22nd October 2014

Attn: Visko Sulicich

Chief Operating Officer

CBH Resources Limited

Broken Hill, NSW

RE: GEOTECHNICAL ASSESSMENT – ZINC LODES

Please find attached GCE's report of the geotechnical assessment for the Zinc Lodes which is located on CML7 in Broken Hill, New South Wales and is owned by CBH Resources Limited.

We trust that this report meets your requirements. Should you require further clarification, please do not hesitate to contact the undersigned.

Yours sincerely,

GROUND CONTROL ENGINEERING PTY LTD

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Principal Geotechnical Engineer

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ZINC LODES

GEOTECHNICAL ASSESSMENT

FOR

CBH RESOURCES LIMITED

Date	Version	Description	Prepared by:
October 2014	V04	G0057.AA_RE01_V04	Delia Sidea Cameron Tucker

EXECUTIVE SUMMARY

Ground Control Engineering Pty Ltd (GCE) has conducted a geotechnical assessment of the mine design and production strategy for the Zinc Lodes. The design and production strategy was provided by CBH Resources Limited (CBH).

The Zinc Lodes were previously mined by Pasminco Ltd in the adjoining mining lease (CML8) to the south of CBH's CML7 lease boundary. The Silver City highway which links South Broken Hill to the greater city of Broken Hill lies directly above the Zinc Lodes.

The zinc lodes occur within the Hores Gneiss of the Broken Hill Group rocks. The zinc lodes comprise from west to east, C, B and A Lodes and 1 Lens, which flank the 2 and 3 Lens lead lodes to the east. This assessment concerns the extraction of the B Lode.

The geotechnical assessment completed by GCE is based on core logging data from twenty two previously drilled geological exploration holes. The holes were originally drilled and logged by CBH Resources Limited (CBH) during two drilling campaigns between 2002 and 2004.

GCE completed a site visit in August 2014 to geotechnically log selected drillholes and downhole intervals from the drilling programs and select samples for intact properties rock testing. A total of 2856.2m of core was logged.

Rock Mass Conditions

According to the empirical assessment methods employed for this study, the expected rock mass conditions in the host rocks and ore are predominantly fair to good. The mine currently does not have a detailed structural model for the Zinc Lodes orebody. Identifying and characterising the macro structural environment is essential for detailed stope design during the production phase. Structural information should be collected and analysed during development mining and resource definition drilling and incorporated into the final stope designs and production sequence.

Access Development

The proposed development mining designs to extract the Zinc Lodes pose little risk to surface infrastructure. Good rock mass conditions are expected during mining. All development headings and wide span areas designed for underground infrastructure will be reinforced according to industry standards.

The assessment and management of ground conditions for the Zinc Lodes will come under the Rasp Mine Ground Control Management Plan.

Stope Stability Assessment

A stope stability assessment has been conducted using the industry accepted Modified Stability Graph method. The empirical assessment indicates that the stability of the hangingwall will control the overall stope stability. Based on mean weighted Q' values, maximum theoretical unsupported spans of 15 metres are predicted in the downhole benching stoping area.

The stability assessments are based on the information at hand. The assessments do not account for the presence of large scale faults or shears. The likelihood of encountering large scale structures (>1m width) is low given no major structures were observed in the recent geotechnical logging. However, the geological environment at Broken Hill is complex and encountering major structures during stoping should not be discounted. The effects of major structure on stoping can be mitigated during the development mining stage by conducting routine, detailed geotechnical mapping to identify structures and to characterise the geotechnical environment.

Stope Hangingwall and Crown Pillar Ground Support

Hangingwall and stope crown exposures will be cablebolted according to the dimensions of the exposure and local conditions identified during development mining. Specific ground support designs for the Zinc Lodes are attached in Appendix C.

Crown Pillar Stability Assessment

The stability of the crown pillar between the ground surface and the production stopes was assessed using the empirical method derived by Carter[1] in 1989. Numerical modelling using non-linear, 2 dimensional modelling techniques was used to investigate potential interaction between the production stopes and the ground surface.

The empirical crown pillar assessment indicates that the crown between the planned longhole stope and the ground surface should be stable. Section 9 describes additional controls planned by CBH to limit disturbance to the crown pillar and surface infrastructure.

The maximum magnitude of vertical displacement predicted by the modelling occurs as expected after full extraction of the bench stoping is complete. At full extraction, the model shows vertical displacement of 1.5mm at the hangingwall interface of the lower lift of the bench stopes. The modelling predicts no vertical displacement at the ground surface following complete extraction.

Based on the results of the model, interaction between the Zinc Lodes production areas and the ground surface is not expected provided that the parameters for mine design and scheduling are not modified during the development and production phases and that the actual ground conditions encountered are similar to predicted ground conditions.

Mining Method

Conventional, downhole benching is proposed for the steeply dipping sections of the Zinc Lodes ore body.

In order to limit the potential for surface infrastructure disturbance, CBH plan to incorporate a 60 metre crown pillar between the downhole bench stopes and the ground surface and to incorporate conservative stope design dimensions according to the spatial relationship between surface infrastructure and the production stopes;

1. Section 1 from northing 365m to northing 415m is located below surface infrastructure. Mine design in Section 1 will incorporate small, 10 metre hangingwall strike length stopes to increase hangingwall stability.
2. Section 2 from northing 415m to 455m. Mine design will incorporate 15 metre hangingwall strike length stopes as recommended by the stope stability assessment.

The mining sequence for both sections will incorporate a fill cycle where each stope is filled immediately after extraction is complete to limit the potential for hangingwall instability that may impact surface infrastructure. GCE recommend that Rasp employ a mining sequence that will limit the number of open voids in the mining block to one stope at any one time.

The flatter sections of the orebody will be mined using cut and fill methods. This method allows very good control of ground conditions by limiting the exposure of unsupported stope surfaces. Fill will be introduced immediately following the completion of each cut and fill stope section.

[1] Carter, T.J. 2000. An Update on the Scaled Span Concept for Dimensioning Surface Crown Pillars for New and Abandoned Mine Workings. Proc. 4th North American Rock Mechanics Conf., Seattle, pp. 465-472

Geotechnical Risks

Key geotechnical risks that have been identified include the following:

- Potential for the differential settlement of subsurface materials initiated by stope overbreak may result in damage to surface infrastructure. Stringent design and mining controls are required to minimise the possibility of stope overbreak.
- No structural model for the Zinc Lodes exists at this stage. This information will be critical for calculating final stable spans for stoping and for assessing the risk of stope failure that may impact surface infrastructure.;
- Structurally controlled failures from hangingwall and crown resulting in smaller stope spans than predicted by the empirical stability analysis;
- Sterilisation of ore through stope failure. Hangingwall or crown failures have the potential to sterilise ore in the vicinity of the failure. Ongoing collection and review of geological and geotechnical conditions and stope performance data is recommended;
- Failure of pillars due to presence of unfavourable defects in the pillar;
- Variability in geotechnical parameters used in the stope and crown pillar stability analyses. There are inherent risks in extrapolating drillhole point data to generalised rock mass conditions across domains. Whilst the host rock mass and the mineralised lenses could be described as close to homogeneous, there are localised variations in rock mass conditions. Assumptions are also made with regards to the presence of the critical defect set within the rock masses forming the stope walls.

Recommended future geotechnical work

The following further geotechnical work is recommended:

- Collection and interpretation of structural defect data and geotechnical data is necessary as mining progresses in the zinc lodes. This will allow validation of design parameters and timely input to the mine design process;
- Develop a comprehensive program to monitor stope stability and potential surface subsidence. The program should be implemented both before and during the extraction of the Zinc Lodes;
- Increase the size and quality of the geotechnical database for the Zinc Lodes by collecting geotechnical information from future resource drilling programs;
- The development of a ground control management plan (GCMP) is recommended for the Zinc Lodes orebody.

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1 INTRODUCTION

This report presents the results of a geotechnical assessment of the zinc lodes undertaken for CBH Resources Limited (CBH). This assessment focuses on the orebody defined as the B Lode within the Zinc Lodes.

1.1 Scope of work

The scope of work is outlined below:

- Geotechnical data collection and validation of exploration core from 2002 -2004 program;
- Geotechnical characterisation including data processing and rock mass characterisation, geotechnical domaining and classification of rock mass description by domain;
- Assessment of expected rockmass conditions, geotechnical properties and design parameters for each geotechnical domain. This incorporates discontinuity data and intact rock properties. The impact of major structure and zones of weakness on development and stoping will be assessed;
- Assessment of key geotechnical risks for the B Lode;
- Assessment of stable stope spans using empirical design methods for all stope walls (hanging wall, footwall, crown and end walls);
- Stability assessment of the crown pillar between the B Lode bench stopes and the ground surface using empirical and numerical modelling methods;
- Recommendations for stope sequencing based on the expected ground conditions and the selected mining method;
- Reporting of findings and recommendations.

2 AVAILABLE DATA

2.1 Data Supplied to GCE

Key reports and data available to GCE for this study included:

- CBH Resources Limited (2002) Zinc Lodes CML7 – Broken Hill, NSW, Report on Drilling Programme November 2002, P. A. Blampain, September 2003;
- CBH Resources Limited (2004) Zinc Lodes CML7 – Broken Hill, NSW, Report on Drilling Programme November 2003 – February 2004, Document 1 of 5, P. A. Blampain, March 2004;
- CBH Resources Limited (2004) Zinc Lodes CML7 – Broken Hill, NSW, Report on Drilling Programme November 2003 – February 2004, Document 2 &5 of 5, P. A. Blampain, March 2004;
- Electronic files of ore lodes, proposed development and preliminary mine design by CBH.

3 SITE VISIT – DATA COLLECTION

A site visit was conducted from 25th to 31st August 2014 by a GCE geotechnical engineer to log selected intervals from the drillholes from the 2002 - 2004 exploration programme.

The following work was undertaken:

- Geotechnical core logging of selected intervals from 22 drillholes totalling 2856.2m of core;
- Selection of samples for intact rock properties testing;

4 DATA ANALYSIS

4.1 Data compilation and processing

The preliminary mining plan involves downhole bench stoping of the steeper part of the B lode and cut and lifts of the flat dipping section of the lode. The geotechnical data was assembled into geotechnical domains based on its proximity to the two main proposed mining methods. The following geotechnical domains were assigned to the data:

Bench stope area

- HW_LH (ground between 0 and 10m from hangingwall of B Lode)
- ORE_LH (B Lode)
- FW_LH (ground between 0 and 10m from footwall of B Lode)

Cut and Fill stopes area

- HW_LF (ground between 0 and 10m from hangingwall of B Lode)
- ORE_LF (B Lode)
- FW_LF (ground between 0 and 10m from footwall of B Lode)

Data intersecting planned development was collated in a separate domain (DEV). Remaining data that did not directly influence the mining areas was grouped in a domain named HOST.

The following process was undertaken by GCE to calculate Q values for the geotechnical domains:

- The geological model and drillhole traces were used to identify the downhole depth intercepts for hangingwall, ore and footwall contacts and planned decline/access infrastructure contacts;
- Valid structural defect orientations were processed to obtain the number and orientation of main defect sets in the database;
- Q and Q' values were calculated for each of the intervals logged in the individual drillholes. The data from all the drillholes was compiled and imported into Surpac to allow the geotechnical domaining of the data;
- The resulting Q values for each domain were compiled and statistics for length weighted Q means and quartiles were calculated as inputs to the empirical Matthews stope stability analysis.

Table 1 presents the list of drillholes logged and downhole intervals.

Table 1 List of drillholes used in geotechnical analysis

Hole ID	Geotechnical Log		Total metres logged
	From (m)	To (m)	
ZLDD5001	29.8	170.6	140.8
ZLDD5002A	26.8	167.3	140.5
ZLDD5003	11.5	135.2	111.3
ZLDD5004	26.0	130.0	101.9
ZLDD5005	20.1	131.3	111.2
ZLDD5006	18.0	138.3	120.3
ZLDD5009	4.2	159.1	154.9

Hole ID	Geotechnical Log		Total metres logged
	From (m)	To (m)	
ZLDD5010	2.9	135.2	132.3
ZLDD5013	57.7	131.1	71.0
ZLDD5017	2.6	130.4	127.8
ZLDD5020	3.4	158.3	154.9
ZLDD5022	2.7	130.3	96.6
ZLDD5024	3.1	150.1	147.0
ZLDD5026	3.0	159.5	156.5
ZLDD5027	3.4	150.2	146.8
ZLDD5029	0.0	122.1	91.9
ZLDD5030	2.5	111.1	108.6
ZLDD5032	3.4	148.8	145.4
ZLDD5033	2.7	149.9	147.2
ZLDD5034	4	139.7	123.6
ZLDD5036	4.2	129.6	125.4
ZLDD5038	36.2	236.5	200.3
			2856.2

5 GEOLOGICAL SETTING

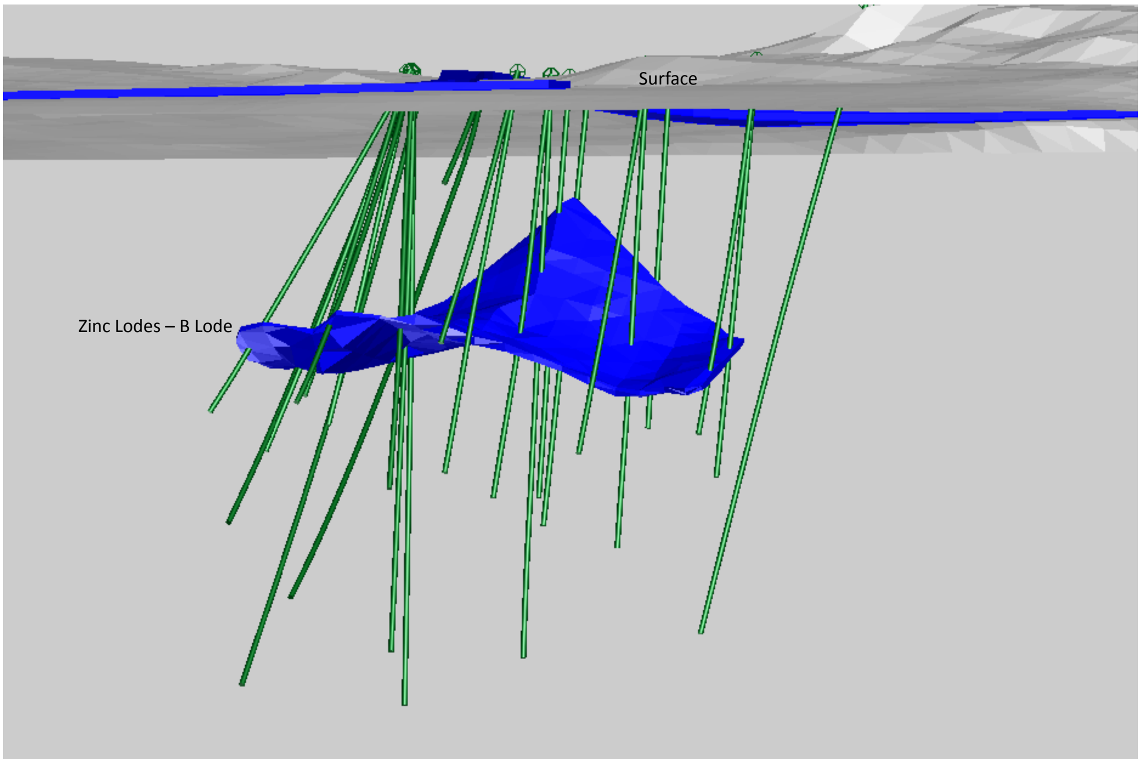
5.1 Geology

The geological summary below is from the 2002 CBH[2] drilling report.

The zinc lodes are known to have been mined by Pasminco Ltd in the adjoining mining lease (CML8) to the south of CBH's CML7 lease boundary. The zinc lodes occur within the Hores Gneiss of the Broken Hill Group rocks. The zinc lodes comprise from west to east, C, B and A Lodes and 1 Lens, which flank the 2 and 3 Lens lead lodes to the east. This assessment concerns the extraction of the B Lode. Figure 1 shows the location of the Zinc Lodes (B Lode) and the diamond drill holes utilised for data collection.

[2] CBH Resources Limited (2002) Zinc Lodes CML7 – Broken Hill, NSW, Report on Drilling Programme November 2002, P. A. Blampain, September 2003

Figure 1 Zinc Lode (B Lode) and diamond drill holes



The principal rock unit on the CML7 that hosts mineralisation is unit 4.7 (Hores Gneiss) of the mine sequence stratigraphy. The unit has been described as a mainly garnet bearing quartzo-feldspathic gneiss. Locally the unit includes medium to fine grained Potosi Gneiss. The rocks comprise politic and psammitic metasediments with persistent quartz-gahnite, garnet-quartz and quartz-garnet (lode) rocks. Individually, the zinc lodes typically comprise one of these lode assemblages with variable sulphides and gangue mineralogy.

5.2 Major Structure

CBH does not have a structural model of the zinc lodes area. Broken zones, faults and shears have been intersected and geotechnically logged from the exploration drillholes, an example of which is presented in Figure 2.

Figure 2 ZLD5013 Broken/faulted zone from 170.8 to 174.5m

A detailed structural interpretation of the faults and shear zones recorded from the geotechnical logging was not undertaken as the required orientation data for the drillcore was not available. The width and physical characteristics of the shear and fault zones were collected during the logging program. Twenty five fault and shear zones ranging from 1 to 8.5 metres in width were recorded in the logging.

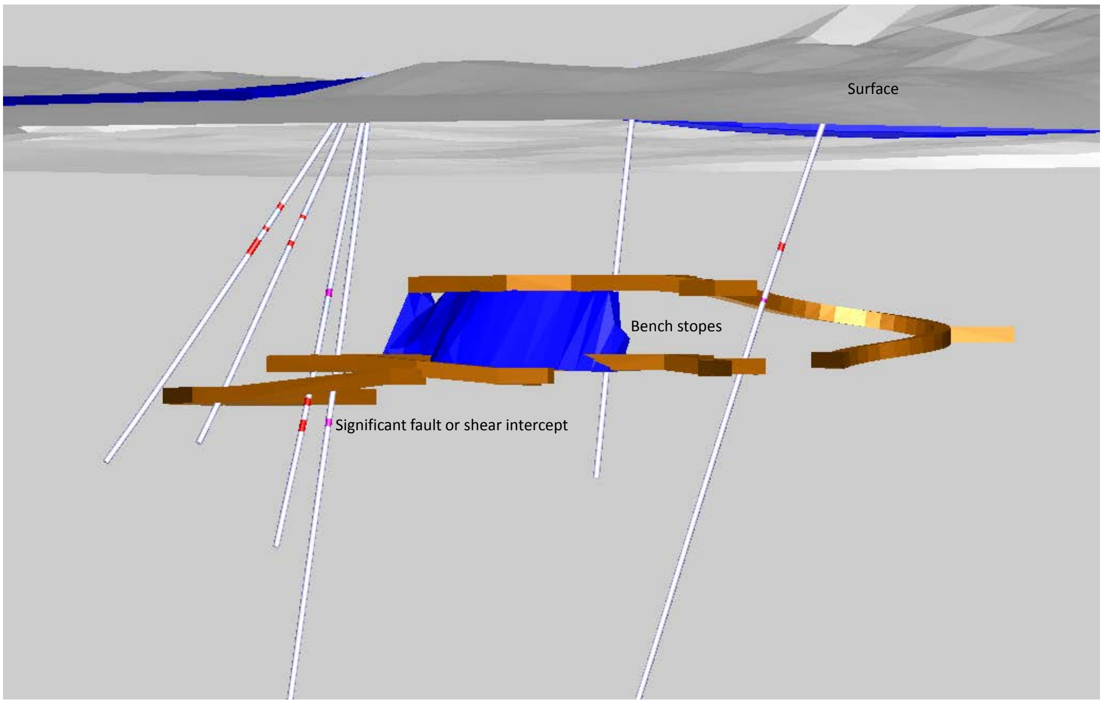
Of the 25 shear zones recorded, 8 shear or fault zones were considered to be geotechnically significant (Table 2).

Table 2 Significant shear zones

Hole id	Depth from (m)	Depth to (m)	Downhole width (m)	Rock Type	Weathering	Strength	RQD	Infill Thickness (mm)	Estimate UCS (Mpa)
ZLDD5005	62	67.7	5.7	PS-SHZ	SW	R3	88	40	25
ZLDD5006	52.3	53.4	1.1	BREC-SHZ	MW	R3	27	30	25
ZLDD5010	77.1	79.8	2.7	PM-SHZ	MW	R3	48	40	25
ZLDD5010	117.2	119.8	2.6	S-SHZ	MW	R3	48	30	25
ZLDD5010	125.2	129.3	4.1	PM-SHZ	MW	R3	24	6	25
ZLDD5013	114.1	116.7	2.6	PE-FLZ	SW	R3	35	100	25
ZLDD5036	73.9	77.5	3.6	LUQ-FLZ	MW	R3	89	10	25
ZLDD5038	100.3	101.5	1.2	RPE-FLZ	SW	R3	17	40	25

Figure 3 shows the location of the significant shear zones recorded during the logging program.

Figure 3 Significant fault or shear intercepts identified during geotechnical logging



The significant shear zones identified from the geotechnical core logging are not located in the hangingwall or crown of the downhole bench stopes and are not expected to have an impact on the stability of the stopes or development access drives. However, the distribution of the available geotechnical data throughout the zinc lode orebody is insufficient to discount the potential risk that development or stoping could intersect structures with sufficient continuity to influence the stope stability during production.

6 GEOTECHNICAL CONDITIONS

6.1 Geotechnical Domains

There is little geotechnical differentiation between the host rocks and mineralised areas. Geotechnical domains were assigned as detailed in Section 4.1.

6.2 Intact Rock Properties

Uniaxial Compressive Strength (UCS) testing, elastic properties and triaxial tests were conducted on samples selected from the exploration drill core.

A summary of the results are presented in Tables 3 and 4 with the full laboratory results in Appendix A.

