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SUBJECT: BLAST VIBRATION REVIEW, OCTOBER 2014

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ESTIMATION OF BLAST VIBRATION AT EYRE STREET LOCATIONS FROM BLASTING AT RASP MINE

INTRODUCTION

The following estimation of vibration impact at Eyre Street residences, for the proposed extension of mining at Rasp Mine, is based on recent blast data provided by Rasp Mine.

Given the change in blasting practices at Rasp Mine over the last 12 months, this most recent data is considered to provide the best available indication of future outcomes. However it must be noted that proposed blasting will be outside the areas in which previous blasting has been carried out, resulting in a high degree of uncertainty.

Ongoing validation and modification of the estimates provided will therefore be required once blasting commences, with small scale blasts used to provide early confidence before larger scale blasts are implemented.

ASSUMPTIONS

1. Initial development blasting is based on 43mm diameter holes, with charge mass around 4kg per hole and up to 12 holes on the same delay number (see Table 1).

2. Subsequent production blasting is based on 89mm or 76mm diameter holes that could be fully charged or decked with up to three decked charges, and between 12kg and 62kg of charge per discrete deck (see Table 1).

3. Vibration limits at Eyre Street residences are based on the usual range of 5 to 10mm/s (PVS) for the nearest residential locations (>250m from closest blasting), with other buildings such

as the Bowling Club and Bocce Club (110m to 200m from closest blasting) subject to agreements between the mine and asset owners (See Figures 1a and 1b).

Table 1 – Blasting parameters provided

Blast Type	Blast location	Sensitive Location	Distance (m)	Charge configuration	Max charge (kg)
Development Blasting (43mm diameter blastholes)	Main Lode	Bowling Club	202	1 hole/delay	4
			202	6 holes/delay	26
			202	12 holes/delay	52
		Nearest Eyre Street Residence	269	1 hole/delay	4
			269	6 holes/delay	26
			269	12 holes/delay	52
	Zinc Lode	Bocce Club	112	1 hole/delay	4
			112	6 holes/delay	26
			112	12 holes/delay	52
		Nearest Eyre Street Residence	184	1 hole/delay	4
			184	6 holes/delay	26
			184	12 holes/delay	52
Production Benching (76mm diameter blastholes)	Main Lode	Bowling Club	311	3 decks/hole	12
			311	2 decks/hole	31
			311	full column charge/hole	45
		Nearest Eyre Street Residence	340	3 decks/hole	12
			340	2 decks/hole	31
			340	full column charge/hole	45
	Zinc Lode	Bocce Club	191	3 decks/hole	12
			191	2 decks/hole	31
			191	full column charge/hole	45
		Nearest Eyre Street Residence	281	3 decks/hole	12
			281	2 decks/hole	31
			281	full column charge/hole	45
Production Benching (89mm diameter blastholes)	Main Lode	Bowling Club	311	3 decks/hole	17
			311	2 decks/hole	42
			311	full column charge/hole	62
		Nearest Eyre Street Residence	340	3 decks/hole	17
			340	2 decks/hole	42
			340	full column charge/hole	62
	Zinc Lode	Bocce Club	191	3 decks/hole	17
			191	2 decks/hole	42
			191	full column charge/hole	62
		Nearest Eyre Street Residence	281	3 decks/hole	17
			281	2 decks/hole	42
			281	full column charge/hole	62

