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Our Reference: 22269-CR01B

Monday, 20 October 2014

CBH Resources Ltd
Broken Hill Operations Pty Ltd
130 Eyre St.
Broken Hill NSW 2880

Attn: Gwen Wilson, Group Manager – Safety Health Environment Community

Dear Madam,

Re: Extension to Rasp Mine at Broken Hill – Zinc Lode
Affects to Road Reserve Infrastructure

As per your request, the undersigned attended a risk assessment for the above project on 9th and 10th October 2014. Reference is also made to a copy of a letter provided by Roads and Maritime Services (RMS) detailing further information required for their assessment of the project proposal.

Attached is our report detailing our findings from investigations to aid in the information required by RMS, in relation to the effect of the mining, to the road reserve infrastructure including road pavements, structures and services.

If you have any further enquiries regarding this matter, please do not hesitate to contact the undersigned.

Yours faithfully

BARNSON PTY LTD

Richard Noonan
BE (Hons) ME MIEAust CPEng (Reg)
Director

1.0 INTRODUCTION

1.1 Aim

The following report aims to provide further information to allow assessment of effects to surface infrastructure from proposed mining of the Zinc Lode ore body at the Rasp mine, South Road, Broken Hill NSW. It is understood this report will be included with the Environmental Assessment application for the mine extension.

The mine is proposed to be an underground operation in hard rock and will continue under the current Silver City Highway, (HW22) also known as South Street. The mine roof or crown is proposed to be a minimum 60 metres under the road surface.

1.2 Commission

This report was requested by Ms Gwen Wilson, Group Manager – Safety Health Environment Community, of Broken Hill Operations Pty Ltd, the mine operator.

1.3 Writer

The writer is Mr Richard Noonan, a practising Civil, Geotechnical and Structural engineer with Barnson Pty Ltd. The writer has in excess of 20 years' experience in the design and assessment of civil infrastructure projects.

1.4 Risk Assessment

The writer attended a risk assessment for the project held at Broken Hill on 9th and 10th October 2014. The risk assessment was convened by Mr Peter Reardon of SP Solutions. It is understood a report will be prepared by SP Solutions to be included with the Environment assessment for the mine extension application.

1.5 Information provided

The below reports were provided by the client to aid in the preparation of this report:

a) Prism Mining Pty Ltd – *Review of blast vibration control at Zinc Lode, Rasp Mine – Draft*, dated 26 sept 2014

b) Ground control Engineering Pty Ltd – *Draft Geotechnical assessment – Zinc Lodes* dated 16 October 2014

2.0 GEOTECHNICAL ENGINEERING ASSESSMENT

The RMS has requested a geotechnical engineering assessment as per the below excerpt from their letter dated 24/9/14.

- *A geotechnical engineering assessment of the proposed mining extension. The geotechnical engineering assessments shall assess and report the existing local geotechnical environment and South Street including the road formation, pavement and ancillary structures.*

To provide this assessment, the writer has taken into account the findings of the Mining Geotechnical Engineer and a surface site inspection to provide the following advice:

2.1 Mining Geotechnical Assessment

A mining geotechnical assessment of the underground mine operation has been prepared by Cameron Tucker of Ground Control Engineering Pty Ltd. This report indicates that from data acquired from exploratory mine drilling in the area to date, the rock below the road reserve is close to the surface and has shallow depth weathering underlain by high strength fresh rock of UCS 70-80 MPa.

The report states that, from the data available to date, the 60 metre crown pillar or cover above the mine roof to the surface, combined with conservative stope design dimensions, will limit the potential for surface infrastructure disturbance due to subsidence, during the mine life period. Further investigation and monitoring during the mining progress has been recommended to further limit the potential for subsistence.

After the mine is completed, it is envisaged the stopes will be filled with hydraulic fill from surface holes which will provide crown support. This will then limit the potential of any long term surface subsidence in the road reserve.

2.2 Surface Geotechnical Engineering Assessment

2.2.1 Current Site Conditions

The site was inspected by the writer on 9th October 2014. The road vertical alignment was noted to be at natural surface or shallow cut near the old mine entrance then falling to the east with substantial fill and a fill batter slope estimated to be 1V:2H. Rock outcrops could be seen on the mine site adjacent to the road at the top of the hill. See photo below.