The valid UCS tests indicate that the samples are generally within the strong category (R4) which correlates to the field assessments undertaken during the logging process.

Table 3 Zinc lodes intact rock properties results test results

Lab Sample No	Borehole ID	Depth (m)		Lithology	UCS (MPa)	Wet density (t/m³)	Young's Modulus (GPa)	Poisson Ratio	Mode of Failure Recorded	Comments	Valid
		From	To								
14090346	ZLDD5002A	71.90	72.10	Pe	17.8	2.78	n/a	n/a	Shear	Appears to have failed on existing plane	no
14090348	ZLDD5036	91.20	91.40	S	60.8	2.98	n/a	n/a	Conical	In intact rock	yes
14090349	ZLDD5017	86.90	87.15	LuQ	103	2.92	57.4	0.03	Shear	Partially in intact rock and on 30deg to core axis defect	yes
14090350	ZLDD5034	14.00	14.30	Pe	16	2.64	3.98	0.094	Shear	On defect at 45 deg to core axis	no
14090351	ZLDD5034	29.30	29.60	GPm	98	2.95	n/a	n/a	Conical	In intact rock	yes
14090352	ZLDD5032	83.70	84.00	Gpe	83.1	3.22	n/a	n/a	Conical	In intact rock	yes
14090353	ZLDD5009	30.80	31.00	GPs	34.1	2.96	n/a	n/a	Shear	On foliation	no
14090355	ZLDD5029	58.50	58.65	LuQ	35.2	3.33	n/a	n/a	Shear	On defect at 45 deg to core axis	no
14090356	ZLDD5001	33.20	33.40	Pe	18.2	2.71	10.7	0.081	Shear	On pre-existing fabric	no
14090357	ZLDD5001	70.4	70.6	Gpe	59.4	3.01	53.1	0.007	Shear	On defect at 30 deg to core axis	no
14090358	ZLDD5006	90.3	90.5	Peg	88.4	2.68	n/a	n/a	Shear	Appears to be intact failure	yes
14090359	ZLDD5003	62	62.2	Pm	95.7	3.1	n/a	n/a	Conical	In intact rock	yes

Table 4 Zinc lodes triaxial test results

Lab Sample No	Borehole ID	Depth (m)		Lithology	Estimated Peak Envelope		Estimated Residual envelope	
		From	To		Friction Angle	Cohesion (MPa)	Friction Angle	Cohesion (MPa)
14090347	ZLDD5036	23.75	26	Gpe	48.3	10.47	13.3	9.19
14090354	ZLDD5022	62.9	63.15	Gpe	53.8	14.59	48.2	2.22
14090360	ZLDD5004	95.4	95.6	S	38.7	27.87	n/a	n/a

6.3 In situ Stress

In situ stress measurements have not been conducted for the Zinc Lodes. The following assumptions for calculating the maximum principal stress (σ_1) was assumed to be a multiple of the overburden pressure, which was calculated using the formula:

$$\sigma 1 = 1.5(\rho\ g\ h)$$

$\rho = 2.94\ t/m^3$ (average wet density from laboratory testing)

$g = 9.81\ m/s^2$

h = depth below surface

As shown above, an approximation of the maximum principal stress (σ_1) was obtained by multiplying the vertical stress by a factor of 1.5, which is has been used in previous studies for the Western Mineralisation area. The estimated σ_1 at the base of the bench stoping area is approximated at 3.9 MPa.

Mining of the nearby Western Mineralisation at the Rasp underground mine has reached depths of over 500 metres with extensive, large scale stoping activities completed without adverse consequences with respect to mining induced stress.

6.4 Rock Defect Analysis

CBH provided oriented structural data from three drillholes which was analysed to identify the orientation of the major defect trends using DIPS. Figure 4 shows a stereonet of the data set, and shows the major defect set orientations identified. This data could not be validated by GCE, it is recommended that representative data surrounding the ore zone is collected from underground mapping.

Figure 4 Zinc Lodes defect analysis all data -

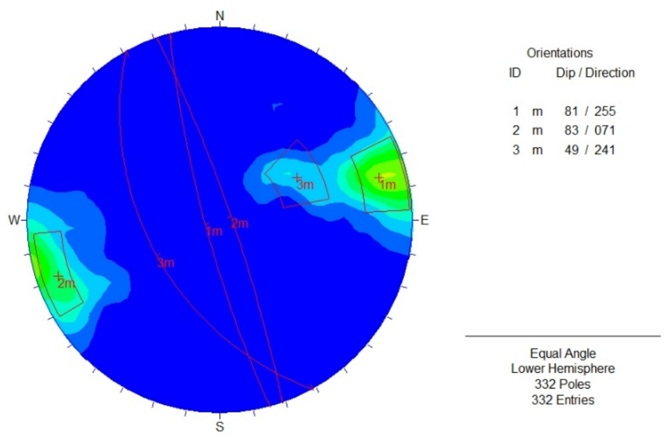


Table 5 presents a summary of the major defect sets identified in the structural assessment.

Table 5 Summary of major defect sets

Defect Set	Dip (deg)	Dip Direction (deg)	Comments
1	81	255	Steeply dipping set, dipping to the south west
2	83	071	Steeply dipping set, dipping to the east (parallel to steeper sections of B lode)

Defect Set	Dip (deg)	Dip Direction (deg)	Comments
3	49	241	Minor set, moderately dipping, to the south west

The core logging identified that the rock mass generally contains three joint sets, with approximately 50% of the intervals logged assessed to have three joint sets.

6.5 Rock Mass Quality (Q values)

Rock mass classification used the Tunnelling Quality Index (Q)[3]. The numerical value of the index Q varies on a logarithmic scale from 0.001 to 1000 and is defined as:

$$Q = \frac{RQD}{Jn} * \frac{Jr}{Ja} * \frac{Jw}{SRF}$$

Where:

RQD = Rock Quality Designation index (defined by Deere et al, 1967). RQD is defined as the percentage of intact core pieces longer than 100 mm in the total length of core. RQD is a directionally dependent parameter and its value might change significantly, depending on the borehole orientation.

Jn = Joint set number. This refers to the number of joint sets identified in the section of core logged. The RQD/Jn parameter is an approximate representation of the block or particle size in the rock mass and logged values varied from 2 (one joint set) to 20 (crushed rock, earthlike). The majority of the data has a Jn of 4 (two joint sets) to Jn of 9 (three joint sets).

Ja = Joint alteration number. This refers to the type and thickness of infill in the joint which affects its frictional characteristics. A high value of Ja denotes lower frictional strength of the joint. Ja values ranged from 0.75 (tightly healed, hard filling) to 16 (Thick gouge, low friction or swelling clay >5mm thick). Clay infill has been logged in approximately 40% of the downhole intervals.

Jr =Joint roughness number. This refers to the surface roughness of the joint. It is made up of two components, namely planarity of the surface and its roughness. The higher the Jr value, the higher the expected peak strength of the joint. The majority of defect surfaces were found to be rough, and undulating. (Jr value of 3).

Jw = Joint water reduction. Jw is a measure of water pressure, which has an adverse effect on the shear strength of joints by reducing the normal effective stress. Water can also cause softening or wash clay infill from joints. Dry excavation or minor inflow (<5 l/m, Jw=1) has been assumed in the analysis.

SRF = Stress Reduction Factor. SRF is a measure of three parameters; loosening load in an excavation through shear zones and clay bearing rock, rock stress in competent rock and squeezing loads in plastic incompetent rock. The Jw/SRF quotient indicates the conditions of active stress around an excavation. The proposed development is relatively shallow at less than 100m below surface and results from intact rock testing indicate strong rocks. The SRF values relevant to weakness zones intersecting the excavation have been used. The SRF value range from a value of 1 to 2.5.

The Q parameters were used to calculate a Q value within each interval logged. The values were weighted by the length of the interval and 1st quartile and weighted means computed. The findings from the rock mass classification are presented in Table 6.

[3] Barton, N, Lien, R and Lunde, J, 1974 Analysis of rock mass quality and support practice in tunnelling and guide for estimation support requirements. NGI Internal Rept No 54206.

Table 6 Summary Q values for B lode geotechnical domains

Geotechnical Domain	Total length assessed (m)	1st Quartile Q Value	Weighted Mean Q Value	Q value range	Expected Q class
HW_LH	76.4	3.7	9.8	1-46.9	Poor to fair
ORE_LH	23.7	3.6	39.8	1.9-150.0	Good
FW_LH	37.9	1.9	26.0	1.9-195.0	Good
HW_LF	47.9	10.0	18.4	1.4-75.0	Good
ORE_LF	29.5	10.5	46.1	4.7-194.0	Good
FW_LF	34.7	10.1	19.0	3.5-19.0	Good
DEV	86.5	2.0	11.9	0.2-93.0	Good
HOST	2531.0	3.1	18.9	0.06-200.0	Good

Ground conditions for development and stoping are expected to be fair to good with localised intersections of poor zones.

7 MINING DEVELOPMENT AND MINING METHOD

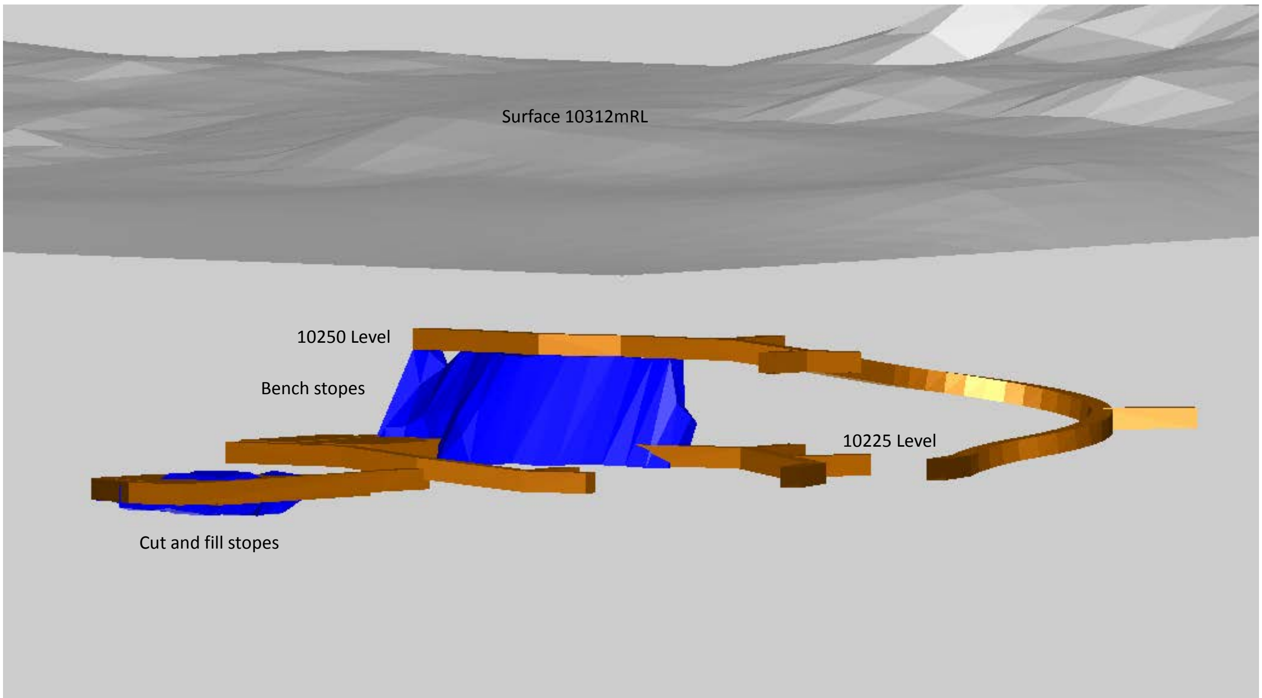
Conventional, downhole benching is proposed for the steeply dipping sections of the Zinc Lodes ore body.

The mining sequence will incorporate a fill cycle where each stope is filled immediately after extraction is complete to limit potential hangingwall instability. GCE recommend that Rasp employ a mining sequence that will limit the number of open voids in the mining block to one stope at any one time.

The flatter sections of the orebody will be mined using cut and fill methods. This method allows very good control of ground conditions by limiting the exposure of unsupported stope surfaces. Fill will be introduced immediately following the completion of each cut and fill stope section.

The preliminary mine design is illustrated in Figure 5

Figure 5 Proposed mining development for the zinc lodes, looking west


Surface 10312mRL
10250 Level
Bench stopes
10225 Level
Cut and fill stopes

8 GEOTECHNICAL ASSESSMENT

8.1 Stope Stability Assessment

Stope stability assessment has been conducted using the Modified Stability Graph method suggested by Potvin (1988) and detailed in Hutchinson and Diederichs (1996)[4]. The method involves the determination of the Modified Stability Number N' which is compared to a database of stope stability performance to derive a Hydraulic Radius (HR). HR is defined as the area of a stope surface divided by the perimeter of the face.

N' is based on Q' values (after Barton et al, 1974) and is defined as:

$$N' = Q' \times A \times B \times C$$

Where:

$$Q' = \frac{RQD}{Jn} \times \frac{Jr}{Ja}$$

Factor A = ratio of maximum induced compressive stress to Uniaxial Compressive Strength (UCS). A mean UCS value of 88 MPa has been used in the analysis based on the valid UCS results presented in Table 2. The maximum induced stress was estimated using an assumed stress: depth relationship.

Factor B = is a measure of the relative orientation of dominant jointing with respect to the excavation surface. The joints most critical to hangingwall and footwall stability are parallel to sub parallel to the stoping surface (defect set 1, 83°/071°). For crown stability, moderately to flat dipping joints are unfavourable for stability (defect set 3, 49°/241°).

Factor C = is a measure of the influence of gravity on the stability of the face being considered.

Figure 6 presents the historical database of unsupported open stopes used to assess resultant N' value and is used to derive the stable unsupported Hydraulic Radius (HR) for the zinc lodes.

[4] Hutchinson, J D and Diederichs, M S. 1996. Cablebolting in Underground Mines, BiTech Publishers Ltd, British Colombia, Canada

Figure 6 Modified Stability Graph Method chart showing database of unsupported open stopes (Hutchinson and Diederichs (1996)

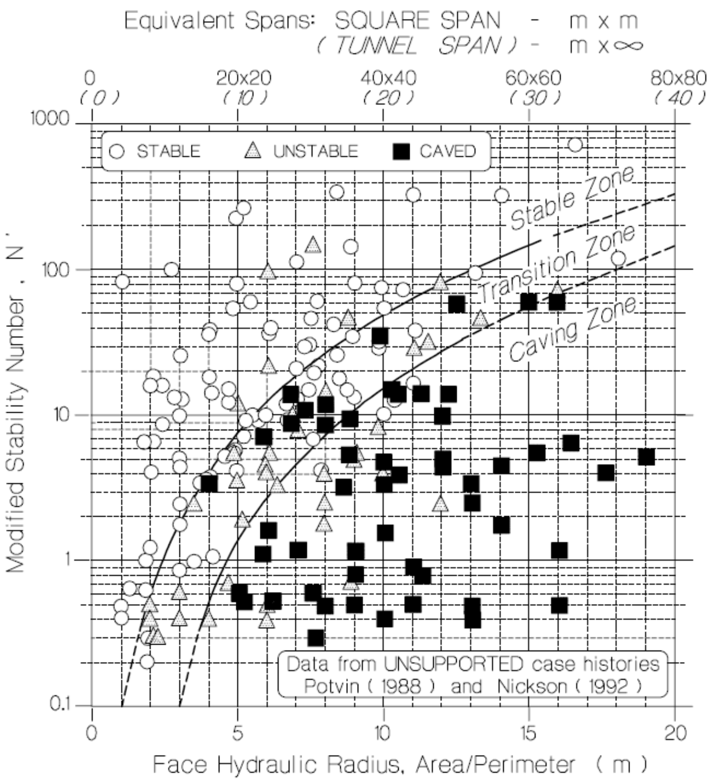


Table 7 presents the maximum unsupported strike spans for 20m level intervals for weighted mean rock mass conditions for the hangingwall and footwall. Due to the very narrow nature of the mineralised zone, the stope crowns and end walls are not considered critical to the overall spans. The hangingwall is considered the most critical and limiting surface for stope stability. The main influence on hangingwall stability is the adverse influence of defects oriented sub parallel to the hangingwall surface.

Table 7 Unsupported stope stability results for HW and FW, weighted mean rock mass conditions

Stope Wall	Depth	Modified Stability Numbers					Hydraulic radius	Wall dimension
	RL(m)	Q'	A	B	C	N'	Unsupported stable zone	Max strike span (m)
HW	10239	9.8	1.0	0.4	2.7	10.0	5.0	15.5
FW	10239	26.0	1.0	0.2	5.0	26.0	7.5	>40

The analysis indicates that unsupported hangingwall spans are predicted to be stable at 15m. The analysis was conducted on the assumption the hangingwall cable bolt support installed in the top and bottom ore drives. The empirical database indicates that with the addition of mid-span cable support in the hangingwall, the maximum span can be increased to a maximum strike span of 34m. Further evaluation of ground conditions from development mining is required to evaluate the efficiency of cable bolts to increase the span.

The critical stability factor in the cut and fill stopes is the crown stability. Using weighted mean Q' values, the calculated stable HR=9.8m. This indicates that the planned 20m high spans should be stable.

8.1.1 Draw-Point Support

The requirements for enhanced draw point support will require an assessment of local ground conditions. The presence of major structure that may require localised cable bolt support.

8.2 Crown Pillar Stability Assessment

8.2.1 Empirical Stability Assessment

The stability of the crown pillar between the ground surface and the production stopes was assessed using the empirical method derived by Carter[5] in 1989. The 'scaled span' database includes over 300 case studies.

A crown pillar should remain stable over the life of the mine. A crown pillar has two main functions, it should protect surface land users (infrastructure) and it should protect the mine from inflows of water, soil and rock.

Studies by Carter and others have demonstrated that crown stability is depended primarily on the crown geometry. The *Scaled Crown Span* as formulated by Carter is as follows:

$$C_s = S\left\{\frac{\gamma}{t(1+S_R)(1-0.4cos\theta)}\right\}^{0.5}$$

Where: S=crown pillar span (m)

γ=specific weight of the rock mass (kN/m^3)

S_R= span ratio = S/L (crown pillar span/crown pillar strike length)

θ=dip of the orebody or foliation (degrees)

The analysis of the case studies allowed the comparison of failed versus stable cases which resulted in the development of the "Critical Span S_c" limit line shown in Figure 8. The limit line defines the widest stable scaled span value for unsupported ground with relation to Q:

$$S_c = 3.3 \times Q^{0.43} \times sinh^{0.0016}(Q)$$

Where: S_c=Critical Span (m)

Q=NGI-Q value

The Scaled Span method is applied by comparing the scaled crown pillar span (C_s) to the critical span value for the controlling rock mass. When the scaled crown pillar span is less than the critical span, the crown pillar would be considered stable.

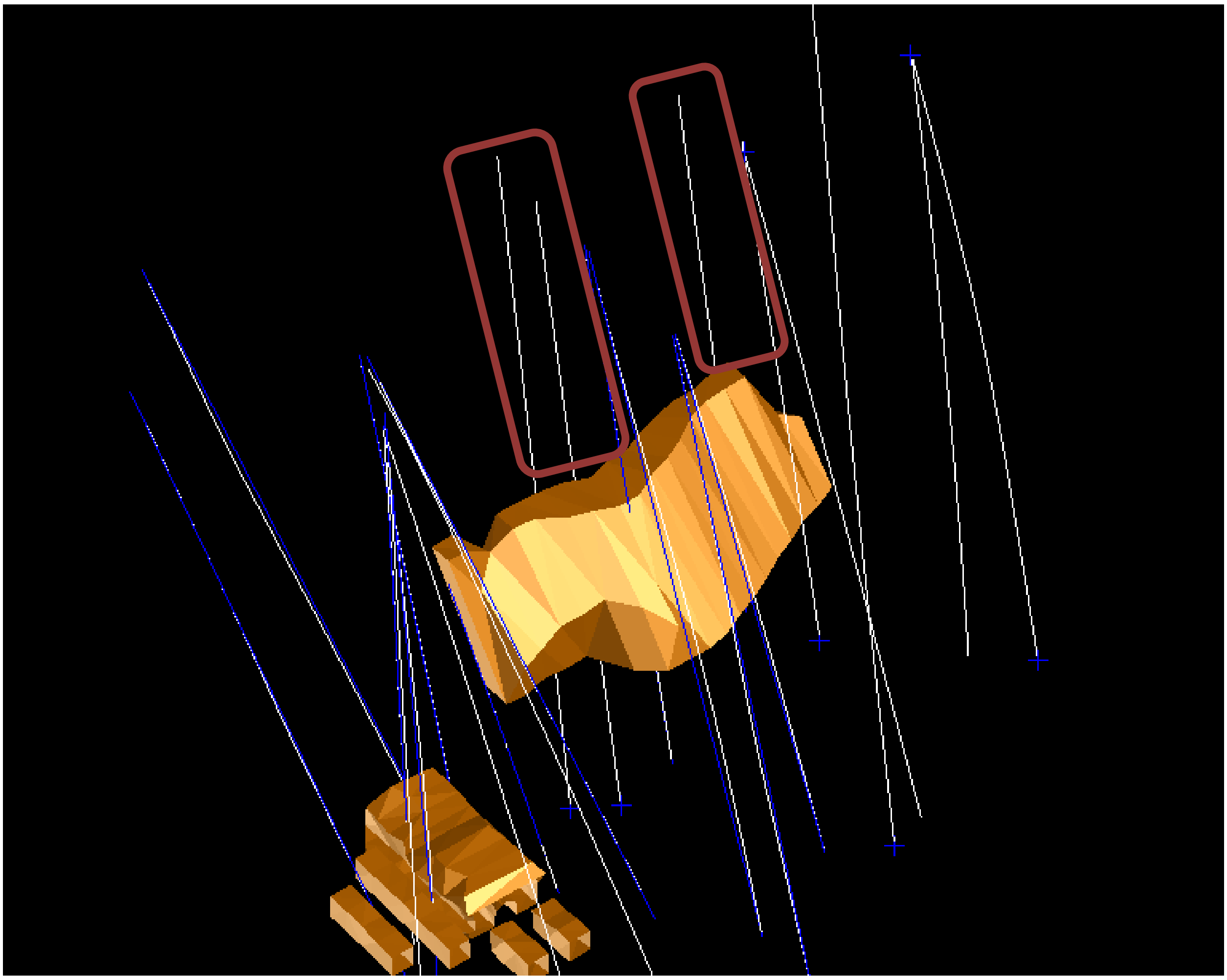
To obtain the most representative rock mass data for the Zinc Lodes crown pillar assessment, Q values were selected from the upper 60m of drillholes intersecting the crown pillar. Figure 7 shows the location of the drillholes used in the analysis. A total of 358.1m of core was used.