Figure 1a – Development blasting with respect to nearest sensitive locations

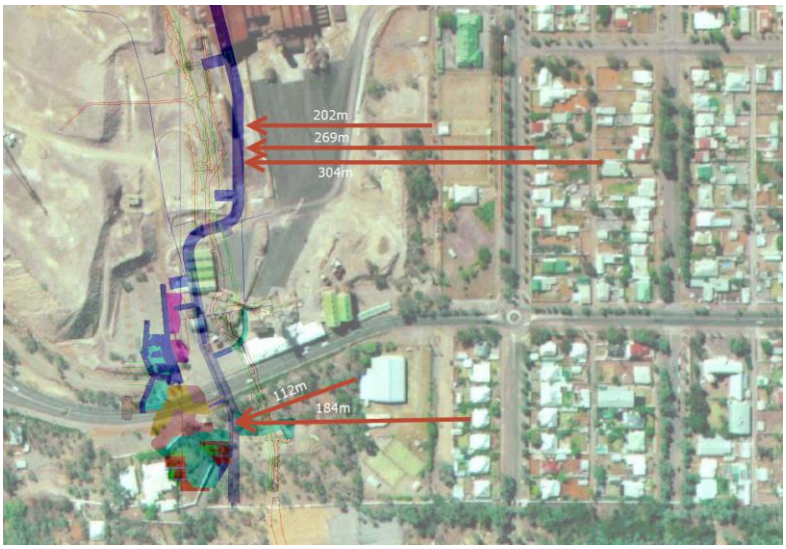
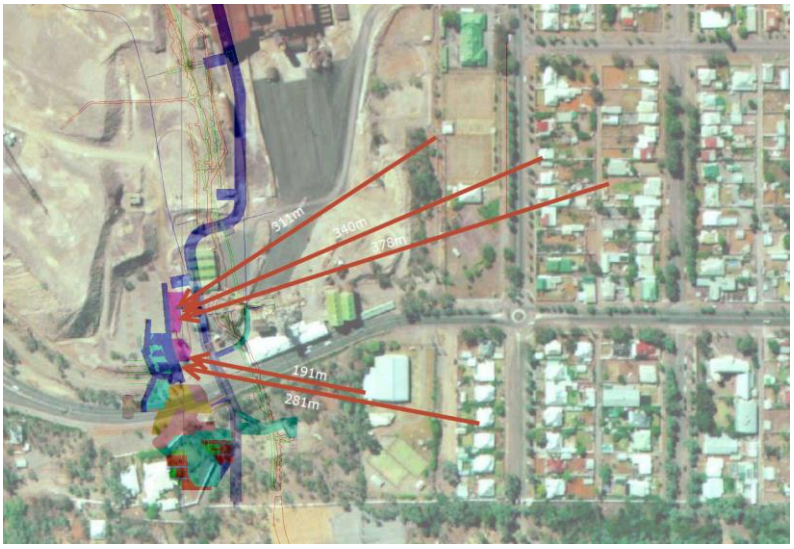


Figure 1b – Production blasting with respect to nearest sensitive locations



ASSESSMENT

The available and recent monitored blast vibration data has not been filtered to any great extent, and has simply been used to provide an indicative range at this stage.

Monitored blast data recorded at the V2 and V3 monitors has been reviewed separately, but is within similar ranges.

Two blasts were considered unrepresentative and were removed from the data set, on the basis of (i) excessive blast duration of a composite shot, and (ii) non-standard blast configuration with additional holes. These scenarios have been reviewed and will not be applicable going forward.

The following assessment has been carried out:

1. Vibration trends with distance and charge mass for recent blasting.

2. Estimation of likely impact of proposed blasting at nearby Eyre Street residences.

3. Given the high degree of uncertainty, and the close proximities involved, a number of recommendations have also been made to assist regarding blasting strategies and minimisation of adverse outcomes.

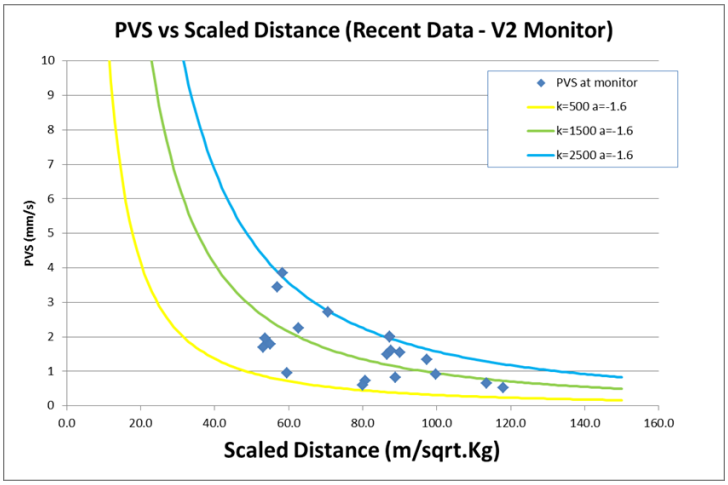
Vibration trend with distance and charge mass for recent blasting