Photo No.1: South Road, looking east

2.2.2 Road Reserve Services

The road reserve was noted to also contain overland electricity supported on timber poles on the north side of the road. Two Ductile iron water mains were also noted to the west of the site and appear to continue underground near the mine fence. Provided Dial Before you Dig site plans from Essential Energy and Essential Water indicate the location of their assets. Telecommunications pits were noted on the south side of the road, which may contain fibre optic cables. Provided Dial-before-you-dig plans from Telstra

also show the location of their mains and indicate fibre optic and / or major network mains are in the area.

No stormwater drainage structures such as culverts or bridges were noted in the immediate vicinity of the site (within 250 metres)

2.2.3 Road Pavement and Formation

The road formation at the site varies from flexible pavement on shallow weathered rock cut to flexible road pavement on fill. The road surface is currently asphaltic concrete, which appears to be of recent construction (1-2 years old). The asphalt thickness was not determined, but from side profiles as per the photo below, appears to be 50-100mm thickness.

Photo no. 2: Current Asphalt seal

The road vertical alignment appears to be fairly uniform, which is probably due to the recent asphalt overlay. However this would also indicate that the fill compaction has performed adequately to date, with no major evidence of uneven settlement.

2.2.4 Effect of Underground Mining on Road Pavement and Other Road Reserve Structures from Mining Subsidence

With the findings of the mine geotechnical assessment, the potential for surface infrastructure disturbance from mine subsidence should be limited to acceptable levels and thus no effect to the surface from subsidence should occur during mining operation or after mine life.

The risk assessment undertaken further explored controls required to limit the potential for any occurrence.

3.0 EFFECTS TO SURFACE INFRASTRUCTURE DUE TO VIBRATION FROM UNDERGROUND MINE BLASTING

3.1 Blasting Effects

Reference is made to the "*Review of Blasting vibration control at Zinc Lode, Rasp Mine*" by Mike Humphreys, Principal Drill and Blast Engineer with Prism Mining Pty Ltd. This report states that acceptable peak particle velocity (PPV) limits for surface infrastructure such as roads, electricity poles, water mains and fibre optic cables is 100mm/s. This is based on a report by Terrock Consulting Engineers "*Effect of blasting on Infrastructure, ACARP project No. C14057*", dated 24th September 2008. The recommended limits as determined in this report is shown in the below excerpt of this paper.

Table A– Recommended 'safe' vibration limits without more detailed analysis

Item		Previous Limit[5] (mm/s)	Recommended PPV Limit (mm/s)	Observation From (mm/s)	Possible Upper Limit (A) (mm/s)
Public roads		-	100		Block movement
Railway lines		-	100[1]0		Block movement
Concrete bridges		25	100[3]		200
Conveyor structures		25	100[5]		200
Power lines	Timber poles	-	100		200
	Concrete poles	25	100[5]		200
	Steel towers	25	100[5]		200
Electrical substations (Buckholz switches)			10-25	10	100[6]
Fixed mine plant and buildings		25	100		200
Underground workings		-	100	10[2]-25	150[8]
Surface pipelines		-	100	25	150
Buried communication cables and pipelines		-	100	100	Block movement
Dams		-	100	50	200[9]
Heritage structures		-	up to 50[5]	20[4]	50
Mine offices, houses		10	up to 50[5]		200

Notes:
1. With track monitoring protocols and inspections
2 If men are present
3 Without traffic loads
4 In maintained condition
5 AS2187.2-2006
6 With reed switches
7 With minor repairs
8 Adequate ground support
9 Fell et al
(A) Only after a detailed investigation to determine frequency response and strain measurements

Figure 1: Excerpt from Terrock Consulting Engineers "*Effect of blasting on Infrastructure, ACARP project No. C14057*", dated 24th September 2008

3.2 Permanent Heave Zone

The Terrock ACARP report indicates that the permanent heave zone at coal mines caused by blasting in open cut situations can be 20m to 50m from the nearest blast hole. The permanent heave zone in hard rock mines would very small due to the effect of the overburden stress and higher rock strength. Based on the geotechnical report by Ground Control Engineering, this will not be an issue at this site.