The resulting 1st quartile Q value and weighted mean of the above data set are 3.8 and 21.8 respectively. The empirical crown pillar assessment presents the results of the assessment within this range of Q values. The spatial distribution of poorer ground conditions is an important consideration in the potential stability of the crown pillar. Significant structures are not anticipated within the crown area (Section 5.2). Zones assessed as poor (Q value ≤4) were intersected in 125.2m of the dataset.

---

[5] Carter, T.J. 2000. An Update on the Scaled Span Concept for Dimensioning Surface Crown Pillars for New and Abandoned Mine Workings. Proc. 4th North American Rock Mechanics Conf., Seattle, pp. 465-472

Figure 7 Location of drillholes used for crown stability assessment



The parameters used to calculate the Scaled Crown Span for the Zinc Lodes crown are:

S=10 m

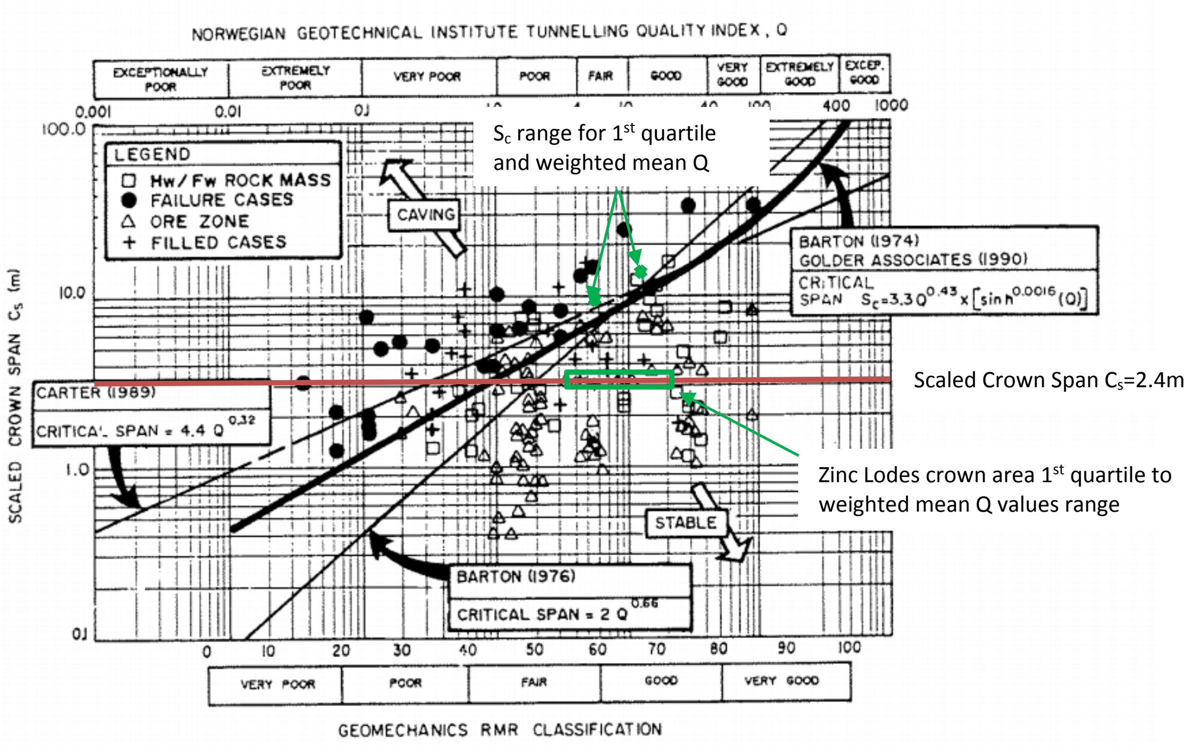
L=75m (conservative assumption made that entire span is open)

γ=2.94(kN/m^3)

θ=48 degrees

The resulting Scaled Crown Span (C_s=2.4m) and the range in ground quality that could be expected within the crown pillar are presented in Figure 8. The calculated Critical Span (S_c) for the Q-values ranges from 5.9m to 12.8m.

Figure 8 Zinc Lodes Crown Pillar Scaled Span plotted on the summary of crown-pillar case records (Carter, 2000)



The empirical crown pillar assessment indicates that the crown between the planned longhole stope and the ground surface will remain stable during extraction. Section 9 describes additional controls planned by CBH to limit disturbance to the crown pillar and surface infrastructure.

8.2.2 Numerical Stability Assessment

The stability of the crown pillar between the ground surface and the Zinc Lodes bench stoping area was undertaken utilising numerical modelling techniques. A simple, 2 dimensional, non-linear numerical model of the Zinc Lodes mining geometry was created using the Rocscience program, Phase2.

The purpose of the numerical modelling assessment was to gain an overall appreciation of the potential interaction between the Zinc Lodes mining operation and surface infrastructure. The main area of interest is the potential for vertical displacement or settlement within the crown pillar following stope extraction.

Limitations of the model

Numerical models are limited by the information available to construct the model. The model constructed to investigate potential interaction between the Zinc Lodes bench stoping area and the ground surface incorporates the following assumptions;

- An absence of significant geotechnical structure linking the stoping area to the rock mass.
- The rock mass is homogenous between the stoping area and the surface.

Constitutive model

The model assumed a homogenous rock mass with strength properties derived from the recent testing program undertaken using rock samples taken from the previous Zinc Lodes resource drilling program. Backfill was not introduced into the model following stope for simplicity and the strength properties of backfill are insufficient to prevent displacement in the stope walls following extraction. The function of backfill is to provide passive support, preventing hangingwall failure which may lead to large scale stope overbreak.

A Mohr Coulomb failure criterion was adopted for the model with the following parameters

Elastic Properties

Young's Modulus	30000 MPa
Poisson's Ratio	0.2

Strength Parameters

Tensile strength	5 MPa
Friction angle (peak)	45 degrees
Friction angle (residual)	25 degrees
Cohesion (peak)	10.5 MPa
Cohesion (residual)	1 MPa

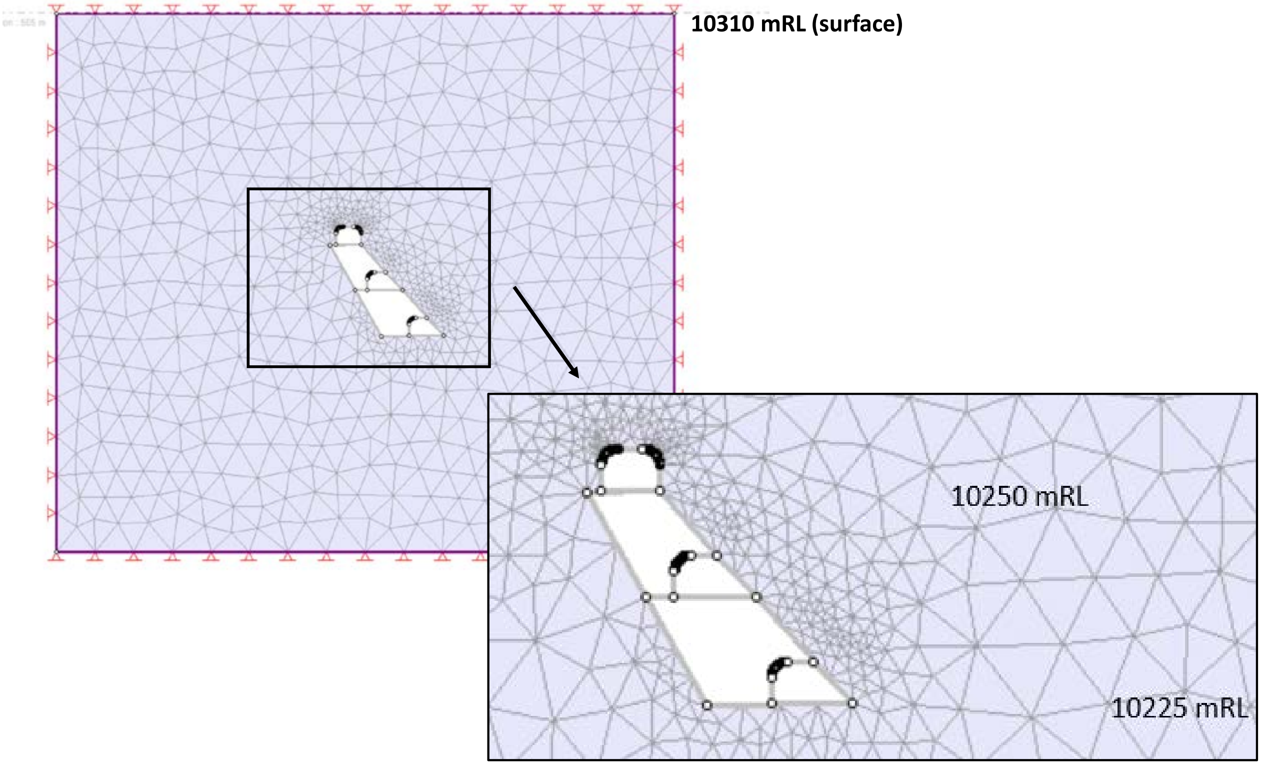
Loading Conditions

Loading conditions assigned to the model were the same as those assigned to the empirical stope stability assessment in Section 6.3.

Model Geometry

The mining geometry sequence is represented in the numerical model as shown in Figure 9.

Figure 9 Model geometry



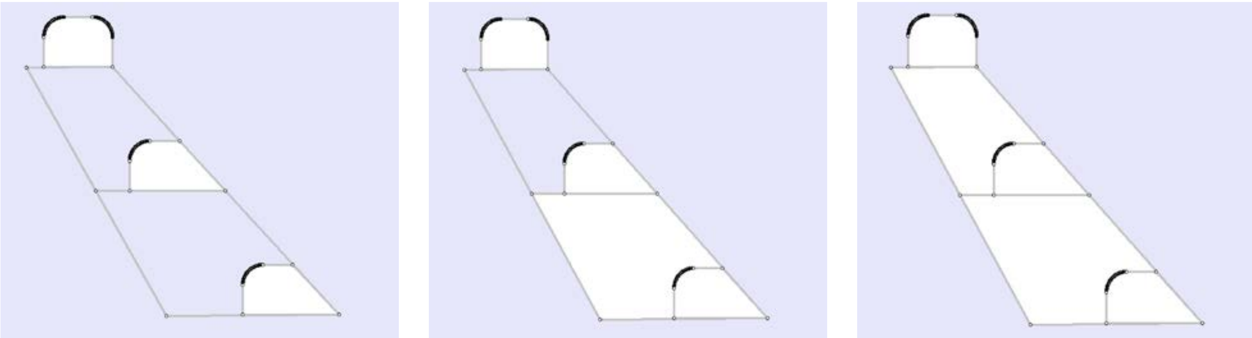
Mining Sequence

The sequence consists of the following steps;

1. Excavate development drives
2. Excavate lower stoping panel
3. Excavate upper stoping panel.

The mining sequence is shown in Figure 10.

Figure 10 Model sequence



Model step 1
Development mining completed

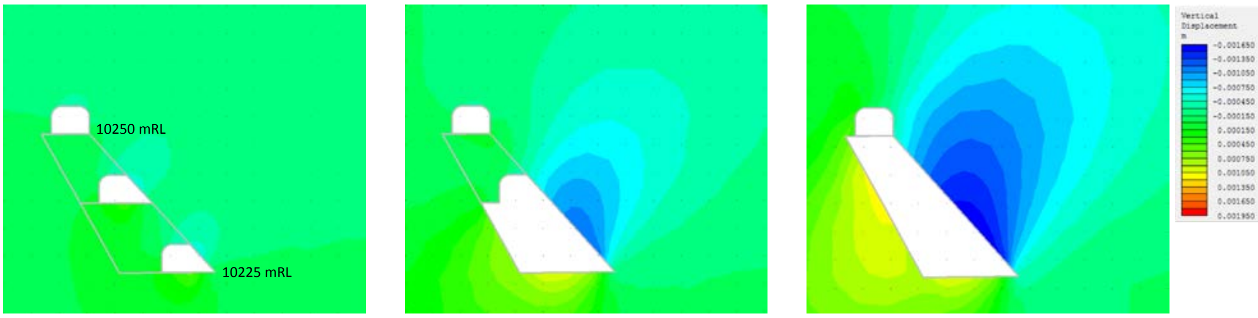
Model step 2
Lower bench stopes extracted

Model step 3
Extraction complete

Model Results

The results of the numerical modelling assessment for the 3 mining steps are shown in Figure 11. The contours represent the magnitude of vertical displacement predicted by the model. Figure 11 does not show the stoping area in relation to the surface which is shown in Figure 12

Figure 11 Numerical model results – Vertical displacement (m)

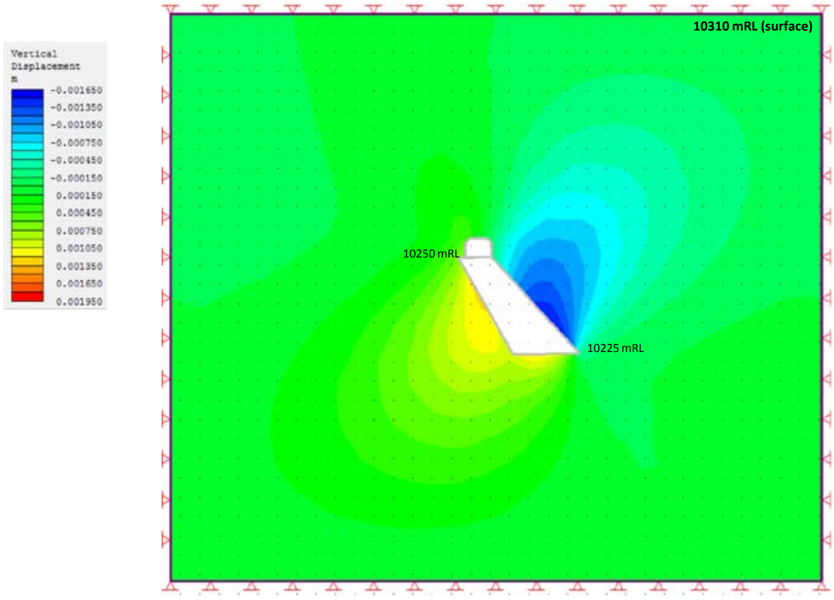


Model step 1
Development mining completed

Model step 2
Lower bench stopes extracted

Model step 3
Extraction complete

Figure 12 Numerical model results – Vertical displacement (m), complete model geometry – complete extraction.



The maximum magnitude of vertical displacement predicted by the model occurs as expected after extraction is complete, where the model shows vertical displacement of 1.5mm at the hangingwall interface of the lower lift of the bench stopes. The modelling predicts no vertical displacement at the ground surface following complete extraction.

Based on the results of the model, interaction between the Zinc Lodes production areas and the surface is not expected. GCE recommend that monitoring instruments are installed in the 10250 level in the crown pillar and on the 10225 level in the hangingwall prior to the commencement of extraction of the lower lift bench stopes. Monitoring data will be required to confirm the understanding of the rockmass response to mining. Changes in the behaviour of the rockmass can be assessed allowing design engineers to adjust mining dimensions and mining schedules if required.

9 SURFACE INFRASTRUCTURE

A section of the Zinc Lodes orebody lies directly under the Silver City Highway. The mining method proposed for the orebody incorporates a 60 metre crown pillar between the production stopes and the ground surface.

A geotechnical risk to the Zinc Lodes extraction is uncontrolled stope wall failure which may propagate towards surface infrastructure. In most cases, stope failures which may be significant with respect to mine production, do not impact nearby infrastructure. The progression of stope failures is accelerated by the stope surface intersecting weak ground or a major geological structure, or the mining of unsupported spans greater in extent than can be naturally supported by the rockmass. This is particularly the case with hangingwall surfaces with a dip angle of less than 60 degrees.

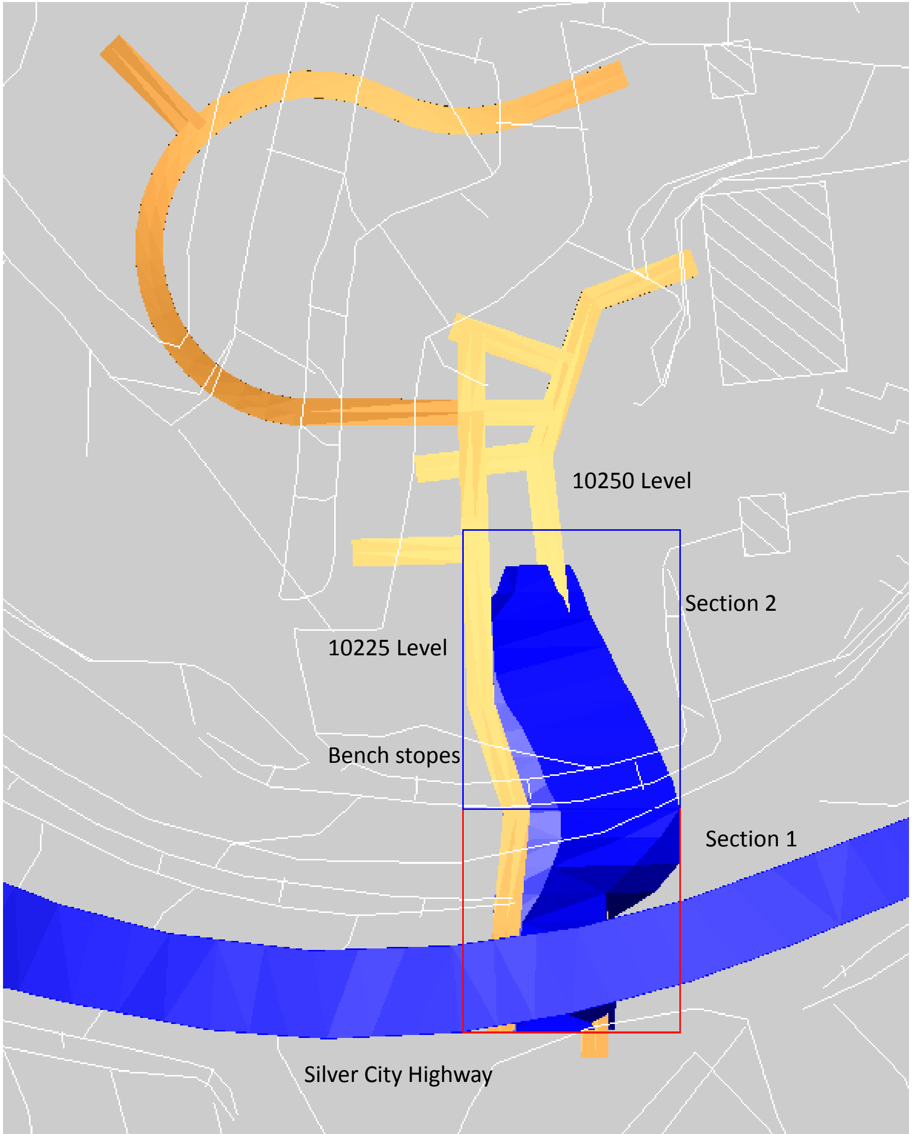
Significant stope wall failure is not expected during the extraction of the downhole bench stoping section of the Zinc Lodes orebody provided that the rockmass conditions encountered during mining are similar to the conditions expected from the assessment.

In order to limit the potential for surface infrastructure disturbance, CBH plan to incorporate a 60 metre crown pillar between the production stopes and the ground surface and to incorporate conservative stope design dimensions according to the spatial relationship between surface infrastructure and the production stopes;

1. Section 1 from northing 365m to northing 415m is located below surface infrastructure. Mine design in Section 1 will incorporate small, 10 metre hangingwall strike length stopes to increase hangingwall stability.
2. Section 2 from northing 415m to 452m. Mine design will incorporate 15 metre hangingwall strike length stopes as recommended by the stope stability assessment.

Figure 13 shows the spatial relationship between the Zinc Lodes orebody and the surface infrastructure.

Figure 13 Spatial relationship between Zinc Lodes Benching Section and surface infrastructure (Plan view).