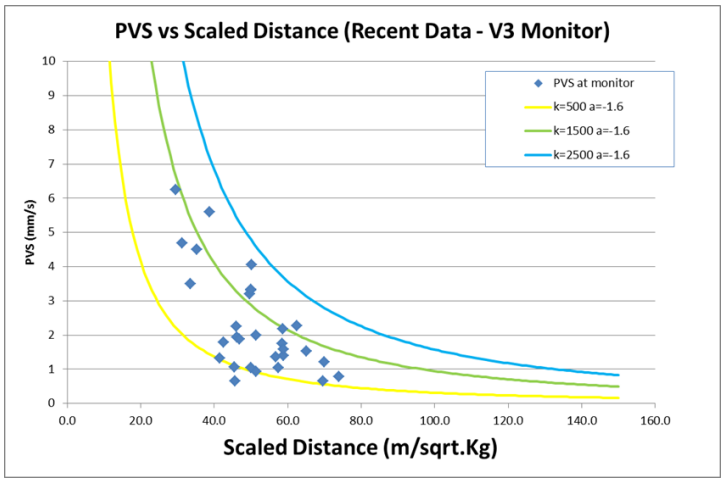
The plots in Figure 2 illustrate the trends in recent monitored blast vibration data at the V2 and V3 monitors (June to September 2014).

The reduced spread of recent data, compared with previous data sets reviewed, can be attributed to an increased level of attention to the design and review process that is now required for compliance purposes. Given the close proximity of sensitive locations to the proposed Main Lode and Zinc Lode mining areas, it is understood that a high degree of planning and control will continue to be exercised for all blasts in these areas.

Previous assessment of vibration data at Rasp Mine has suggested that an exponent of a=-1.6 is appropriate, based on best-fit trends of consistent data sets (similar blasts monitored at the same location). The indicative K-factor range provided by recent data (between 500 and 2500, based on the selected exponent) therefore provides a reasonable starting point.

Figure 2 – Recent vibration trends based on data from Rasp Mine





Impact of proposed blasting at nearby Eyre Street residences

Based on the K-factor range suggested (K=500 to 2500, with an exponent a=-1.6), a range of change mass limitations can be determined at different distances for different vibration limits using the standard equation:

$$V = K \times SD^{a}$$

where SD = D/(sqrt(MIC))

V = PVS vibration (mm/s)
K = K-factor (500 to 2500 in this case), a = exponent (-1.6 in this case)
SD = Scaled distance (m/sqrt.MIC)
D = Distance (m)
MIC = Maximum instantaneous charge (Kg per blasthole, deck or delay interval as appropriate[#])

[#] A consistent method of calculating MIC must be used when comparing trends in vibration for 'similar' blasts. This may be on the basis of maximum charge per hole (for full column charges), maximum charge per deck (for separate electronically timed deck charges), or maximum charge per delay interval (where groups of blastholes are deemed to have fired simultaneously or likely to reinforce in the direction of firing). Where different methods of assigning MIC are used, then those blasts are not 'similar' and should not be combined as part of any assessment or estimation process, and must be assessed separately.

Based on the selected blast parameters (Table 1) and trends in recent data (Figure 2), the potential range in peak vibration impact at nearby sensitive locations can be estimated for the charge configurations planned for the proposed mining areas (see Table 2).

Table 2 – Estimated ranges for peak ground vibration at sensitive locations, adjacent to the proposed mining areas, based on expected blast parameters and recent vibration trends