3.3 Road Reserve User Issues

From the below table, that is referenced in the Terrock ACARP report, It is considered that a peak particle velocity above PPV=90mm/s could cause people standing in the area to fall over. A PPV of 45mm/s is stated that "everyone feels movement". The effect would be less felt in motor vehicles due to the absorption offered by the suspension.

It is therefore proposed that for surface vibration expected to be above PPV=65mm/s at the road reserve, pedestrians be stopped 200m either side of the centre of the blast, along the road corridor.

Table 15 – Dowrick of Earthquake Response

PPV [mm/s]	MMI	Magnitude [M]	Human response and damage to structures and environment (Dowrick, 1996)
1.5	I	1-2	**People:** Do not feel any Earth movement
3	II	2-3	**People:** A few people might notice some movement if they are on the upper floors of tall buildings
6	III	3-4	**People:** Many people feel movement
11	IV	4	**People:** Most people feel movement **Structures:** Walls and frame of building are heard to creak
22	V	4-5	**People:** Almost everyone feels movement **Structures:** Some windows can crack.
45	VI	5-6	**People:** Everyone feels movement **Structures:** Slight damage to domestic buildings.
90	VII	6	**People:** People have difficulty standing **Structures:** In general damage is slight to moderate and well-built buildings. Damage is considerable in poorly built buildings.
180	VIII	6-7	**Structures:** Domestic buildings heavily damaged, some collapse or with partial collapse. Commercial buildings damaged in some cases. Houses not secured to foundation may move. Tall structures such as towers and chimneys might twist and fall **Environment:** Cracks appear on steep slopes and in wet ground. Small to moderate slides in roadside cuttings and unsupported excavations.
360	IX	7	**Structures:** Many residential, moderately constructed buildings destroyed. Residential and commercial buildings well-built heavily damaged, some collapse, some with flexible frames seriously damaged. Houses not secured to foundations shifted off. Some underground pipes are broken **Environment:** Cracking of the ground noticeable. Land sliding general on steep slopes. Liquefaction effects intensified and more widespread.
720	X	7-8	**Structures:** Most buildings are destroyed. Building footings are destroyed. Some bridges are destroyed **Environment:** Dams are seriously damaged. Large landslides occur.

It is also recommended that warning signs be placed approaching the site to warn motorists and pedestrians of the possibility of blast vibrations being felt while travelling that section of road.

It was advised by the mine, that the development will cause no increase in traffic to South Road.

3.4 Monitoring Of Blast Vibrations

It is recommended that a blast monitor is placed on the mine lease land directly above the proposed mine stopes, as close as possible to the road. This will give some indication of surface vibration and indicate if the proposed limit of 100mm/s is exceeded. It will also give an indication from previous blasts, when pedestrians should be stopped, as the blasts get closer to the road reserve, and when surface PPV = 65mm/s or greater.

4.0 RECOMMENDATIONS

4.1 Subsidence

The mining activity shall be further investigated, modelled and monitored by practising Geotechnical and mining engineers to limit the potential of ground subsidence in the area of the road reserve, to acceptable risk levels.

On completion of mining, the stopes shall be hydraulic filled to the crown obvert under the road reserve to the design and specification of the mining geotechnical engineer.

4.2 Blast Vibration

It is recommended a Peak Particle Vibration limit of 100mm/s is placed upon for any point in the road reserve. A suitable monitor should be placed close to the road reserve boundary to measure this. Pedestrians should be stopped when the design PPV at the road reserve surface will be greater than 65mm/s.

It would be prudent for the Mine to engage a suitably qualified engineer to assess the pre-mining condition of the road and other road reserve infrastructure. This could be done by surface inspection only. It is regarded as not necessary to do a pre-mine survey.

5.0 CONCLUSION

This report has investigated the effects of proposed mining 60 metres below the current Silver City Highway (HW22) or South road, near the Rasp Mine old entrance on the same road.

It has been found that proper mine operation will not cause any damage to the road reserve infrastructure.

Recommendations on the controls to limit any subsidence and vibration damage have been provided in this report. Further recommendations are also contained in the reports of the Drill and Blasting engineer (Prism) and mine Geotechnical engineers (Ground Control engineering) along with the risk assessment report by SP solutions.