9.1 Controls for Stope Stability

Without appropriate controls in place, damage to surface infrastructure above the Zinc Lodes downhole benching stoping block is theoretically possible. Differential settlement of subsurface material may result in surface displacements leading to damage to surface infrastructure. From a mine design and operating perspective, preventing stope overbreak will be contingent on the following factors;

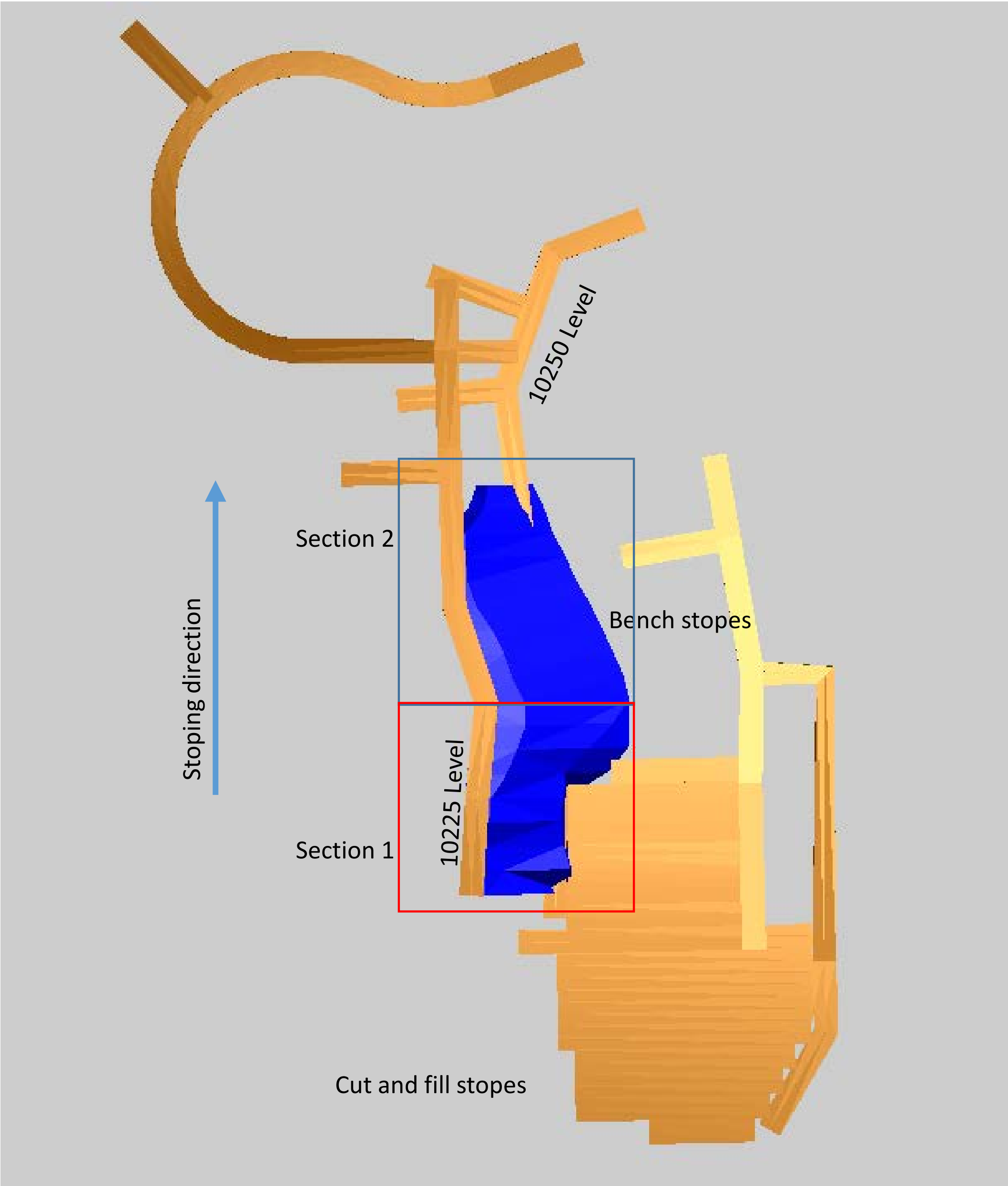
- Data collection and detailed characterisation of ground conditions in the hangingwall and crown of the ore lens.

- Sufficient and ongoing testing of representative samples of the rock mass to characterise the engineering properties.
- Ensuring that stope production spans do not exceed stable dimensions.
- Ensure that ongoing monitoring and back analysis of the performance of stope spans is carried out.
- Ensure that stope performance data is recorded and applied to stope design.
- Ensure that a complete strategy to extract each stope is in place that incorporates appropriate infrastructure to fill each stope after the completion of extraction.
- Ensure that ground support designs are appropriate to control stope overbreak.
- Ensure ground control strategies are in place to protect the crown between surface infrastructure and the planned downhole benching stoping block.

10 PRODUCTION SEQUENCE

The development design for the downhole benching stoping block allows for a single access to the production front limiting the sequencing options to a single stope advance towards the access cross-cut. Figure 144 illustrates the development and stoping configuration for the benching stoping block.

Figure 14 Plan view – benching and cut and fill stope development design



The production sequence will be governed by the availability of mine fill. Each stope in the downhole benching stoping section of the orebody must be filled immediately following completion. The strike length of the hangingwall will dictate the overall size and stability of each stope. For the downhole benching stoping block, the stable hangingwall span is estimated to be approximately 15 metres according to this assessment. Rib pillars between the downhole benching stopes are not strictly required if fill is placed in the completed stope in a timely manner. Rib pillars may be required if weak ground conditions or a large scale geological structure is encountered. The minimum strike length for reliable rib pillar performance for open stoping is 5 metres in the experience of GCE but is contingent on good mining practices, particularly slot design and firing sequences designed to protect the rib pillar. Larger pillars may be required to control more extensive poor ground conditions.

11 GEOTECHNICAL RISKS

The prominent geotechnical risks identified in this assessment are as follows:

- Potential for the differential settlement of subsurface materials initiated by stope overbreak may result in damage to surface infrastructure. Stringent design and mining controls are required to minimise the possibility of stope overbreak.
- Structurally controlled failures from hangingwall and crown resulting in smaller stope spans than predicted by the empirical stability analysis;
- Sterilisation of ore through stope failure. Hangingwall or crown failures have the potential to sterilise ore in the vicinity of the failure. Ongoing collection and review of geological and geotechnical conditions and stope performance data is recommended;
- Failure of pillars due to presence of unfavourable defects in the pillar;
- Variability in geotechnical parameters used in the stope analysis. There are inherent risks in extrapolating drillhole point data to generalised rock mass conditions across domains. Whilst the host rock mass and the mineralised lenses could be described as close to homogeneous, there are localised variations in rock mass conditions. Assumptions are also made with regards to the presence of the critical defect set within the rock masses forming the stope walls.

12 RECOMMENDED FURTHER GEOTECHNICAL WORK

- Collection and interpretation of structural defect data and geotechnical data is necessary as mining progresses in the zinc lodes. This will allow validation of design parameters and timely input to the mine design process;
- Develop a program to monitor stope stability and potential surface subsidence. The program should be implemented both before and during the extraction of the Zinc Lodes;
- Increase the size and quality of the geotechnical database for the Zinc Lodes by collecting geotechnical information from future resource drilling programs;

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V04	D Dickson	Principal Geotechnical Engineer

13 COPYRIGHT NOTICE

Appendix A Ground Control Management Plan incorporating Zinc Lodes development and production activities.

CBH RESOURCES

RASP MINE

UNDERGROUND GROUND CONTROL MANAGEMENT PLAN

This document has been approved by:

Date	Name (printed)	Position	Signature
		Underground Mine Manager	
		Production Manager	
		Mine Superintendent	

The designated Standard Co-ordinator of this document is:

Date	Name (printed)	Position	Signature
		Senior Geotechnical Engineer	

Document Review

Date	Name (printed)	Position	Signature
		Underground Mine Manager	
		Production Manager	
		Mine Superintendent	

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1 PURPOSE

This Ground Control Management Plan (GCMP) establishes the accountabilities and processes used to identify and mange geotechnical hazards associated with the Rasp underground mine. The overall purpose of this document is to provide a systematic approach so as to eliminate fatalities, serious injuries and equipment damage from rock falls (also referred to as 'uncontrolled falls of ground'), maintain safe and efficient operations and to achieve 'best practice' in ground control across development and production.

The systems and processes presented in the GCMP have been developed to meet the following objectives:

- Provide a **safe** mining environment that complies with all relevant legislative requirements.
- Ensure that appropriate and applicable safety, planning, design, operating and documentation **standards** are applied to mining geotechnical activities.
- Outline risk based **systems** for design, planning and operational geotechnical activities.
- **Sustain** the resource by optimising geotechnical designs, while at the same time managing geotechnical mining risks within acceptable safety and business levels.
- **Verify** that the appropriate levels of competence and due diligence have been exercised and adequately documented.

2 PROCESS OWNERS

- The respective Underground Mine Manager for the Rasp underground mine.
- The Senior Geotechnical Engineer (or designated equivalent competent person).

3 DESCRIPTION OF ACTIVITY

The objectives of the GCMP are to:

- Detail the responsibilities and requirements of all personnel involved in ground control.
- Provide site technical personnel with a systematic approach to planning, designing, installing and reviewing all aspects of work associated with ground control.
- Improve the planning, design and decision making process associated with ground control.
- Establish minimum standards to be applied to the design and support of all underground excavations.
- Provide rules and guidelines for controlling rock fall hazards during mining operations.
- Formalise ground control systems that are currently in use underground across Broken Hill Operations Pty Ltd (BHOP) operations.

4 INTRODUCTION

The potentially hazardous nature of underground mining requires the application of sound geotechnical engineering practices to determine the ground conditions, ground support and reinforcement requirements and design of all openings that can be safely and economically excavated.

The GCMP is a systematic, auditable framework for assessing the geotechnical risks to underground mine personnel and equipment associated with potential rock falls throughout mining operations. As an effective tool, the GCMP applies sound engineering practice to the management of ground control challenges during the whole life of mine.

The GCMP will be reviewed every 12 months (or more frequently if deemed necessary) to correct areas of deficiency exposed by experience in the previous 12 months, or by active investigation, analysis, planning and design of new mining areas that will be developed in the near future.

The GCMP seeks to encourage the application of current geotechnical engineering knowledge, methodology, instrumentation and ground support to obtain practical solutions to ground control challenges in the underground environment.

This document covers:

- Legislative framework
- Responsibilities of key personnel
- Summary of operational and geotechnical conditions
- Data collection procedures
- Geotechnical risk management
- Analysis, design and planning procedures
- Planning and implementation
- Response plans and geotechnical investigation
- Document and process review and auditing

5 LEGISLATIVE FRAMEWORK

Mining safety in New South Wales (NSW) is regulated by the NSW Division of Resources and Energy, under the Mine Health and Safety Act 2004 (Ref. 1) and the Mine Health and Safety Regulation 2007 (Ref. 2). This legislation is applied in conjunction with NSW Work Health and Safety Act and Regulation 2011.

In particular, the Mine Health and Safety Regulation 2007 Part 4 refers to OH&S risk assessments relating to prescribed hazards including ground instability (Clause 36) and in-rush (Clause 37), and Part 5 referring to risk controls including ground instability (Subdivision 1) and in-rush (Subdivision 2). Subdivision 1, Clause 46 reads:

> **46 Mine safety and stability**
>
> If there is a risk of unplanned fall of ground, ore or other substance that impedes passage, disrupts production or ventilation or involves a fall of ground support where persons could be present, the operator of the mine must ensure:
>
> (a) the ongoing monitoring of the condition of ground, and
>
> (b) the training of persons at the mine in ground support principles, interpretation of ground support design, ground support installation and recognition and planned responses to indicators of change that may affect excavation stability in a mine

6 RESPONSIBILITIES

The GCMP applies to all underground personnel who must comply with the requirements outlined in this document. As a minimum, all underground personnel must comply with the mandatory requirements which are:

- No person is to enter an unsupported excavation.
- All underground personnel have the responsibility to recognise and report adverse conditions. This is done using workplace inspection sheets and/or the geotechnical report form (see Section 14.1 and Appendix A) and reported to the Geotechnical Engineer. Ground awareness training is provided to facilitate this.

Several positions have specific responsibilities relating to ground control, which are outlined in the following sections.

6.1 Underground Mine Manager

The Underground Mine Manager is ultimately responsible for implementing the GCMP and complying with all regulatory requirements concerning ground control. Specific tasks are delegated to personnel as described in Sections 6.2 to 6.9. The Underground Mine Manager's main responsibilities are:

- Comply with all relevant regulatory requirements.
- Approval of the GCMP.
- Ensure that sufficient resources are allocated to meet the requirements of the GCMP.
- Approval of minimum ground support standards/regimes.
- Ensure that suitably qualified and experienced persons are formally appointed to positions with a ground control function.
- Ensure that all underground personnel receive ground awareness training to be able to recognise geotechnical hazards, take appropriate action and report these to management.
- Ensure that geotechnical aspects are considered in design, operation and abandonment of the mine.
- Ensure that all procedures concerning ground control are followed and monitored.
- Ensure that suitable equipment is supplied and maintained to comply with the GCMP.
- Ensure that clear and frequent communication regarding ground control issues is maintained between the underground workforce, supervisory, technical and management staff.
- Sign off geotechnical report forms.

6.2 Production Manager

The Production Manager is required to develop an understanding of the geotechnical conditions in the mine and the GCMP, and must ensure that:

- The GCMP is communicated to relevant employees.
- Appropriately skilled personnel are appointed to work in the mine.
- Safe Work Procedures (SWPs) for ground support installation are implemented.
- Ground control work is planned and scheduled.
- Appropriate training is provided to underground personnel to safely undertake ground control work to the standard specified in the GCMP.
- Appropriate equipment is used for ground control tasks.
- Ensure that ground support quality monitoring and testing is carried out according to the GCMP.
- The GCMP is maintained.

6.3 Mine Foreman and Shift Supervisors

Mine Foreman and Shift Supervisors are expected to have a strong working knowledge of ground control theory and practice and a good understanding of mine-wide ground conditions. They are to ensure that:

- Shift plans consider all potential hazards and plans to minimise exposure.
- Mining does not take place without an approved design which includes the minimum required ground support.
- Ground support is installed to the specified standard.
- Ground conditions in active work areas are inspected during the course of normal duties.
- Ground control work follows approved procedures.
- Every active work area is scaled before support installation.
- Ground control maintenance at work sites and travel ways is prioritised.
- Regular check scaling is conducted according to the scaling plans and schedule.

6.4 Mine Superintendent and Mining Engineers

The Mine Superintendent and Mining Engineers are required to develop an understanding of the geotechnical conditions in the mine and the constraints that these place on mine design and scheduling. They are to ensure that:

- Mine designs are reviewed and approved.
- All excavations designed take into account criteria provided by the Geotechnical Engineer.
- The mining schedule takes into account sequencing constraints provided by the Geotechnical Engineer.
- If excavation designs or the mining schedule do not conform to the criteria provided by the Geotechnical Engineer, then the Mining Engineers must discuss these with the Geotechnical Engineer to develop a workable compromise based on a risk management process.

6.5 Geotechnical Engineer

The Geotechnical Engineer is required to develop a detailed understanding of the ground conditions, support requirements, failure mechanisms, mining methods and rock mass response to mining over the life of the mine. Key responsibilities are:

- Collect, analyse and interpret geotechnical data to characterise the rock mass conditions and undertake sufficient engineering design of excavations and support systems.
- Specify ground support designs for new development.
- Specify additional support for existing development if required.
- Undertake routine geotechnical inspections of all working areas.
- Investigate adverse occurrences, including rock falls, and make recommendations to limit the risk posed by similar occurrences.
- Provide advice on optimal stoping layouts and sequences to minimise geotechnical risks over the mine life.
- Review environmental data (specifically water composition test data) to assess the likely effects of corrosion on ground support elements.
- Maintain geotechnical records that includes:
    - Raw data from drill core, laboratory testing and underground mapping
    - Completed geotechnical report forms
    - Monitoring data, including the seismic data
    - Geotechnical characteristics for each domain
    - Rock fall investigations
- Update the GCMP when conditions or procedures change.
- Ensure the content of ground awareness training is appropriate for conditions in the mine, and update the content of the training modules as conditions change.
- Ensure that clear and frequent communication regarding ground control issues is maintained between the underground workforce, supervisory, technical and management staff.

6.6 Mine Geologists

Mine Geologists are required to develop an understanding of the geotechnical conditions in the mine, and this GCMP, and must also:

- Conduct routine geological mapping and identify lithology and major structures of geotechnical significance as listed in Section 9.
- Maintain 3D records of mapped lithology and geotechnically significant structures.
- Maintain a 3D mine-scale interpretation of the geology and geotechnically significant structures.
- Include drill holes and the expected geology and major structures on mine plans.

6.7 Mine Surveyors

The Mine Surveyors are required to:

- Ensure that all excavations are surveyed.
- Ensure development headings with more than 10% over-break are reported to the Geotechnical Engineer for inspection and assessment.
- Report intersections where the effective span is 1m or greater than the design span to the Geotechnical Engineer for inspection and assessment.
- Issue mining instructions according to the approved design.
- Ensure that existing excavations are included on the mine development plans.
- Mark-up cable bolt collars and pick-up cable bolts after installation.

6.8 Mine Technicians

The Mine Technicians involved in geotechnical data collection are required to have a basic understanding of ground control theory and practice, and must be able to recognise structures and conditions of geotechnical significance.

6.9 Ground Control Operators

Ground control operators are underground workers directly involved in ground control work and include jumbo operators, service crews and charge-up crews. Responsibilities of ground control operators include:

- Have a working knowledge of ground support theory and practice.
- Inspect ground conditions in every working area before work starts.
- Scaling (jumbo and manual scaling) of their workplace.
- Installation of support to specified minimum standards.
- Follow blasting designs to minimise blast-induced damage.
- Install additional support if required according to the TARP as provided in Section 16.1.

7 SUMMARY OF OPERATIONS

The Rasp Mine is located centrally within the City of Broken Hill and the leases occupy the central region of the historic Broken Hill Line of Lode ore body incorporating the original mine areas that commenced operations in the 1880s.

Underground activities at Rasp focus on the development and mining of the Western Mineralisation and Centenary Mineralisation along with the high grade pillars left unmined from the Main Lode ore body. This document also relates to the development and extraction of the Zinc Lodes.

Annual production is planned to average 34,000 tonnes of zinc metal in concentrate, 28,000 tonnes of lead metal in concentrate, and 1.1 million ounces of silver in the lead concentrate over a mine life in excess of 15 years.

Broken Hill Operations Pty Ltd (BHOP) operates the mine as a wholly owned subsidiary of CBH Resources Limited (CBH).

7.1 Mining

The Western Mineralisation, Main Lodes and Zinc Lodes are three discrete mining areas and ore zones within the Rasp Mine. The mining methods employed vary within each of these ore zones, with the most appropriate mining method being utilised based on individual stopes. Long-hole open stoping (LHOS) will be the most prevalent method used in the Western Mineralisation, up-hole stoping and LHOS in the Zinc Lodes, with room and pillar and up-hole pillar retreat in the Main Lode pillars.

The underground operations are accessed through the existing portal located at the northern end of the Kintore pit. The current decline has been developed between the Western Mineralisation and the Main Lodes, with a secondary decline to be developed providing access to the Main Lode and Zinc Lode stoping.

8 SUMMARY OF GEOTECHNICAL CONDITIONS

8.1 Background

The Geotechnical Engineer assimilates all available geotechnical information to identify geotechnical domains and build an understanding of the range of conditions and likely behaviour within each domain.

The current understanding of geotechnical conditions for the Rasp Mine is formed from a combination of sources including underground mapping and observations, past mine performance and geotechnical assessment undertaken by Coffey Mining Pty Ltd (Coffey Mining) as part of a bankable feasibility study (BFS) in 2010 (Ref. 3).

8.2 Geology

The geology model of the Rasp deposit is maintained by the Underground Mine Geology Department. The deposit is hosted within a quartz/gahnite and garnet quartzite unit. The ore units are hosted within a metasediment sequence, with the Potosi Gneiss unit found in both the hanging and foot walls. Both the ore units and Potosi Gneiss have been described as competent rock types, angular and blocky.

8.3 Rock Mass Domains

Previous work by Coffey Mining and CBH divided the mining area into four primary rock mass domains generally based on ore body geometry:

1. Decline;
2. Hanging wall domain;
3. Footwall domain; and
4. Ore domain

Analysis of mean structure sets, empirical rock mass classifications (e.g. Q, MRMR) and subsequent stability assessments by Coffey Mining have been undertaken for hanging wall, footwall and ore domains. Further assessment of the ore domain has been undertaken by sub-dividing the domain based on levels as follows:

- Above 6 Level;
- 6 Level to 8 Level; and
- 8 Level to 11 Level
- *Below 11 Level

*Characterisation of the rock mass below 11 Level is undertaken by utilising structural information collected from structural mapping of development headings. Specific geotechnical data is collected when required for design purposes. Mine development completed below the 11 Level to date has shown similar geotechnical characteristics to previously mined areas between the 8 and 11 Level.

Ground Control Engineering Pty Ltd (GCE) conducted the geotechnical study for the Zinc Lodes (October 2014). The rock mass was divided into the following domains:

Longhole stope area

- HW_LH (ground between 0 and 10m from hangingwall of B Lode)
- ORE_LH (B Lode)
- FW_LH (ground between 0 and 10m from footwall of B Lode)

Cut and Fill stopes area

- HW_LF (ground between 0 and 10m from hangingwall of B Lode)
- ORE_LF (B Lode)
- FW_LF (ground between 0 and 10m from footwall of B Lode)

8.4 Intact Rock Properties

Limited laboratory testing was completed in 2007; the results are presented in Table 1 below. Additional laboratory testing is recommended and the results used as part of systematic updates and revision of stability modelling. Details of rock properties and laboratory testing results are located in the geotechnical folders on the Rasp Mine server.

Laboratory testing was conducted on selected samples from the Zinc Lodes. The results are presented in Table 2.

