7.3	The list is based on Enbridge’s guideline in Appendix E. Communication with Enbridge in advance of blasting would allow for them to communicate any additional requirements.	

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<tr><th></th><th>Initial CAART Comments (Date)</th><th>Page / Section</th><th>Applicant Response
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(Date)</th></tr>
<tr><td>22.</td><td>The sections on heritage attributes, water wells, and repeated low level vibration effects on structures are well written and correct. RESPEC agrees with these sections.</td><td>Blast Impact Assessment: Page 30 and 31, Sections 7.4, 7.5, 7.6</td><td>Acknowledged. No action is required.</td><td></td></tr>
<tr><td>23.</td><td>RESPEC verified the minimum separation required based on the estimated maximum flyrock range calculations and provided data. However, Row 1, Column 6 appears to be incorrect and should show 230 meters instead of 330 meters.</td><td>Blast Impact Assessment: Page 33, Table 7</td><td>Please see below revised Table 7.

Table 7: Estimated Maximum Flyrock Range for a Range of blast Designs for the Proposed Caledon Quarry
<table>
<tr><th rowspan="2">Blasthole Diameter (mm)</th><th rowspan="2">Burden (m)</th><th rowspan="2">Stemming (m)</th><th colspan="2">Maximum Throw (m) [1]</th><th rowspan="2">Minimum [2] [3] Separation (m)</th></tr>
<tr><th>Face Burst</th><th>Cratering</th></tr>
<tr><td>102</td><td>3.3 [4]</td><td>2.1 [5]</td><td>36</td><td>115</td><td>230</td></tr>
<tr><td>102</td><td>3.3 [4]</td><td>2.5</td><td>36</td><td>73</td><td>146</td></tr>
<tr><td>102</td><td>3.3 [4]</td><td>3.0</td><td>36</td><td>46</td><td>92</td></tr>
<tr><td>102</td><td>3.3 [4]</td><td>3.5</td><td>36</td><td>31</td><td>62</td></tr>
</table></td><td></td></tr>
<tr><td>24.</td><td>RESPEC recommends adding the following information and references to the blast impact assessment.
a. Discuss creating and implementing a planned approach for completing pre- and post-blast inspections of residential structures as the site develops.</td><td>Blast Impact Assessment: General Comment</td><td>See answer for comment 1a.</td><td></td></tr>
<tr><td>24.</td><td>b. Include consideration of pre-blast processes (i.e. reviewing drill logs, checking hole deviation, and inspecting any open faces) to help ensure blasting is safe and effective.</td><td>Blast Impact Assessment: General Comment</td><td>A Quality Assurance program will be developed between CBM and the blasting contractor and implemented prior to the commencement of operations and adjusted as needed during operations.</td><td></td></tr>
<tr><td>25.</td><td>The report mentions an independent third-party will perform blast vibration monitoring services for the site. RESPEC recommends expanding on this role earlier in Section 7.0. It is also recommended this section discusses the roles and responsibilities of reporting and maintaining accountability for any potential exceedances.</td><td>Blast Impact Assessment: Page 34, Section 8.0</td><td>MECP via NPC119 requires monitoring at the nearest sensitive receptor to the blast. We have recommended monitoring at the nearest sensitive receptor in front and behind the blasts by an independent third-party. Including a discussion of the roles and responsibilities of reporting and maintaining accountability for any potential exceedances. Also see response to 1c).</td><td></td></tr>
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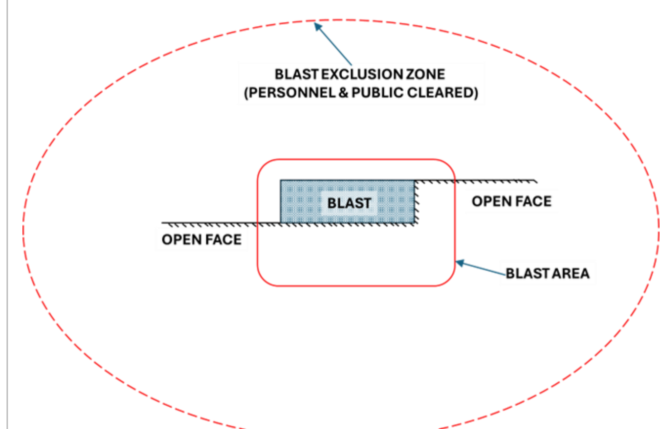
26.	RESPEC recommends adding that the contractor should attempt to blast at approximately the same time frame each day blasting is scheduled. Neighbors will better expect and understand what is happening when a blast goes if there is more regularity and consistency around the blast events.	Blast Impact Assessment: Page 34, Section 8.0	The blasting contractor has not been determined. The chosen contractor should attempt to blast at approximately the same time frame each day blasting is scheduled. With such consistency, the neighbouring residents will better expect the timing for a blast. Furthermore, the ARA Site Plans already require the following: “The licensee shall establish a blasting notification program for residents within 500 metres.” The residents will be aware of upcoming blasts prior to them occurring.	
27.	The last point suggests monitoring the first five production blasts with multiple seismographs. RESPEC agrees with this suggestion; however, several sinking shots will be required to open up the ramps and start development before production blasting. Sinking shots tend to be heavily loaded (because they are more confined than a regular face shot) and produce higher vibrations. RESPEC recommends stating that the location of the sinking shots and ramp development should be done with this in mind and be monitored at five locations.	Blast Impact Assessment: Page 35, Section 8.0	Acknowledged. Add to the end of the bullet: As sinking blast and ramp development blasts tend to be more heavily confined, they often induce higher vibration levels than typical production blasts. Sinking blasts and ramp development blasts should be monitored but used to develop a separate model type.	
28.	RESPEC recommends updating the glossary as follows: - Add the definition of “air overpressure.” - Use the term “flyrock” instead of “rock missile” in the definition of blast area. - Update the definition for “blast area” to reflect how it is used in the report and define it as an area where controlled blast effects, such as controlled and intended rock movement, take place. - Clarify the definition of “deck.” A deck can be referenced as inert (stemming deck) material or explosive material (explosive deck). - Update the definition of “flyrock.” RESPEC assumes flyrock is being defined as uncontrolled and unintended rock movement using the current definition. - RESPEC recommends adding an illustration to help define the blast zone and to differentiate between controlled and intended rock movement and flyrock.	Blast Impact Assessment: Appendix B	The following are additions to the glossary items: **Air Overpressure –** The airborne shockwave or acoustic transient generated by an explosion. **Blast Area –** The definition provided in the BIA is from the ISEE Blaster’s Handbook (ISEE 2016). This refers to an area where controlled blast effects, such as controlled and intended rock movement, take place.  **Deck** - In blasting a portion of a blast hole loaded with explosives that are separated from the main charge by stemming. Commonly, a deck can refer to inert material (stemming deck) or explosive material (explosive deck). **Flyrock** - The definition provided in the BIA is from the ISEE Blaster’s Handbook (ISEE 2016). This refers to uncontrolled and unintended rock movement beyond the blast area.	