								Site trends		
							k	500	1500	2500
							a	-1.6	-1.6	-1.6
Blast Type	Blast location	Sensitive Location	Distance (m)	Charge configuration	Max charge (kg)	Scaled distance		Expected peak vibration range (mm/s)		
Development Blasting (43mm diameter blastholes)	Main Lode	Bowling Club	202	1 hole/delay	4	97.4		0.3	1.0	1.6
			202	6 holes/delay	26	39.7		1.4	4.2	6.9
			202	12 holes/delay	52	28.1		2.4	7.2	12.0
		Nearest Eyre Street Residence	269	1 hole/delay	4	129.7		0.2	0.6	1.0
			269	6 holes/delay	26	52.9		0.9	2.6	4.4
			269	12 holes/delay	52	37.4		1.5	4.6	7.6
	Zinc Lode	Bocce Club	112	1 hole/delay	4	54.0		0.8	2.5	4.2
			112	6 holes/delay	26	22.0		3.6	10.7	17.8
			112	12 holes/delay	52	15.6		6.2	18.6	30.9
		Nearest Eyre Street Residence	184	1 hole/delay	4	88.7		0.4	1.1	1.9
			184	6 holes/delay	26	36.2		1.6	4.8	8.0
			184	12 holes/delay	52	25.6		2.8	8.4	14.0
Production Benching (76mm diameter blastholes)	Main Lode	Bowling Club	311	3 decks/hole	12	89.8		0.4	1.1	1.9
			311	2 decks/hole	31	55.9		0.8	2.4	4.0
			311	full column charge/hole	45	46.4		1.1	3.2	5.4
		Nearest Eyre Street Residence	340	3 decks/hole	12	98.1		0.3	1.0	1.6
			340	2 decks/hole	31	61.1		0.7	2.1	3.5
			340	full column charge/hole	45	50.7		0.9	2.8	4.7
	Zinc Lode	Bocce Club	191	3 decks/hole	12	55.1		0.8	2.5	4.1
			191	2 decks/hole	31	34.3		1.7	5.2	8.7
			191	full column charge/hole	45	28.5		2.4	7.1	11.8
		Nearest Eyre Street Residence	281	3 decks/hole	12	81.1		0.4	1.3	2.2
			281	2 decks/hole	31	50.5		0.9	2.8	4.7
			281	full column charge/hole	45	41.9		1.3	3.8	6.3
Production Benching (89mm diameter blastholes)	Main Lode	Bowling Club	311	3 decks/hole	17	75.4		0.5	1.5	2.5
			311	2 decks/hole	42	48.0		1.0	3.1	5.1
			311	full column charge/hole	62	39.5		1.4	4.2	7.0
		Nearest Eyre Street Residence	340	3 decks/hole	17	82.5		0.4	1.3	2.1
			340	2 decks/hole	42	52.5		0.9	2.7	4.4
			340	full column charge/hole	62	43.2		1.2	3.6	6.0
	Zinc Lode	Bocce Club	191	3 decks/hole	17	46.3		1.1	3.2	5.4
			191	2 decks/hole	42	29.5		2.2	6.7	11.1
			191	full column charge/hole	62	24.3		3.0	9.1	15.2
		Nearest Eyre Street Residence	281	3 decks/hole	17	68.2		0.6	1.7	2.9
			281	2 decks/hole	42	43.4		1.2	3.6	6.0
			281	full column charge/hole	62	35.7		1.6	4.9	8.2

Based on the primary constraint that peak ground vibration from blasting should not exceed 5mm/s (peak vector ppv) at identified residential locations, for at least 95% of blasts, the following blast design limitations are suggested by this exercise:

- Development blasting should be limited to no more than 6 holes per delay (and possibly fewer) when blasting at the closest proximity to residential locations.

- Production blasting with 89mm diameter blastholes will require decking, and may not be appropriate at the closest proximity to residential locations.

- Production blasting with 76mm diameter blastholes may require decking, but should be suitable for blasting at the closest proximity to residential locations.

- There is potential to exceed 'residential' limits (5 to 10mm/) at the Bocce Club and Bowling Club. These locations will be subject to agreements with Rasp Mine regarding acceptable levels of disturbance.

- Subject to actual vibration outcomes as the project advances, and the actual distances from sensitive locations, the use of 89mm diameter blastholes and/or full column production charging may be achievable for some blasts, but should be implemented with care.

Other Recommendations

The proposed mining areas are significantly closer to nearby infrastructure and residences, than previous blasting with a higher level of associated risk. This must be taken into account and requires a high level of control regarding data collection, vibration assessment, and QA/QC of the blasting process in order to remain compliant.

Geological structures (dolerite dykes and shear zones) have had a strong influence on vibration outcomes in the past and it is recommended that a review is carried out of the extent to which these structures could influence vibration outcomes for blasts within the Main Lode and Zinc Lode areas.

Preliminary estimates in this report are based on vibration data from other mining areas, measured at greater distances and with generally greater charge mass than for this exercise. Additional data from both development and production blasts monitored at close distances would be helpful to validate the estimates made.

In addition to fixed monitors required for compliance monitoring at identified residential locations, additional roving monitors should be budgeted in the event of unexpected results and/or complaints.

Cost analysis should be carried out to ensure that the project remains profitable if a significant reduction in the scale of blasting is required across the entire mining area.

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