Table 1 Summary of 2007 laboratory testing results

Rock Type	Density (t/m^3)	UCS (MPa)	Young's Modulus (GPa)	Poisson's Ratio
Potosi Gneiss	2.8	228	76.8	0.35
Potosi Gneiss	2.8	205	83.6	0.23
Pegmatite	2.6	158	64.2	0.24

Table 2 Zinc Lodes laboratory testing results

Lab Sample No	Borehole ID	Depth (m)		Lithology	UCS (MPa)	Wet density (t/m^3)	Young's Modulus (GPa)	Poisson Ratio	Mode of Failure Recorded
		From	To						
14090346	ZLDD5002A	71.90	72.10	Pe	17.8	2.78	n/a	n/a	Shear
14090348	ZLDD5036	91.20	91.40	S	60.8	2.98	n/a	n/a	Conical
14090349	ZLDD5017	86.90	87.15	LuQ	103	2.92	57.4	0.03	Shear
14090350	ZLDD5034	14.00	14.30	Pe	16	2.64	3.98	0.094	Shear
14090351	ZLDD5034	29.30	29.60	GPm	98	2.95	n/a	n/a	Conical
14090352	ZLDD5032	83.70	84.00	Gpe	83.1	3.22	n/a	n/a	Conical
14090353	ZLDD5009	30.80	31.00	GPs	34.1	2.96	n/a	n/a	Shear
14090355	ZLDD5029	58.50	58.65	LuQ	35.2	3.33	n/a	n/a	Shear
14090356	ZLDD5001	33.20	33.40	Pe	18.2	2.71	10.7	0.081	Shear
14090357	ZLDD5001	70.4	70.6	Gpe	59.4	3.01	53.1	0.007	Shear
14090358	ZLDD5006	90.3	90.5	Peg	88.4	2.68	n/a	n/a	Shear
14090359	ZLDD5003	62	62.2	Pm	95.7	3.1	n/a	n/a	Conical

Table 3 Zinc Lodes triaxial test results

Lab Sample No	Borehole ID	Depth (m)		Lithology	Estimated Peak Envelope		Estimated Residual envelope	
		From	To		Friction Angle	Cohesion (MPa)	Friction Angle	Cohesion (MPa)
14090347	ZLDD5036	23.75	26	Gpe	48.3	10.47	13.3	9.19
14090354	ZLDD5022	62.9	63.15	Gpe	53.8	14.59	48.2	2.22
14090360	ZLDD5004	95.4	95.6	S	38.7	27.87	n/a	n/a

Structural Model

Geotechnically significant structures are those that are mechanically weak compared to the surrounding rock mass. These structures can include:

- Faults
- Shears
- Joints
- Lithology contacts
- Dykes
- Bedding planes
- Foliation planes and schistosity
- Veins

There is an important distinction between mechanically weak structures of geotechnical interest and structures of geological interest. The former have a strong impact on ground conditions, while the latter, which are of most interest to mine geologists for determining ore positions and grade, are not always mechanically weak and are therefore often not geotechnically significant.

The following information is recorded for mapped geotechnically significant structures:

- Orientation (dip and dip direction)
- Persistence
- Roughness
- Shape
- Infill minerals
- Water conditions

Coffey Mining has defined the mean structure sets from data collected during logging of geotechnical and resource drill holes. The structure sets are summarised inTable 4.

Table 4 Mean structure sets for each rock mass domain

Rock Mass Domain	Structure Set (dip/dip direction)				
	Joint Set 1	Joint Set 2	Joint Set 3	Joint Set 4	Foliation
Footwall	73/180	15/090	67/100	65/050	66/259
Hanging Wall	68/122	73/359	-	-	71/251
Ore	80/019	59/088	49/127	-	61/246

Note: All orientations are in degrees relative to AMG North

All sets except foliation are relatively widely dispersed in both dip and dip direction. Foliation is moderately to steep dipping towards the southwest, while the joint sets are mostly steeply dipping to the northeast and southeast.

From experience at other underground mines in the Broken Hill area, the following defect properties are observed:

- The majority of joints observed have no infilling and are closed.
- About 1 to 3% of joints have infillings of chlorite, sericite or calcite. Average thicknesses of these infillings are in the order of 1 to 2mm. Occasional infillings of several centimetres have been observed.
- Some structure sets, particularly those parallel to the strike of the ore body, are slickensided and polished defect surfaces can be observed near the ore-waste contact.
- Where defects are exposed for their full length and width (such as in long-hole stopes and maintenance bays), the observed and measured average continuity in these openings is in the order of 1 to 2m along strike and 0.5 to 1m along dip.
- Occasional defects as long as 10 to 15m along strike and 2 to 4m along dip have been observed. The occurrence of these defects is mainly restricted to ore-waste contacts. These defects represent an incoherent strain domain boundary, where the material on either side exhibit different Young's moduli and Poisson's ratios, producing differential strains in the two adjacent materials, which ultimately will result in fracture and slippage along this boundary.

The identification of major structures is crucial to implementing sound geotechnical engineering practices that result in stable and economical designs. Regular mapping of development and ore drives and logging of available drill core are invaluable tools that are used to identify major structures. Data collection and interpretation relating to major structures should be undertaken as a joint venture between the Mine Geology and Geotechnical Engineering departments.

Ongoing geotechnical data collection of defect orientations and characteristics is required from development for the Zinc Lodes to verify parameters used in the initial empirical assessment.

8.5 Rock Mass Conditions and Material Properties

Intact rock properties and structural conditions can be used to classify rock mass quality in each domain according to the Q and RMR (and MRMR) rock mass classification systems (which are used widely in the mining industry).

Three different methods of rock mass classification have been used to characterise the rock mass and to provide estimates for excavation dimensions. The methods used by Coffey Mining include Barton's Q system, Mathews Modified Stability Number and RMR. Each system takes into account different parameters for different purposes so the results are not expected to be exactly the same, but they will indicate where any problems may be anticipated.

The parameters and results of the rock mass classification systems are displayed in Table 5 below. To-date the analysis has been completed only on the backs and hanging wall as the low angle of the footwall indicates a low probability of failure.

Table 5 Parameters and results for various rock mass rating systems.

Method	Parameter	Above 6 Level		6 Level to 8 Level		8 Level to 11 Level	
		Back	HW	Back	HW	Back	HW
Q' = RQD/Jn x Jr/Ja	RQD	72.0	81.0	92.0	97.0	98.0	99.0
	Jn	9.0	9.0	6.0	6.0	6.0	6.0
	Jr	3.0	3.0	3.0	3.0	3.0	3.0
	Ja	2.0	2.0	1.0	2.0	1.0	0.8
Q'		**12.0**	**13.5**	**46.0**	**24.3**	**49.0**	**66.0**
Q = Q' x Jw/SRF	Jw	1.0	1.0	1.0	1.0	1.0	1.0
	SRF	5.0	5.0	5.0	5.0	5.0	5.0
Q		**2.4**	**2.7**	**9.2**	**4.9**	**9.8**	**13.2**
N' = Q' x A x B x C	A	0.4	0.4	0.4	0.4	0.4	0.4
	B	0.8	0.3	0.8	0.3	0.8	0.3
	C	2.0	4.0	2.0	4.0	2.0	4.0
N'		**8.3**	**6.9**	**31.6**	**12.5**	**33.7**	**34.1**
HR (from graph)		**5.1**	**4.9**	**8.4**	**6.0**	**8.6**	**8.7**
RMR = IRS + RQD + Js + Jc + Jw	UCS Rating	5.8	5.8	5.8	9.1	9.1	9.1
	RQD Rating	13.0	18.0	20.0	15.0	20.0	20.0
	Js	9.0	8.5	9.5	8.5	10.0	9.5
	Jc	25.0	25.0	25.0	25.0	25.0	25.0
	Jw	10.0	10.0	10.0	10.0	10.0	10.0
RMR		**62.8**	**67.3**	**70.3**	**67.6**	**74.1**	**73.6**
MRMR = RMR x Jo x Aw x As x Ab	Jo	1.0	1.0	1.0	1.0	1.0	1.0
	Aw	1.0	1.0	1.0	1.0	1.0	1.0
	As	1.0	1.0	1.0	1.0	1.0	1.0
	Ab	0.9	0.9	0.9	0.9	0.9	0.9
MRMR		**57.2**	**61.4**	**64.2**	**61.7**	**67.8**	**67.3**

Note: Refer to Refs. 4, 5, 6 and 7 for specific notation

As development advances and resource infill and exploration drilling continues these parameters will need review. Regular review and update will improve their confidence and usefulness, ensuring the correct stope shape and support design is in place and can be re-evaluated to be updated and verified to ensure the designs are appropriate for each level.

The Q system was used to characterise the geotechnical domains for the Zinc Lodes. The expected rock mass conditions are presented in Table 6.

Table 6 Zinc Lodes Summary Q-values for B Lode geotechnical domains.

Geotechnical Domain	Total length assessed (m)	1st Quartile Q Value	Weighted Mean Q Value	Q value range	Expected Q class
HW_LH	76.4	3.7	9.8	1-46.9	Poor to fair
ORE_LH	23.7	3.6	39.8	1.9-150.0	Poor to good
FW_LH	37.9	1.9	26.0	1.9-195.0	Poor to good
HW_LF	47.9	10.0	18.4	1.4-75.0	Good
ORE_LF	29.5	10.5	46.1	4.7-194.0	Good
FW_LF	34.7	10.1	19.0	3.5-19.0	Good
DEV	86.5	2.0	11.9	0.2-93.0	Poor to fair
HOST	2531.0	3.1	18.9	0.06-200.0	Poor to good

8.6 Stress Field and Seismicity

The stress field at Broken Hill is the result of an east-west acting tectonic stress. This tectonic stress component is a live force as evidenced by the continuous deformation of shaft pillars and the regular stress build-up and subsequent release in shear zones.

Seismic events occur frequently in the wider Broken Hill mining precinct, however most activity is mining induced. The major principal stress acts approximately perpendicular to the strike of the ore body. In the nearby underground mines there are many remnant pillars and abutments being targeted for mining and this is what causes most of the activity at the underground mines in the area. There is regular activity recorded by the micro-seismic network at the adjacent Perilya Mine, but their regional network does not record many events outside of their mining lease.

To-date, no in-situ stress measurements have been collected for Rasp Mine. Published in-situ stress measurement data for the Broken Hill area is presented in Table 7.

Table 7 Published in-situ stress measurement data for the Broken Hill area

Location	Rock Type	Depth (m)	σ_v	$\sigma_{h\,av} / \sigma_v$
NBHC Mine, Broken Hill NSW	Gneiss	570	14.7	1.5

8.7 Groundwater

The combination of groundwater and exposure to air may have an adverse influence on rock mass strength, particularly in poor or soft ground conditions. There is also the potential for corrosion of the ground support and reinforcement associated with groundwater.

The extent of the corrosion problem within underground excavation ground support and reinforcement systems is a function of the amount and quality of water flow through the rock mass. The corrosiveness of the running water is a function of pH, oxygen concentration, temperature, water conductivity and dissolved ions. The rate of corrosion of steel products in an underground environment is difficult to predict and measure due to the variability of the environmental factors described above. Corroded ground support elements can become an issue in older areas of the mine where rehabilitation is planned or where life of mine access is required.

The rock mass at Rasp does not generate large inflows of water during mining activities, the results of periodic water sampling undertaken at Rasp indicate that the chemical composition of the water utilised underground should not be particular aggressive with respect to corrosion. Observations of the effects of corrosion on ground support elements to date indicate that the effects of corrosion do not adversely affect the serviceability of the elements.

Ground water testing results are reviewed by the geotechnical engineer on a six monthly basis. The inspection of ground support elements for corrosion is undertaken where rehabilitation activities are planned in older mine development and where life of mine access is required or whenever corroded ground support elements are reported.

8.8 Geotechnical Library

Geotechnical reference documents, including internal and external reports, are stored electronically on the server W:\TechServ\Geotech. The most important references for the Rasp Mine are included in Section 18.

9 DATA COLLECTION PROCEDURES

9.1 Purpose

Data collection involves ongoing collection of technical information that is required for compliance with the geotechnical design process as specified by the GCMP. Sufficient geotechnical data must be collected to maintain, critically assess and update the geotechnical model and rock mass domains, to confirm design parameters and to assess ground performance against design.

Mine Geology shall coordinate the collection of data to form geological and geotechnical models. These models of the ore body and host rock should be used when making technical assessment. The information used in developing the model may come from many different source including core logging, mapping, historical underground information and regional experience.

The proceeding sections outline procedures for geotechnical data collection through core logging, geology and geotechnical mapping, laboratory testing and stress measurements.

9.2 Core Logging

Drilling provides an initial assessment of anticipated geotechnical conditions along each drill hole path, and is therefore typically biased by hole orientation and location. The following geotechnical characteristics should be logged and recorded in the relevant geotechnical section on the mine server:

- Lithology
- Rock quality designation (RQD)
- Field strength estimate
- Number of defect sets
- Defect type (e.g. fault, shear, joint, etc.)
- Defect spacing / fracture frequency
- Defect roughness and planarity
- Defect infill type and thickness
- Defect orientations and the quality of orientation measurements. Core is orientated wherever possible.

Logging of core should be carried out in intervals representing reasonably consistent rock mass conditions. Faults and other major structures of geotechnical significance are recorded and described separately. Core must be photographed for record purposes and later referral.

9.3 Geology Mapping

Regular mapping of development drives is undertaken to identify lithology, mineralisation, alteration and major structures. Face and backs mapping is conducted periodically by Mine Geologists. Features of geotechnical significance are communicated to and assessed by the geotechnical engineer.

9.4 Geotechnical Mapping

Routine geotechnical mapping to assess dominant structures, rock mass conditions and potential failure mechanisms is undertaken periodically, (i.e. for every 50m section of development) or when there is a rapid change in conditions or when adverse or unexpected conditions are encountered. Geotechnical mapping can include face mapping, wall mapping or photogrammetric methods if available, as long as the structural and rock mass conditions are resolved. A geotechnical mapping template is included in Appendix A2.

9.5 Laboratory Testing

Laboratory testing programmes to determine intact rock properties have been conducted in the past for specific projects. Further campaign testing will be identified as the need arises. Routine laboratory testing is not considered necessary at this stage.

9.6 Stress Measurements

Stress measurements are conducted to determine the in-situ stress field. Over-coring and acoustic emission methods are the most common stress measurement methods in hard rock mines. At this stage no in-situ stress measurements have been collected for Rasp Mine, with published stress measurement data for the Broken Hill area and regional experience utilised instead.

9.7 Rock Mass Classification

Rock mass classification systems are used as inputs for mine design and geotechnical design and for mine planning at Rasp Mine. The required resolution of rock mass classification is dependent on end-use design requirements and will vary with ground conditions and structure continuity.

Table 8presents the classification systems and tools required for the application of sound geotechnical assessment and review associated with underground operations. These datasets are revised and updated as incoming data is collected and analysed such that design decisions may be based on the most up-to-date information.

Table 8 Systems required for geotechnical review

Review Item	Primary Data Source	Required Systems
Geological / geotechnical domains	Core logging and mapping	Digital model of unit boundaries
Rock Mass Characterisation (grouped by domain)	Core logging and mapping	Minimum: RQD and Fracture Frequency and defect characteristics
Regional Structures	Core logging and mapping	Digital model of extent and material properties

10 GEOTECHNICAL VULNERABILITIES

Geotechnical vulnerabilities arise through exposure of mine excavations to physical features of the rock mass. The extent to which any excavation is deleteriously affected by these features is a function of the designed exposure. As such, consideration of the geotechnical vulnerabilities is essential at all levels of the mine planning process.

Geotechnical vulnerabilities may be classified as either:

1. **Primary:** Where exposure to the vulnerabilities may be managed using approved minimum ground support standards; or
2. **Residual:** Where exposure to the vulnerability may affect the performance or suitability of approved minimum ground support standards.

Examples of where **primary** geotechnical vulnerabilities may occur include:

- Rock mass structures and properties
- Blast damage in the rock mass
- Stress redistribution during development
- Mine water and corrosion

Examples where **residual** geotechnical vulnerabilities may occur include:

- Regional structures
- Deviation of stress orientation and magnitude associated with production
- Deterioration of ground conditions
- Geological condition and continuity

The residual geotechnical vulnerabilities require specific consideration prior to their management using approved processes and control measures. Effective ground control systems are maintained by both minimising exposure to vulnerabilities and establishing engineering control measures. The performance of control measures used to manage vulnerabilities must be routinely assessed to permit the evolution of control systems and optimise mine design.

Mine design scenarios requiring routine assessment with regard to the performance of control measures include:

- Stand-off distances to regional structures
- Development proximity to production areas
- Production sequences and spans
- Development geometry
- Development separation distances
- Pillar geometry and dimensions

Control measures currently in place to manage **primary** vulnerabilities include:

- Standard development profiles
- Standard drilling patterns and charging procedures
- Minimum ground support standards

Control measures currently in place to manage **residual** vulnerabilities include:

- Mine design checklist and approval systems for access and production excavations
- Routine inspection of ground conditions and performance of ground support
- Hazard reporting systems
- Modelling of the rock mass response to mining if required.

11 MANAGEMENT OF GEOTECHNICAL RISKS

Risk management is the central theme of ground control management and is used to guide design and operational decisions as discussed above. The current risk management standard is AS/NZS ISO 31000:2009 which is based on (and supersedes) AS 4360 and follows the basic process shown in Figure 1.

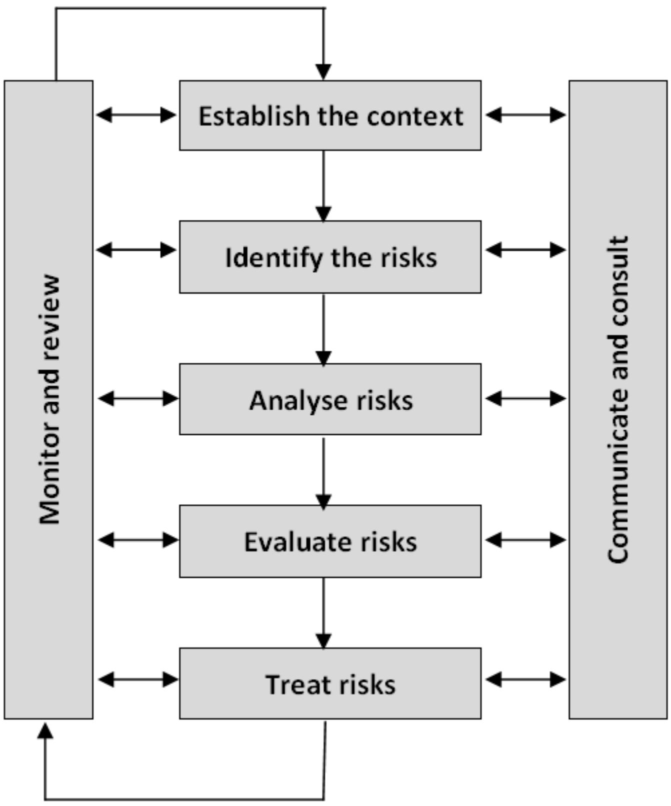

Figure 1 Risk management process according to AS/NZS ISO 31000:2009

The process used to manage geotechnical vulnerabilities and prevent rock falls comprises a sequence of activities integrated into mine design approval systems supported by operational standards. The approval systems facilitate control over all new development and mining activities, and the integration of activities within the geotechnical management process. This permits continued analysis and management of existing excavations in order to provide a safe working environment. The geotechnical risk management process is shown in Figure 2.

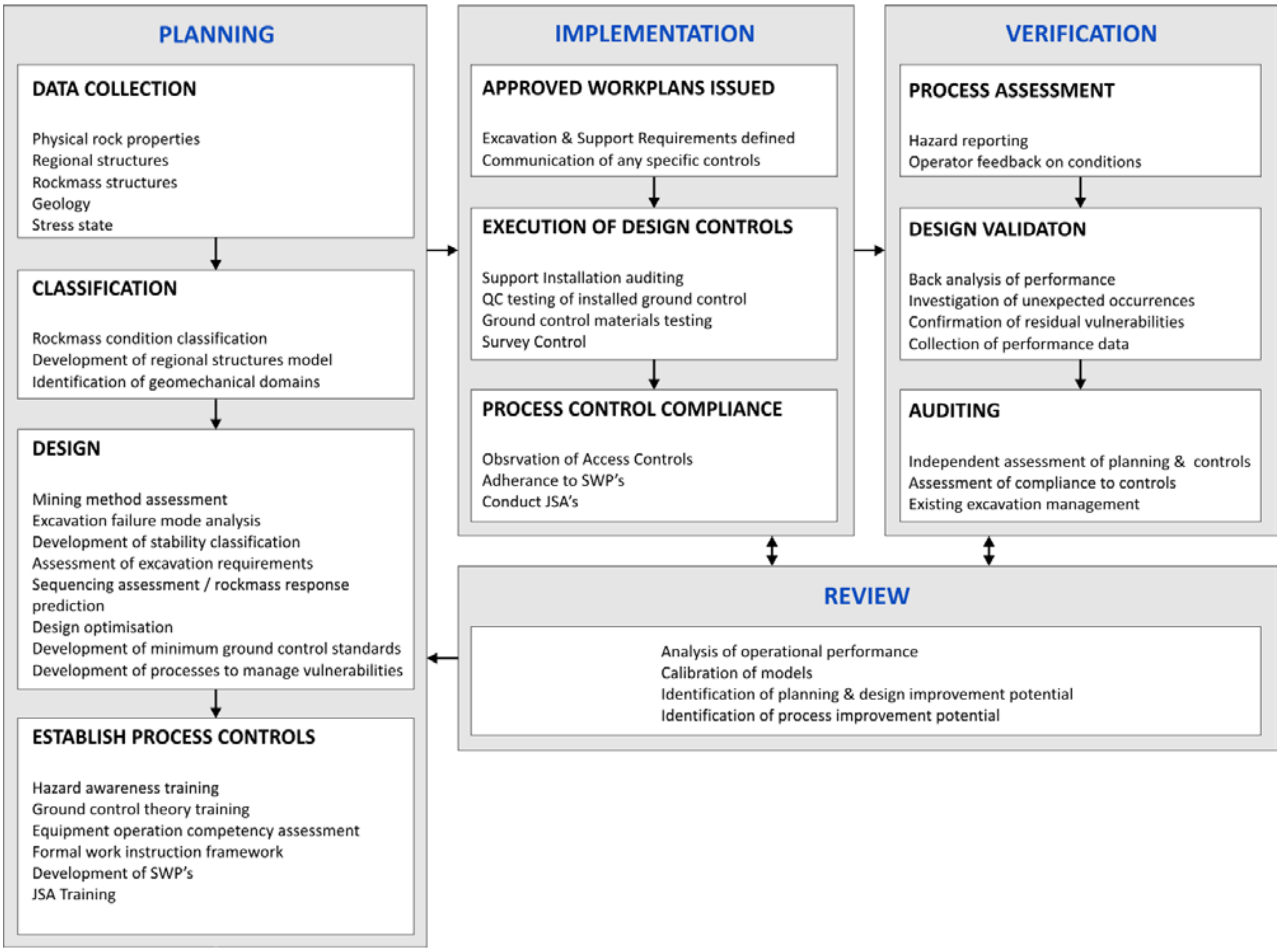

Figure 2 Components of the geotechnical risk management process

12 ANALYSIS, MODELLING AND DESIGN

This section outlines analysis, modelling and design procedures. Analysis and design decisions should follow the risk management processes outlined in Sections 10 and 11.