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			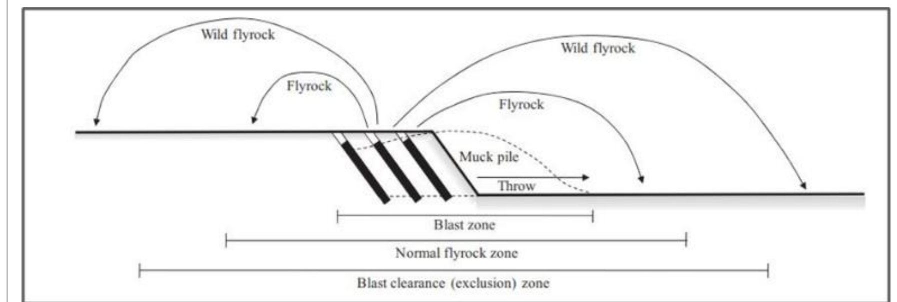	
29.	RESPEC agrees with Golder's view that blasting can be done within the current quarry blasting guidelines (NPC-119) at all surrounding sensitive land uses. RESPEC recommends the clarifications and additions previously outlined be added to the report, but overall Golder has done a thorough job of assessing the impacts of blasting.	Blast Impact Assessment: Page 35 and 36, Section 9.0	Acknowledged. Recommended clarifications and additions are addressed above.	