12.1 Life-of-Mine Geotechnical Vulnerabilities

Numerical modelling is the most effective method for identifying life-of-mine geotechnical vulnerabilities for long term mine design and planning. Coffey Mining completed preliminary modelling work as part of the geotechnical component for the BFS in 2010 (Ref. 3). Similar modelling work will be undertaken periodically for ongoing assessment of vulnerabilities and model calibration on an as needs basis.

12.2 Mine Design and Planning Process

Mine Planning (in conjunction with the Mine Manager and Superintendents) shall use all available information to determine the mining method (or methods) and equipment options.

The mining methods and equipment shall be determined using experience and knowledge of the anticipated conditions based on sound mining practices, principles and with reference to the BHOP Mine Planning and Design Guidelines.

Factors of safety (FOS), excavation ratios, pillar and long-hole extraction sequences, maximum powder factors, use of down-hole in preference to up-holes, air, water, power and ventilation services, access and egress routes and excavation dimensions shall be determined as per the BHOP Mine Planning and Design Guidelines.

Mine Planning (following consultation with the Mine Manager and Superintendents) shall recommend the preferred mining method.

Development designs are prepared by Mining Planning with input from the Geotechnical Engineer and other mine technical staff.

If the designs do not conform to the design criteria provided by the Geotechnical Engineer, then the Mining Engineers discuss these with the Geotechnical Engineer to develop an agreed design based on risk management principles (see Sections 10 and 11).

All development designs are circulated for review with sing-off required for sections covering:

- Planning
- Services
- Ventilation
- Electrical
- Geology
- Geotechnical
- Survey
- Planning Superintendent
- Mine Foreman / Production Superintendent
- Underground Mine Manager

12.3 Geotechnical Assessment

The Geotechnical Engineer is involved at all stages of the planning process to ensure that thorough analysis of geotechnical vulnerabilities may be completed.

During planning and design, the following geotechnical issues must be considered and design approval documented via the approval checklist documents.

Table 9 Geotechnical considerations during mine planning and design

Excavation Type	Minimum Geotechnical Considerations
Development Designs	- Intended use and exposure - Failure modes, both static (block or wedge failure) and dynamic (stress induced strain) - Proximity to other excavations (existing and proposed) - Development orientation and geometry - Ground conditions (current and for life of excavation) - Proximity to regional structures or adverse geotechnical conditions - Future confinement loss at brow locations
Stope Designs	- Maximum probable span stability (including over-break and dilution predictions) - Effect of regional structures on excavation stability - Stress redistribution, and its effects on: - stability of production areas - nearby development or infrastructure - nearby unfilled production areas - regional pillar stability - Regional stoping effects on future production - Influence on development and infrastructure
Vertical Development	- Effect of regional structures on excavation stability - Failure modes, both static (block or wedge failure) and dynamic (stress induced strain) - Access and exposure - Pillar dimensions and stand-off distance to adjacent development, production and surface pit limits

The analysis of the issues identified above is intended to ensure that the application of minimum ground support standards, and any additional control measures employed to manage residual vulnerabilities is adequate to maintain safe access and efficient production.

12.3.1 Excavation Design

Mine designs are prepared by the Mining Engineers in consultation with the Geotechnical Engineer. Key considerations for specific development and production excavations are outlined in this section.

12.3.1.1 Infrastructure, access and production development

Infrastructure and development excavations are designed to reduce (as far as possible) the exposure of the excavations to deterioration potential over their effective life. Factors influencing deterioration potential will vary for each design; however a set of **key design principles** has been established as a guide to optimising design performance. These design principles include:

1. Arched profiles are to be mined unless local slab or wedge potential may be better managed using specifically modified geometries (e.g. mining to a lithology contact).
2. Turn-out spans should be kept to a minimum, particularly in ore, to maximise stability conditions which will in turn minimise cable bolting requirements.
3. Stripping or turn-out fillets must be mined to an approved design.

4. Mining 4-way turnouts should be avoided where possible.
5. Parallel drives less than 5m apart (pillar width) should be avoided as they may be difficult to maintain particularly where poorer ground conditions are encountered, or where significant stress redistribution associated with production may occur.
6. The creation of brows in turn-outs or wide spans should be avoided.
7. The location of ore drives must take into consideration stope reinforcement opportunities both for individual stopes and the overall production geometry of the completely mined ore block.

12.3.1.2 Production

The sequence of production is considered in terms of:

- Inter-stope sequence;
- Inter-ore body sequence; and
- The sequence between discrete stoping areas

Consideration of these factors will influence development access methodologies and backfilling strategies. Due to the diversity of the geometry, continuity and orientation of the deposit, the approach to managing production excavation risk needs to take into consideration the following key parameters where applicable:

- Inter-stope sequence: with consideration of the following factors:
    - Limiting the need for charging up-holes at open brows
    - Limiting the production risks associated with blind up-hole slot firings
    - Stress redistribution
    - Slot winze caps should not have a vertical thickness to undercut-span ratio less than 1:1
        - Ring firing sequences must consider temporary or undercut spans over which access is needed for subsequent production. Undercut spans with a vertical-thickness to undercut-span ratio less than 1:1 must be avoided and may need to be increased where regional structures or poor ground are encountered.
- Inter-ore body sequence:
    - Secondary stoping blocks must be maintained with sufficient dimensions to prevent difficulty establishing production drilling or mucking access and minimise the requirement to mine development within back-filled areas.
    - Production from secondary ore blocks will result in combined stope back spans where confinement from fill is likely to be poor. Cable bolting of both primary and secondary stope spans will reduce the likelihood of both individual stope dilution and late-stage production dilution or instability.
    - The sequence of extraction should consider minimising the ratio of primary to secondary stopes due to the risks associated with back-filled voids and likely poorer ground conditions in secondary stopes associated with combined spans and accumulated stress damage.
- Sequence between ore lenses:
    - Where the recovery of a stope or stopes may initiate a regional or widespread stress response, most likely associated with regional structures, the impact of this on other active production or backfilling areas must be considered.

12.3.1.3 Drill and Blast

The design of development and production firings must include measures to minimise damage to the surrounding rock mass. The following practices have been established to optimise excavation stability:

- Low energy explosives are to be used in development perimeter holes.
- The design of 'cleaner rings' or back-break rings should be considered where small pillar dimensions arise by design.
- Winzes should be fired in lifts no greater than twice the winze section span.
- Production drill holes should not extend through ore-waste contacts at stope boundaries.

12.3.1.4 Backfill

The Rasp mine predominantly utilizes development waste material to backfill stope voids. A hydraulic fill plant has been constructed but is yet to be commissioned. A backfill management plan will be required to coincide with the commissioning of the fill plant; the management plan will contain the design and installation procedures for activities associated with hydraulic fill.

Where backfill is used in the larger stopes, the type and strength will depend on the dimensions of the stope and the future exposure of the fill. If a fill exposure is designed, the strength of the cemented fill will depend on the exposed height and width.Table 10displays example minimum fill strength requirements based on excavation width. The final strength requirements must be determined for each individual exposure through risk assessment and design.

Where no post-filling exposure will occur, waste rock or uncemented hydraulic fill will be acceptable. The backfilling strategy will need to be revisited once detailed stoping designs are completed to ensure that the appropriate fill (i.e. waste, uncemented or cemented) is used.

Where a stope is mined above a previously filled stope, good quality filling and high strength fill is required to minimise loading problems. An additional, reinforced screed may also be required. Good reticulation and adequate barricade and drainage arrangements are critical to the successful application of fill.

Any exposure of cemented fill requires geotechnical assessment, whether as an unsupported production span or a supported development excavation. The following guidelines have been adopted to minimise geotechnical risk associated with fill exposure in development:

- Arched profiles are to be mined
- A row of closely spaced uncharged perimeter holes must be drilled to protect the fill-mass from blast damage and maintain the design profile.
- Turnouts and wide spans should be avoided
- Access to established fill should be restricted where there is likely to be a change in the state of stress in the fill-mass without appropriate monitoring controls.
- No backfill tipping point may be established at the edge of an unconfined fill mass.

The quality of filling is crucial for subsidence control, to minimise the potential for long term caving of stope crowns. This is particularly apparent in the LO4 stopes.

Table 10 Example fill strength minimum requirements.

Exposure Width (m)	5	10	15	20	25
Fill strength (kPa) at 40m high	131	235	321	392	453
Fill strength (kPa) at 80m high	138	262	372	471	561
Fill strength (kPa) at 120m high	141	272	392	505	609

12.3.1.5 Subsidence and In-rush

The upper levels of the Western Mineralisation come within 110m of the surface, underneath existing strategic infrastructure such as roads, railways and services. Coffey Mining have completed geotechnical assessments to determine the subsidence potential at Rasp, including a study to determine the likelihood of any subsidence to Australian Railway Track Corporation (ARTC) assets (Ref. 9).

The analyses indicated a stope failure is not expected to propagate through to the surface and significant surface subsidence is not predicted above the stopes. The analysis estimated some hanging wall failures with the proposed open stope geometry. These failures are expected to be localised and to not result in continuous caving to the surface. The presence of the more competent Potosi Gneiss unit above the stope hanging walls will restrict any failure from propagating upward assuming the unit is always above the stopes.

Cable bolting and other ground control measures are used where appropriate to minimise the possibility of caving occurring.

Review of subsidence potential is ongoing as more information regarding ground conditions becomes available and mine designs are finalised.

The Zinc Lodes are located within 60m of the surface, with one section of the Zinc Lodes orebody directly under the Silver City Highway. To minimise the risk of subsidence and impacts on infrastructure, the design incorporates a 60m crown pillar between stoping and ground surface and conservative stope span dimensions. Hangingwall strike spans have been reduced to 10m below surface infrastructure and 15m in the remainder of the stope area.

In-rush involves the sudden and unplanned entry of water, gas, rock or other substances into underground workings of the mine. When assessing the potential for in-rush, the following needs to be considered:

- Location of other workings
- Strength of ground between workings
- Possibility of accumulation of hazardous water, gas, rock or other substances

An in-rush event at Rasp may be associated primarily with two scenarios:

1. An uncontrolled significant connection to a large body of surface water
2. An uncontrolled ingress of saturated backfill

At this time, existing and planned underground excavations are not located where there is a plausible risk of connection to surface bodies of water or large volumes of saturated material.

The risk of cemented fill in-rush is primarily associated with inadequate cement addition. Management of in-rush associated with paste filling is documented in the site Backfill Management Plan (Ref. 8).

13 GEOTECHNICAL DESIGN

This section outlines the key parameters for optimised design of excavations and complementing engineering controls necessary to manage risk associated with geotechnical vulnerabilities.

13.1 Minimum Ground Support Standards

Coffey Mining used the Q system as the basis for rock quality estimation for development ground support requirements.

The Rasp Mine has seven main ground support standards based on profile size and application as listed in Table 8. Where fibrecrete is specified, a minimum 50mm layer of fibre reinforced concrete (fibrecrete) is applied.

Ground support standards are reviewed and updated as required to better reflect the actual ground conditions and underground development. Important considerations when assessing the suitability of ground support and application of support standards include:

- Galvanised support used to minimise corrosion
- All development is to be screened to within 3.5m of the floor
- Cable bolts provide deep ground support for spans over 6m where normal rock bolt lengths are insufficient.

The application of the minimum ground support standards is defined during the development design approval stage when consideration of excavation vulnerabilities is documented. The objective of the approval process from a ground control perspective is to pre-emptively manage foreseeable rock related hazards.

Specific assessment of stability is undertaken for all excavations for which minimum standards have not been developed. This assessment follows the planning and design framework defined in the GCMP.

Table 11 lists the current minimum ground support standards and the design figures are included in Appendix B1.

Table 11 Minimum ground support standards

Profile Code	Minimum Ground Support			
	Backs	Walls	Row Spacing	Surface support
Profile A Decline 5m x 5.5m ARCHED	3 x 2.4m Resin Bolts & 2 x 2.4m Split Sets in shoulder	2 x 2.4m Split Sets per side	1.5m	F/C to Grade-line 50mm
Profile B Permanent infrastructure 5m x 5.5m ARCHED	3 x 2.4m Resin Bolts & 2 x 2.4m Split Sets in shoulder	2 x 2.4m Split Sets per side.	1.5m	F/C to 3.0m from floor 50mm
Profile C 5m x 5m ARCH	5x 2.4m Split Sets	2 x 2.4m Split Sets per side	1.3m	Mesh, to 3.2m from floor
Profile C2 5m x 5m ARCH	5 x 2.4m Split Sets	2 x 2.4m Split Sets per side	1.3m	F/C to 3.2m from floor 50mm
Profile D Main Lode pillar work	5 x 2.4m Split Sets per row	4 x 2.4m Split Sets per side	1.3m	Mesh floor to floor F/C floor to floor 75mm
Profile E 5m x 5.5m ARCHED	5 x 2.4m Split Sets	3 x 2.4m Split Sets per side	1.3m	Mesh, to 1.8m from floor
Profile F 5m x 5.5m ARCHED	5 x 2.4m Split Sets	3 x 2.4m Split Sets per side	1.3m	Mesh, to 2.7m from floor

13.2 Wide Spans – Intersections

Wide spans are defined as excavations having a span greater than 6.0m. Spans greater than 6.0m require deeper reinforcement than routine development profiles to manage increased exposure to structures in the rock mass. Ground support at wide spans is managed using plated cable bolts. The cable bolting requirement calculation defines the minimum number of cables required for spans of a nominated size. The positioning of cable bolts is determined by engineering personnel after assessment of the span geometry.

Cable designs are issued as approved cable bolt plans as required. The following are key requirements in the management of all wide spans:

- First-pass turn-out cables are installed prior to excavating wide spans.
- Second-pass cable installation is completed as soon as practical following the development of wide spans. Second-pass cable installation (and plating) is to occur and no later than 1 full cut from a drag or within 1 week of developing the wide span.
- All cables are plated (1 strand on twin installation). First-pass cables may be plated in conjunction with second pass cables.

Where continuous wide spans are to be mined the Geotechnical Engineer is to assess the requirement to split the planned strip into multiple discrete advances of firing and support.

The cable bolt reinforcement design method used at Rasp follows typical Australian practice. The design procedure is detailed in BHOP SWP *BHO-GEO-PRO-014 Intersection cable bolt design*. The SWP is presented in Appendix B2.

13.3 Wide Spans – Continuous

In other wide spans, such as decline passing bays, the volume to support is assumed to be a parabolic prism along the length of the wide span. Using the rational presented in SWP *BHO-GEO-PRO-014 Intersection cable bolt design,* with the prism mass calculated using:

Prism mass = $2\rho hS/3x$; where x is length and S is cross section span

This mass can be used to calculate the number of cables required in the excavation on a lineal basis.

With due consideration of the rock mass conditions and abutment off-sets, the cable installation pattern should be defined as a square or staggered pattern of uniformly spaced rings of cable bolts as determined by the geotechnical engineer.

13.4 Unconfined Spans

Where level development intersects stopes or vertical development, the resultant loss of confinement in the backs and the associated increase in potential block or wedge failure is managed using cable bolts. As with wide span cable bolting, there is a minimum standard for brow cable bolting and all designs are issued via approved cable bolt plans.

The support requirements of intermediate or temporary brows shall be assessed by the Geotechnical Engineer for each stope during the design approval process.

Cable bolting requirements for brows are calculated based on the following criteria:

- The assumed dead weight to be reinforced by cablebolts is arbitrarily defined as a uniform wedge with an apex height and exposure length equal to the drive span.
- The wedge apex is assumed to occur at the brow.
- Cable length is the total of the height of the wedge extents plus a minimum of 2m.

13.5 Production Spans

Stopes are designed to be self-supporting only to a standard sufficient for production within acceptable dilution limits, not to permit personnel access. Unlike development spans, production spans are mined with partial or limited access to final stope spans and reinforcement opportunities are limited in extent.

Stope reinforcement design should take into consideration the local stope span size and geometry, and the size and geometry of the combined spans of primary and secondary stopes.

The function of cable bolt reinforcement is to limit dilution associated primarily with rock mass structures and stress redistribution at the excavation surface. Practical limitations on cable bolt installation densities and spatial distribution over the stope spans exist and will vary for stoping at Rasp.

As a guide, the assumed dead weight to be reinforced by cable bolts is arbitrarily limited to a maximum depth of one fifth of the production span at the centre of the span with the following additional considerations:

- Ore drives on cable bolting horizons should be designed to optimise the central location of cable bolt arrays for discrete stopes and take into consideration access location and reinforcement opportunities in existing or planned adjacent stopes.
- Stope design must avoid unfavourable pendant or convex exposures which cannot be practically reinforced using cable bolts.
- The spatial restrictions on cable bolt installation will result in locally reinforced areas of the final stope span separating unsupported regions. Cable bolting stopes will not completely eliminate the risk of dilution or prevent local failure if stope spans are excessive.

All cables used in support of production spans are either single or double strand 15.6mm diameter cable with 2 bulbs per metre cable length.

Hanging wall support in 6 Level ore drives and above utilises line pattern bolting comprising a determined number of rows of twin strand cable bolts installed on a regular ring spacing.

Ore drives in all areas of the mine are assessed for cable bolting requirements taking into account the expected geotechnical conditions during stoping.

Drawpoints and stope brows are cable bolted where geotechnical conditions are considered to be detrimental to brow stability.

Depending on the stoping method and ground conditions, the ore drives are cable bolted with 6m long, twin strand cable bolts.

13.6 Ground Support Specifications

Supplier specifications for ground support consumables are included in Appendix B3.

14 PLANNING AND IMPLEMENTATION

This section covers the planning and operational procedures involved in implementing the GCMP. Operational procedures are established according to the risk management process outlined in Sections 10 and 11.

14.1 Planning Meetings

Weekly planning meetings are held to discuss medium-term mine planning and geotechnical issues.

14.2 Mining Instructions

Mining instructions in the form of memos are prepared by the Surveyors according to the design approved in the mine development plan process. The required ground support standard for each cut is listed on the daily work instruction board. A copy of the ground support standards should be readily accessible to all employees who are associated with ground support activities.

14.3 Ground Control Procedures and Equipment

The following is a list of standard procedures relating to ground control at Rasp Mine:

- BHOP Rasp Mine General and Underground Inductions

- Jumbo operation (development drill, scale and mesh)
- Conducting manual scaling
- Development charge-up (scaling before charge-up)
- Load haul dump operation (scratching walls and face with bucket)
- Long-hole rise charge-up (scaling before charge-up)
- Long-hole drill operation (cable bolt holes)
- Production charge-up (scaling before charge-up)
- Service crew (bleeding mesh)
- Ground awareness training
- Underground mapping (scaling and washing down walls)

The following equipment is used for ground control tasks:

- Twin boom jumbo for mechanical scaling, drilling and installation of ground support
- IT with certified fixed work platform for check scaling, inserting resin cartridges and installing, grouting and plating cable bolts.
- Concrete batch plant for fibrecrete batching
- Fibrecrete sprayer
- Underground concrete agitator truck
- Refrigerated container for resin storage
- Grout mixer and pump
- Cable bolt tensioner

14.4 Training

All underground personnel must complete the BHOP Rasp Mine General and Underground Induction before working underground. A short ground control component is included in the underground induction. BHOP is responsible for providing ground awareness training to all underground personnel.

15 INSPECTIONS AND MONITORING

15.1 Inspections

Three systems are in place for workplace inspections with a geotechnical reporting function:

1. All underground workplaces are inspected every shift by workers according to BHOP workplace inspection sheet, as given in Appendix A3. This includes an item for ground support. Adverse conditions are reported using workplace inspection sheets and/or the geotechnical report form.
2. The Shift Supervisor visits each worker at least twice per shift. A heading checklist is used which includes checks for scaling and ground support installation. This checklist is given in Appendix A4.
3. Periodic geotechnical inspections of active underground workplaces and other non-active areas are conducted by the Geotechnical Engineer. These inspections aim to:
    - Identify developing problems with ground conditions and support for immediate rectification.
    - Build a historical record of conditions that cause problems for later mine design and planning.

- Continue geotechnical data collection for longer term engineering design of excavations, pillars and ground support systems.
- Verify that the support has been installed to the minimum standard.
- Verify that ground support procedures are being followed.
- Develop a program for scheduled rehabilitation.

If significant geotechnical risks are identified in any inspection method, then normal hazard management procedures are followed. In such cases, reporting can follow at a later date.

15.2 Check Scaling

Routine check scaling of the main travel ways is undertaken according to the scaling plans and schedule to remove loose rock below mesh and fibrecrete. Check scaling observations are recorded in the site Check Scaling Record Book. Check scaling crews are trained and assessed as competent to safely conduct scaling operations and recognise adverse ground conditions or support performance that must be reported.

15.3 Ground Support Quality Control

15.3.1 Pull Testing

Pull tests are conducted on a regular basis at Rasp Mine. These tests are to be conducted by/on behalf of BHOP by the supplier of the ground control consumables to confirm compliance to current procedures.

The type of ground control element to be tested will be determined on the day of testing and at a random location. The results are reviewed by the Geotechnical Engineer and any non-conforming results are addressed to rectify any problems.

15.3.2 Cable Bolt Cement Grout Tests

The test will constitute cement grout cylinder compressive tests and must prove an average strength of at least 45MPa after seven days curing. The tests are carried out in accordance with the International Society of Rock Mechanics (ISRM) recommended procedures. The Production Manager is notified should any of the results fail, with appropriate actions being carried out to rectify any problems with the cement grout process.

15.3.3 Fibrecrete Testing

One test panel shall be prepared for compressive strength testing for every 50m^3 of accumulated fibrecrete sprayed. The minimum confined compressive strength of fibrecrete shall be 40MPa after curing as measured from test panels according to relevant Australian Standards. The Production Manager is notified should any of the results fail, with appropriate actions being carried out to rectify any problems with the fibrecrete process.

15.4 Surveying

All development is surveyed. Survey data is stored in Surpac format. This information can be utilised to measure overbreak if necessary. The geotechnical engineer and the underground superintendent monitor over-break during routine inspections. The stability of headings that display greater than 10% overbreak or more than 1 metre for intersections must be assessed by the geotechnical engineer.

15.5 Seismicity

Seismicity is associated with all mining but in many cases the activity is minimal and goes unnoticed. As mining depth and extraction ratio increase, the stresses increase with an accompanying increase in seismicity. The first evidence of this is usually rock noise. If seismicity becomes more extreme, rock bursting conditions develop which pose safety and production risks.

At Rasp the major principal stress acts approximately perpendicular to the strike of the ore body. In the nearby underground mines there are many remnant pillars and abutments being targeted for mining and this is what causes most of the activity at the underground mines in the area. There is regular activity recorded by the micro-seismic network at the adjacent Perilya Mine, but their regional network does not record many events outside their mining lease.

Rock noise heard by the underground workforce can be reported using the geotechnical report form (see Appendix A). The Geotechnical Engineer reviews the level of rock noise during inspections.

15.6 Workforce Reporting of Geotechnical Observations

A geotechnical hazard report form (Rasp Ground Conditions Awareness Form - GCA) (included in Appendix A) is used to report and record observations by the underground workforce, supervisory staff and mine technical staff. The GCA is a key communication tool and is vital for effective implementation of the GCMP. The GCA includes sections for review and sign-off by the Mine Manager. Geotechnical reports are reviewed before routine inspections to provide the Geotechnical Engineer with an overview of conditions between inspections. If adverse conditions are identified between inspections then normal hazard management procedures are followed.

15.7 Geotechnical Observation Information

Geotechnical information is collected and stored on the Rasp Mine servers. Along with the geotechnical model and domains, the stored information also contains observations and recommendations made during geotechnical inspections.

16 RESPONSE PLAN AND INVESTIGATIONS

This section outlines procedures to be followed when unexpected ground conditions are encountered and additional support is deemed necessary. Also presented in this section are the procedures followed during the investigation of rock falls.

All sufficiently adverse changes to ground conditions are communicated to the Geotechnical Engineer for inspection and assessment of ground support requirements.

If a serious geotechnical hazard is identified, normal hazard management procedures are followed to immediately limit exposure to the hazard. In such cases, the routine checklists and inspection systems can be bypassed.

16.1 Trigger Action Response Plan for Additional Ground Support

A trigger action response plan (TARP) outlines the procedures to be followed when ground conditions are encountered that cannot be supported under the minimum ground support standards, and additional support is required. The TARP for additional ground support is summarised in Table 12. The geotechnical report form is used to document and report the additional support, and ground support plans are used to communicate the additional ground support required.

Table 12 TARP for additional ground support

Additional Support Needed	Authority Required	Notification Required for Documentation
Spot bolts	Shift Supervisor	Geotechnical Engineer
Spot mesh	Shift Supervisor	Geotechnical Engineer
Pattern bolts	Mine Superintendent	Geotechnical Engineer and Mine Manager
Pattern mesh	Mine Superintendent	Geotechnical Engineer and Mine Manager

Cable bolts	Mine Superintendent	Geotechnical Engineer, Mine Manager and Surveyor
Fibrecrete	Mine Superintendent	Geotechnical Engineer, Mine Manager and Surveyor

16.2 Rock Fall Reporting and Investigation

All rock falls must be reported to the Shift Supervisor or Mine Superintendent immediately, who must notify the Underground Mine Manager and the Geotechnical Engineer. The geotechnical report form includes a section for recording the initial details of rock falls.

Under NSW mine regulations unplanned falls of ground that impede passage, disrupt production or ventilation or involve failure of ground support where persons could be present are all incidents that require the notification of the Chief Inspector of Mines. All such rock falls are investigated by the Geotechnical Engineer to identify, rectify and document the cause of the fall. The results of such investigations are to be made available to the workforce.

In the case of bolt failure or a fall of ground where reinforcement or support is stripped from the ground, or, where rock failure has the potential to cause damage or injury, a full investigation of the causes of the failure will be undertaken by the Geotechnical Engineer. Where possible the results of such investigations are made available to the workforce

All rock falls, deterioration in ground conditions or failed support are to be investigated by the Geotechnical Engineer. The investigation will record observations and details about the following:

- Excavation design
- Ground support installed
- Geological controlling mechanisms
- Probable stress state
- Impact of external influences (e.g. blast vibration)

It is intended that investigation outcomes are used as a review mechanism and that the results be used to improve safety in the mines through:

- Identifying similar circumstances with the same hazard or damage potential; and
- Eliminating a recurrence of the event.

Failed support and subsequent rehabilitation is documented in order to identify necessary review of minimum ground support standards with the goal of eliminating rehabilitation requirements as far as possible.

16.3 Non-Conforming Ground Support

Where ground support is found to be not installed in accordance with the minimum ground support standard, test results indicating non-conformance of support elements, or support becomes damaged and ineffective, the ground support must be replaced.

17 PROCESS AUDITING AND REVIEW

17.1 Auditing

Auditing of geotechnical processes outlined in this document are adopted to assess compliance with approved standards, operating procedures and control systems.

17.1.1 Operational Compliance

The audit process is intended to capture weaknesses in compliance to the controls defined in the GCMP, rather than in the activities within the system itself. Auditing compliance to controls includes, but is not limited to:

- Compliance with access protocols
- Reporting and communication efficiencies
- Deviation from approved operating procedures

17.1.2 Maintenance of Access

All accessible development, regardless of the frequency of access, will be audited to identify ground condition and/or ground support deterioration. This audit is undertaken at intervals not exceeding 12 months and will document:

- Deterioration of the installed ground support mechanisms
- Deterioration of ground conditions
- Potential geotechnical hazards

Ground support plans shall be issued as required to maintain safe access and where possible, uninterrupted production. Each rehabilitation job should be linked to development or production activities for which the rehabilitation is required, such that resources can be allocated and activities planned to minimise disruption with other activities.

Scheduling of work-plans must take into consideration any hazard priority defined during the audit process.

17.2 Review

The review process encompasses activities undertaken to integrate incoming or new information from the implementation and verification processes into future planning activities. Routine review is required to ensure that weaknesses in the ground control planning system are resolved once they have been identified.

Independent reviews shall be undertaken in the event of a significant unplanned event occurring, or at any time at the discretion of management. The scope of reviews shall be determined by management, based on the review trigger.

17.2.1 Management of Ground Support Standards

The application and technology behind ground support materials is not static, therefore the minimum ground support standards shall be reviewed at intervals not exceeding 12 months and improvements made where possible.

Where rehabilitation is required in development mined prior to the implementation of the current standards, the rehabilitation shall conform to the current minimum ground support standards. Management of these areas shall take into account the routine actions required to maintain a safe workplace (e.g. workplace inspections, check scaling). The requirement for rehabilitation of these areas shall be triggered by a failure of routine actions to render a work location safe by current standards.

17.2.2 Assessment of Access and Production Performance

Review of access and production excavation stability is required to confirm design assumptions and improve production performance and efficiency. Reviews may comprise back analysis of empirical estimates for stability, or assessment of outcomes from ground conditions and hazard reporting.

18 GCMP AUDITING

18.1 Internal Audits

A formal audit program shall be implemented to monitor compliance with the GCMP, assessing its relevance and effectiveness. The frequency of internal audits and the frequency at which each requirement on the GCMP is audited shall reflect the risk of exposure of underground personnel to serious injury (but as minimum, at least every 12 months). Personnel who are technically competent in the subject matter shall conduct internal audits.

18.2 External Audits

An external auditor shall audit the GCMP in full once every 24 months. Following both the internal and external audits, amendments will be made where necessary.

The GCMP will exist as a controlled document.

19 REFERENCES

1. Government of New South Wales, 2004, “Mine Health and Safety Act 2004 No 74”.

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5. Hutchinson, D.J., and Diederichs, M.S., 1996, “Cablebolting in Underground Mines”, BiTech Publishers Ltd, Richmond, British Columbia.

6. Bieniawski Z.T., 1973, “Engineering classification of jointed rock masses”, Trans. S. Afr. Inst. Civ. Engrs., 15, pp.335-344.

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8. Broken Hill Operations Pty Ltd <Backfill Management Plan>

9. Coffey Mining Pty Ltd, 2007, “CBH Resources Limited: Rasp Underground Mine – Subsidence Study”.

10. Ground Control Engineering Pty Ltd (2014), “Zinc Lodes Draft Geotechnical Assessment for CBH Resources Limited”, October 2014

Appendix A

Reporting and Inspection Forms

Appendix A1

Rasp Mine Ground Conditions Awareness Form (GCA)

GROUND CONDITIONS AWARENESS (GCA) **REPORTING FORM** **Observer:**	CBH Resources Limited RASP MINE **Date:** **DS / NS**

Location:	**Time**
What is the Ground Support Standard for this area?	

Observations (Yes/No)	
Have you completed a workplace inspection for this area?	
Is the ground support not installed to standard?	
Is the ground support damaged?	
Is the mesh is bagged or loaded up?	
Do the walls need scaling?	
Has the ground has deteriorated since you were last in this area?	
Has a fall of ground occurred?	
Did you hear rock noise?	
Is the rock affected by faults or shears?	
Is the ground soft? (mudshears?)	

Please describe in your own words. Diagrams are useful. Eg (Large faults present or bad ground).

Pass completed sheets to your Supervisor.

1. Report Form

FOLLOW UP

TO GROUND CONDITIONS OBSERVATION FROM OVERLEAF

CBH Resources Limited

RASP MINE

By:

Date:

Classification:	If there was a rockfall, when did it occur:
☐ Rockfall in development ☐ Rockfall in stope ☐ Visible ground movement ☐ Rocknoise ☐ Potential ground movement	☐ During blasting ☐ Outside blasting

Incident Report: Y / N ,   Number:
Engineer/Superintendent's Notes/Instruction
Feedback given to observer
Sign off;
Geotechnical Engineer / Investigator:
Mine Manager:

2. Follow Up Form

Appendix A2

Rasp Mine Rockfall Reporting Form

CBH Resources Limited

FALL OF GROUND
GEOTECHNICAL REPORTING FORM

FORM_

TIME, LOCATION AND EXTENT OF FOG / DAMAGED ROCKMASS / DAMAGED SUPPORT					
Time and extent	Time of FOG?	FOG tonnes (t)	Damaged area – depth (m)	Damaged area – width (m)	Damaged area - length (m)

Depth (m below surface)	Mine (deepest active stopes)	At fall of ground (FOG)

Location of damage site	Lode/block name	Northing	Easting	RL

EXCAVATION DESIGN (For damaged development / accessway)				
Excavation details – in area of FOG / damage	Date mined	Development width/span (m)	Development height (m)	Perimeter blasting used?

SUMMARY DESCRIPTION OF FOG/ DAMAGED ROCKMASS	
Damage site description	
Site geology, structures, stress conditions, presence of water	Attach Geotechnical map of the FOG area

Kaiser Rock Damage Scale (tick) (see Table 1)	R0 (no rockmass damage)	R1 (minor new fractures)	R2 (minor damage <<1t	R4 (1-10 t displaced)		R5 (>10 t displaced)
Failure mode (tick correct box)	Static Wedge Sliding block Toppling Unravelling	Strain burst (including bulking)	Buckling	Face crush/ pillar burst	Shear rupture/ fault slip	Shakedown

SEISMICITY (fill in this section only if a seismic event has occurred)					
Source mechanism (e.g. high S:P = fault slip)	Time of event	Level RL	Northing	Easting	Distance from Damage site(s)?
Magnitude	Seismic system	Local (ML) (ESG)	S:P energy ratio		

CBH Resources Limited

FALL OF GROUND GEOTECHNICAL REPORTING FORM

FORM_

BLASTING (provide details of last blast before the FOG/seismic event)					
Most recent blast details	Time of blast	Blast tonnes	Blast type (stope production / development/other?)	Exclusion zone details (part of mine closed)	Re-entry period – hours after blast

SUPPORT DAMAGE RATING IN FOG/ DAMAGED AREA						
Kaiser Support Damage Rating (see Table 2) (tick one only)	S0 (no damage)	S1 (1st signs of distress)	S2 (loaded, plates deformed, mesh bagged but OK)	S3 (heavy loaded, few broken, mesh bagged, some torn/open)	S4 (major damage, many broken bolts, mesh failed or bagged to capacity, rock ejected between bolts)	S5 (complete failure of support components)
	SC0 (no damage)	SC1 (1st cracks in shotcrete)	SC2 (shotcrete cracked and loaded)	SC3 (shotcrete fractured, debonding, some fragments)	SC4 (shotcrete heavily fractured, large pieces fallen)	SC5 (shotcrete Non functional)

FORM_

INSTALLED GROUND SUPPORT IN FOG/DAMAGED AREA								
Order of installation	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Support type								
Black / galvanised?								
Bolt length (m)								
Pattern (burden x spacing, m)								
Bolt load capacity (t)								
Bolt energy capacity (kJ/bolt)								
Displacement limit (mm)								
Age of support (months)								
Condition / corrosion?								
Mesh	Sheet size (W x L, m)	Aperture (mm)	Gauge (mm)	Energy (kJ/m2)	Overlap pinned?	Coverage		
						Backs / Shoulder /Grade line		
Shotcrete / fibrecrete	Design thickness (mm)	Actual thickness (mm)	Energy (kJ/m2)	Fibre dosage (kg/m3)	UCS (MPa)	Coverage		
						Backs / Shoulder /Grade line		
GENERAL COMMENTS AND REMEDIAL ACTIONS								
Provide further relevant information. Describe immediate rectifications and actions as a result of this event. Please attach relevant photos, investigation memos, seismic history and data analyses.								

Appendix A3

Rasp Mine Geotechnical Mapping Template

CBH Resources Limited **RASP MINE**

GEOTECHNICAL DEVELOPMENT ASSESSMENT

GEOLOGY

Date:______________ Level: ______________ Heading:________________ Chainage:______________

Geotech: ______________ Profile: ______________ Material Classification: Ore / Waste

Rocktype:_________________________

_____

Alteration:________________________

Comments

GEOTECHNICAL

Label	Dip/Dip Dir	J_{rough}	J_{alt}	Freq	Remarks
1					
2					
3					
4					

Water: dry / damp

Ground Noise: Y / N

Half Barrels:

Profile: Good Poor Very Poor

Overbreak: < 0.3 m / 0.3 – 0.5 m / > 0.5m

ASSESSMENT

Ground Stability: Good / Poor / Very Poor

Possible Failure Mechanisms: ____

GROUND SUPPORT RECOMMENDATIONS

Additional Scaling Advised: ____

____

Additional Support Advised:____

____

(If advised then specify where)

Comments:____

____

____

Signed:

____

Geotechnical Engineer

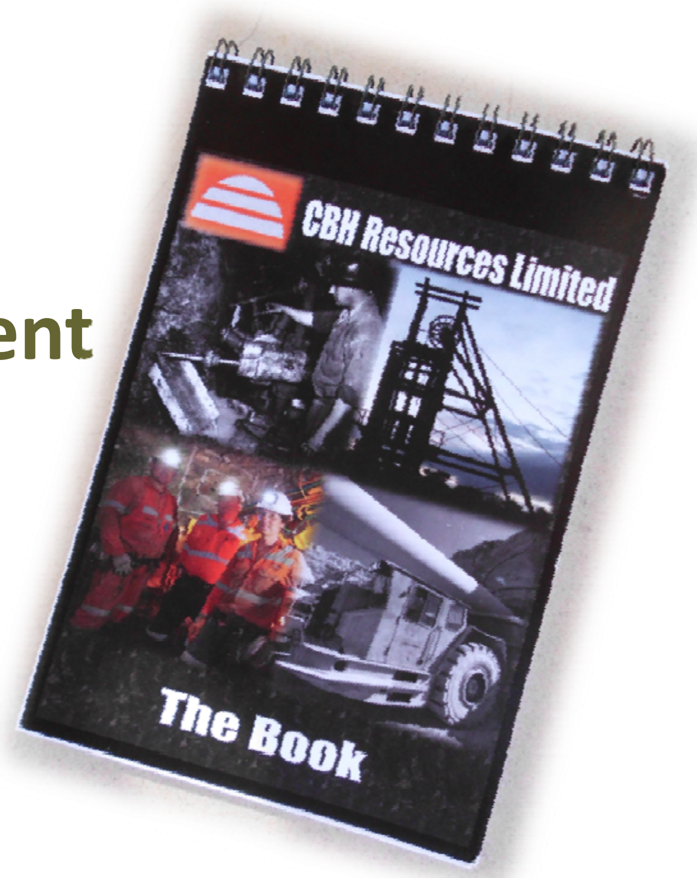
Appendix A4

Workplace inspection sheet

CBH Resources Limited

BHOP Rasp Mine

Broken Hill Rasp Mine
Quick Check Risk Assessment
Presentation



The reasons for changing from the TAKE 5 to the new format are that:

- There was an opportunity to develop a system that was more suited to our needs.
- A system was needed for a mini/quick Incident Report system.

Format

CBH Resources Limited

- Easier to use process following the same principles as the TAKE 5.
- Place name and details at top of page.
- Tick YES or NO to the questions.
- If the square you ticked is GREEN you are OK to proceed.
- If the square you ticked is RED you need to do something about why or contact the Supervisor.
- Sign bottom of form when filled in.

BHOP Task Assessment # 000001

Name:		
Time & Date:	Crew number:	
Dept:	Company:	
Task description:		
Pre Task Questions	**Yes**	**No**
Do I know where the nearest muster point, safety shower and/or refuge chamber is?	Green	Red
Can I be struck by objects while performing the task?	Red	Green
Do I have the required tools and/or PPE?	Green	Red
Can my work cause injury or damage?	Red	Green
Do I require any permits to perform the task?	Red	Green
Have I identified any hazards in the environment I will be working in?	Red	Green
Will my work directly affect other workers?	Red	Green
Can I eliminate the hazards associated with the task?	Green	Red
I have a clear plan to complete the task	Green	Red

- N/A if not applicable
- RED boxes require controls to be in place before starting the task
- Green boxes indicate you are ok to start the task

Employee signature:	**Visitor initials:**		
Supervisor signature:			

Format

CBH Resources Limited

- Back of the form has a found hazard and control section.
- If you are confident you can do the job safely tick the GREEN box and commence the job.
- If you don't think the job can be done safely, tick the RED box and contact the Supervisor.
  A JSA may be required.

Hazard	Control

I am satisfied with my control measures and am ready to begin the task. YES ☐ NO ☐

If you are unable to adequately control the hazard, stop and contact your supervisor

Hazard Report ☐	Near Miss ☐	DATE:	24hr Time:
Description:			
Location:			
Corrective action taken:			

The bottom section is used to report incidents and other hazards that you may come across.

You only need to fill in your name and details on the front page and this section if used as a Mini Incident Report.

Hazards & Controls

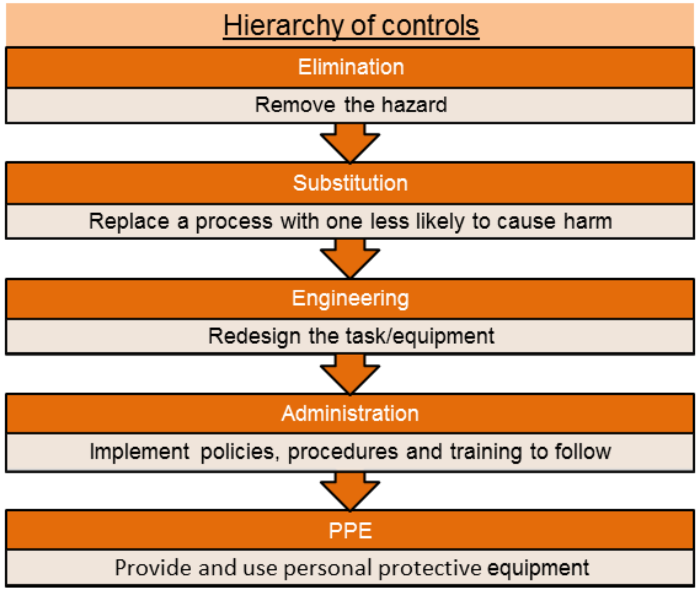
CBH Resources Limited

The book can help as there is a list of potential hazards to reference.

There is also a reference to how you may be able to work out the best control for the hazard.

Potential hazards in your area

Physical	Chemical	Biological	Ergonomic	Engineering
Spills/liquid	Slip/trip/fall	Manual handling	Confined space	Vehicles
Heat	Lighting	Working at heights	Tools / equipment	Dust / fumes / gas
Pressure	Noise	Ground conditions	Other workers	Stored energy



Why do a Risk Assessment?

CBH Resources Limited

This page is to remind you that the more we do this type of risk assessment the safer we make the workplace.

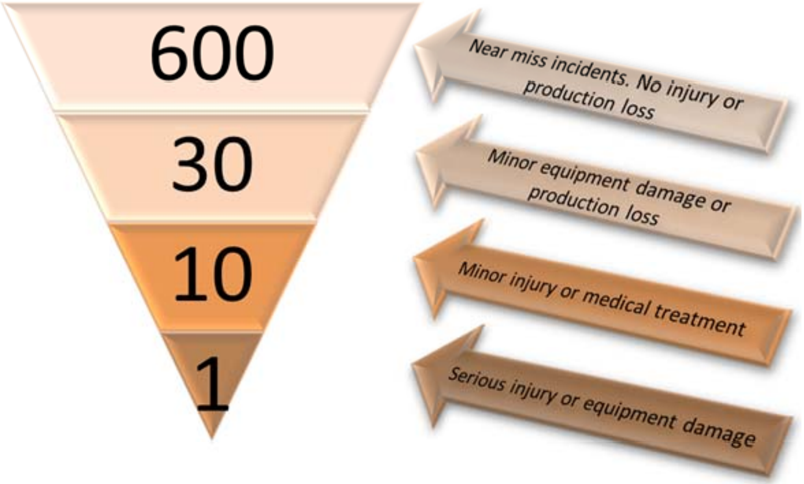
Every time we find and remove a hazard from the work place we remove a chance that someone may get hurt.

Based on a study of

- 1,753,498 reported incidents from;
- 21 industrial groups; and
- Over 3 billion man hours.

Frank bird developed a ratio of incidents and their varying severity

Frank Bird's inverse pyramid



This is a good guideline to compare our reporting culture against.

A strong reporting culture at BHOP

- Empowers proactive health and safety initiatives;
- Controls and reduces the number of incidents; and
- Dramatically reduces the likelihood of a significant event.

How would you rate our reporting culture?

Emergency Information

CBH Resources Limited

The back page has been used as a quick guide to emergency calls should you find yourself in the middle of an emergency situation.

Remember once you make the call don't hang up.
Wait until all questions have been asked and you are told that it is OK hang up.

BHOP Site Emergency Contacts

Phone: 8088 9113

Extension: 113

Main Radio Channels For Communication

Mining: Rasp 1
Processing: Mill 3

What to say when transmitting for an emergency

Emergency, Emergency, Emergency

Then provide the following information

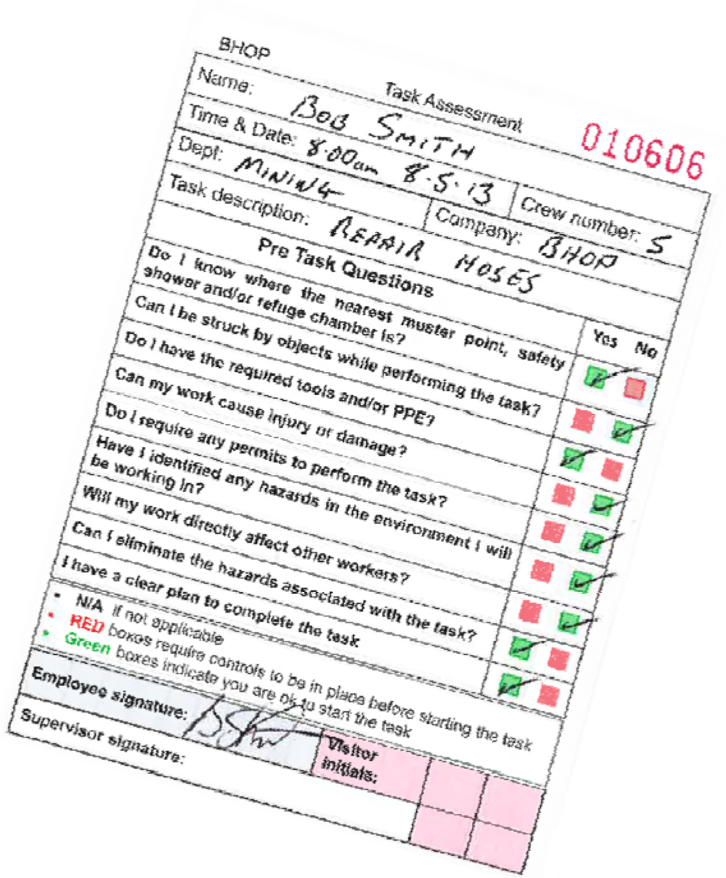
Who:	Your Name
Where:	Location of where help is required
What:	Type of incident
How Many:	How many people are injured

DO NOT HANG UP UNTIL TOLD TO DO SO

Completed Forms

CBH Resources Limited

When the job has finished and at the end of shift, the assessment form is handed onto the Supervisor who will check the hazards and sign off on the bottom the front page.



BHOP

Task Assessment 010606

Name: Bob Smith

Time & Date: 8:00am 8.5.13

Dept: Mining

Crew number: 5

Task description: Repair hoses

Company: BHOP

Pre Task Questions

Do I know where the nearest muster point, safety shower and/or refuge chamber is? — Yes / No

Can I be struck by objects while performing the task? — Yes / No

Do I have the required tools and/or PPE? — Yes / No

Can my work cause injury or damage? — Yes / No

Do I require any permits to perform the task? — Yes / No

Have I identified any hazards in the environment I will be working in? — Yes / No

Will my work directly affect other workers? — Yes / No

Can I eliminate the hazards associated with the task? — Yes / No

I have a clear plan to complete the task — Yes / No

- N/A if not applicable
- RED boxes require controls to be in place before starting the task
- Green boxes indicate you are ok to start the task

Employee signature:

Supervisor signature:

Visitor initials:

Appendix A5

Rasp Mine Development Heading Checklist

Development Checklist Form

Date:		**Heading:**	
Chainage From:		**Chainage to:**	
Profile:		**Ground Support Standard:**	

Bolting Pattern	Yes	No	Comments
Does the pattern conform to the standard?	☐	☐	
Bolt installation angles? *(standard ± 10^o)*	☐	☐	
Condition of split set ring? *(damaged during installation?)*	☐	☐	
Number of pull test rings installed? *(standard 2 per cut)*	☐	☐	
Mesh overlap? *(standard 200mm)*	☐	☐	
Mesh contact with rock surface?	☐	☐	
Damage to mesh? *(equipment related damage)*	☐	☐	
Fibrecrete coverage?	☐	☐	
Fibrecrete thickness indicators?	☐	☐	

Cable Bolts	Yes	No	Comments
Pattern conforms to design?	☐	☐	
All cables are plated and tensioned?	☐	☐	
Is grout testing data available for this installation?	☐	☐	

Observations	Yes	No	Comments
Wall condition below support?	☐	☐	
Bagging of mesh?	☐	☐	
Condition of ground support?	☐	☐	

Geotechnical Conditions	Yes	No	Comments
Are the conditions as expected? *E.g. geological structure or adverse stress conditions*	☐	☐	

Assessment	Yes	No	Comments
Does the ground support installation conform to the design standard?	☐	☐	
Further work required?	☐	☐	

Sign-Off	Full Name	Signature	Date
Geotechnical Engineer:			
Mine Superintendent:			

Appendix B

Ground Support

Appendix B1

Minimum Development Ground Support Standards

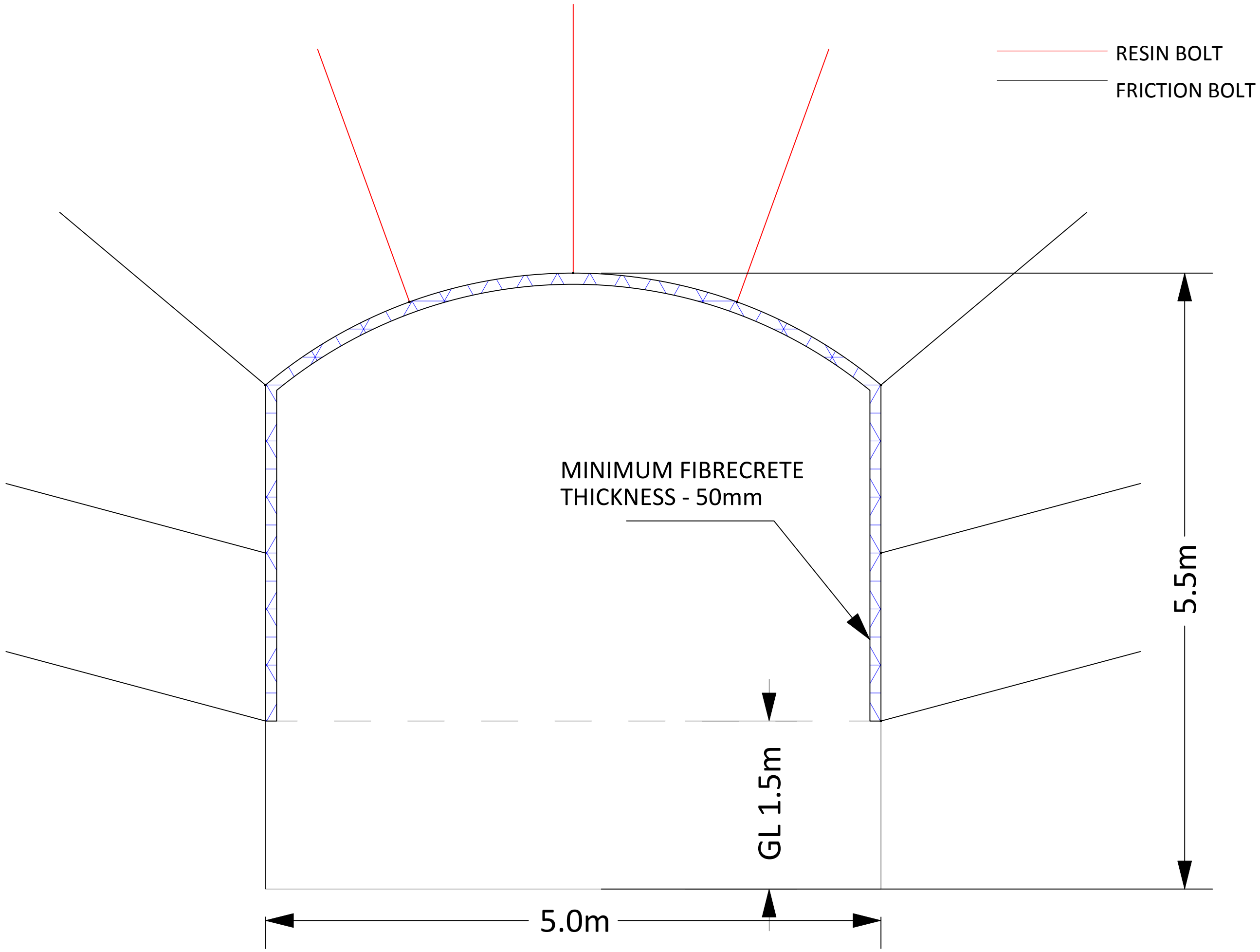
CBH Resources Limited

RASP MINE

GROUND SUPPORT STANDARD
PROFILE A

PROFILE: 5.5mH x 5.0mW ARCH

GOOD GROUND CONDITIONS



MINIMUM GROUND SUPPORT REQUIREMENTS

- SCALE HEADING WITH JUMBO
- INSTALL EXTRA BOLTS IF REQUIRED

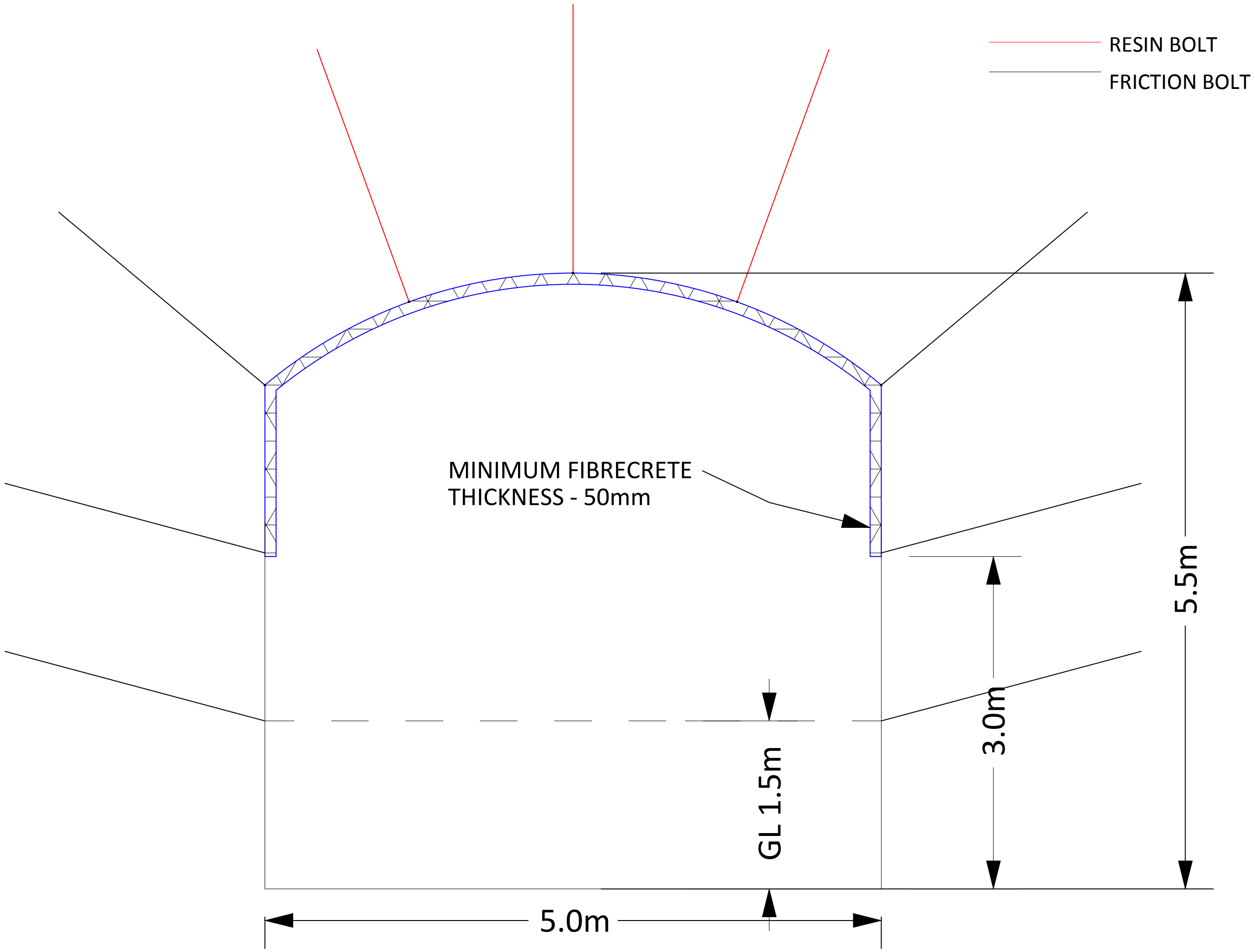
SPECIFICATIONS		
DRILLING DETAILS	HOLE DIAMETER FRICTION BOLT RESIN BOLT HOLE DEPTH COLLAR TOLERANCE ROW & RING SPACING	 45mm 32mm 2.4m 100mm 1.5m
RESIN BOLT	BOLT LENGTH NOMINAL DIAMETER MINIMUM YIELD STRENGTH	2.4m 20mm 195 KN
FRICTION BOLT	BOLT LENGTH NOMINAL DIAMETER YIELD CAPACITY - MINIMUM	2.4m 46mm 130 KN
FIXTURES	DOMED PLATES STUBBY BOLTS	150mm X 150mm X 5mm 39mm x 0.9m
FIBRECRETE	UCS (28 DAY) MINIMUM TOUGHNESS FIBRE TYPE FIBRE DOSAGE MINIMUM THICKNESS	40 MPa 400 J STEEL 40 KG/M3 50 MM

GEOTECHNICAL ENGINEER	UNDERGROUND SUPERINTENDENT	MANAGER MINING	DATE

DO NOT SCALE

CBH Resources Limited

RASP MINE



GROUND SUPPORT STANDARD PROFILE B

PROFILE: 5.5mH x 5.0mW ARCH

GOOD GROUND CONDITIONS

MINIMUM GROUND SUPPORT REQUIREMENTS

- SCALE HEADING WITH JUMBO
- INSTALL EXTRA BOLTS IF REQUIRED

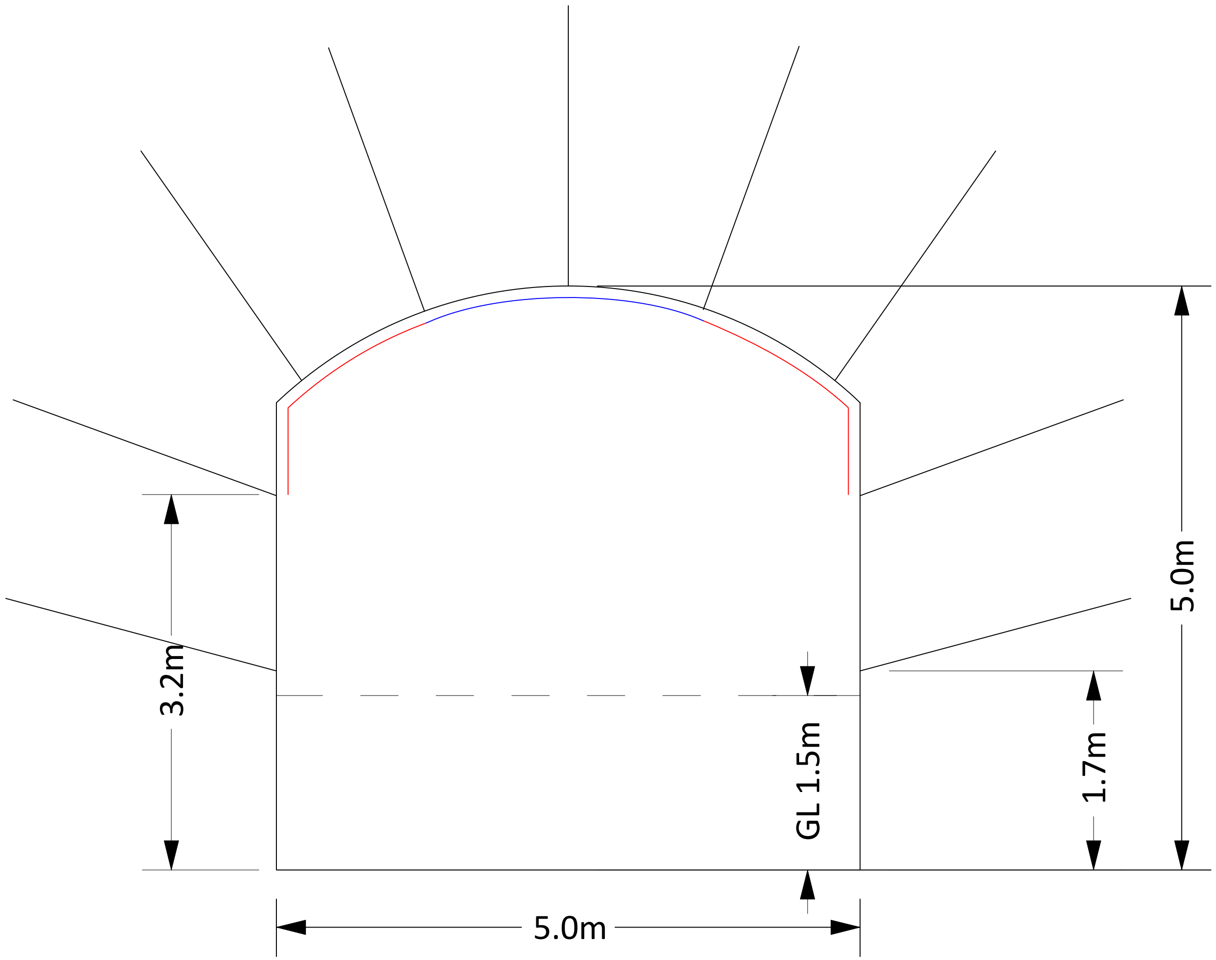
SPECIFICATIONS		
DRILLING DETAILS	HOLE DIAMETER FRICTION BOLT RESIN BOLT HOLE DEPTH COLLAR TOLERANCE ROW & RING SPACING	 45mm 32mm 2.4m 100mm 1.5m
RESIN BOLT	BOLT LENGTH NOMINAL DIAMETER MINIMUM YIELD STRENGTH	2.4m 20mm 195 KN
FRICTION BOLT	BOLT LENGTH NOMINAL DIAMETER YIELD CAPACITY - MINIMUM	2.4m 46mm 130 KN
FIXTURES	DOMED PLATES STUBBY BOLTS	150mm X 150mm X 5mm 39mm x 0.9m
FIBRECRETE	UCS (28 DAY) MINIMUM TOUGHNESS FIBRE TYPE FIBRE DOSAGE MINIMUM THICKNESS	40 MPa 400 J STEEL 40 KG/M3 50 MM

GEOTECHNICAL ENGINEER	UNDERGROUND SUPERINTENDENT	MANAGER MINING	DATE

DO NOT SCALE

CBH Resources Limited

RASP MINE



GROUND SUPPORT STANDARD PROFILE C

PROFILE: 5.0mH x 5.0mW ARCH

GOOD GROUND CONDITIONS

MINIMUM GROUND SUPPORT REQUIREMENTS

- SCALE HEADING WITH JUMBO
- INSTALL EXTRA BOLTS IF REQUIRED

SPECIFICATIONS		
DRILLING DETAILS	HOLE DIAMETER HOLE DEPTH COLLAR TOLERANCE IN RING SPACING ROW SPACING	43.5 - 44.5mm 2.4m 100mm 1.1m 1.3m
FRICTION BOLT	BOLT LENGTH NOMINAL DIAMETER YIELD CAPACITY - MINIMUM	2.4m 46mm 130 KN
FIXTURES	DOMED PLATES STUBBY BOLTS	150mm X 150mm X 5mm 39mm x 0.9m
MESH	OVERLAP APERTURE SURFACE PROTECTION SIZE	200mm 100mm SQUARE GALVANISED 4.0m X 2.4m

PLEASE TURN OVER FOR MESH PLAN

GEOTECHNICAL ENGINEER	UNDERGROUND SUPERINTENDENT	MANAGER MINING	DATE

DO NOT SCALE

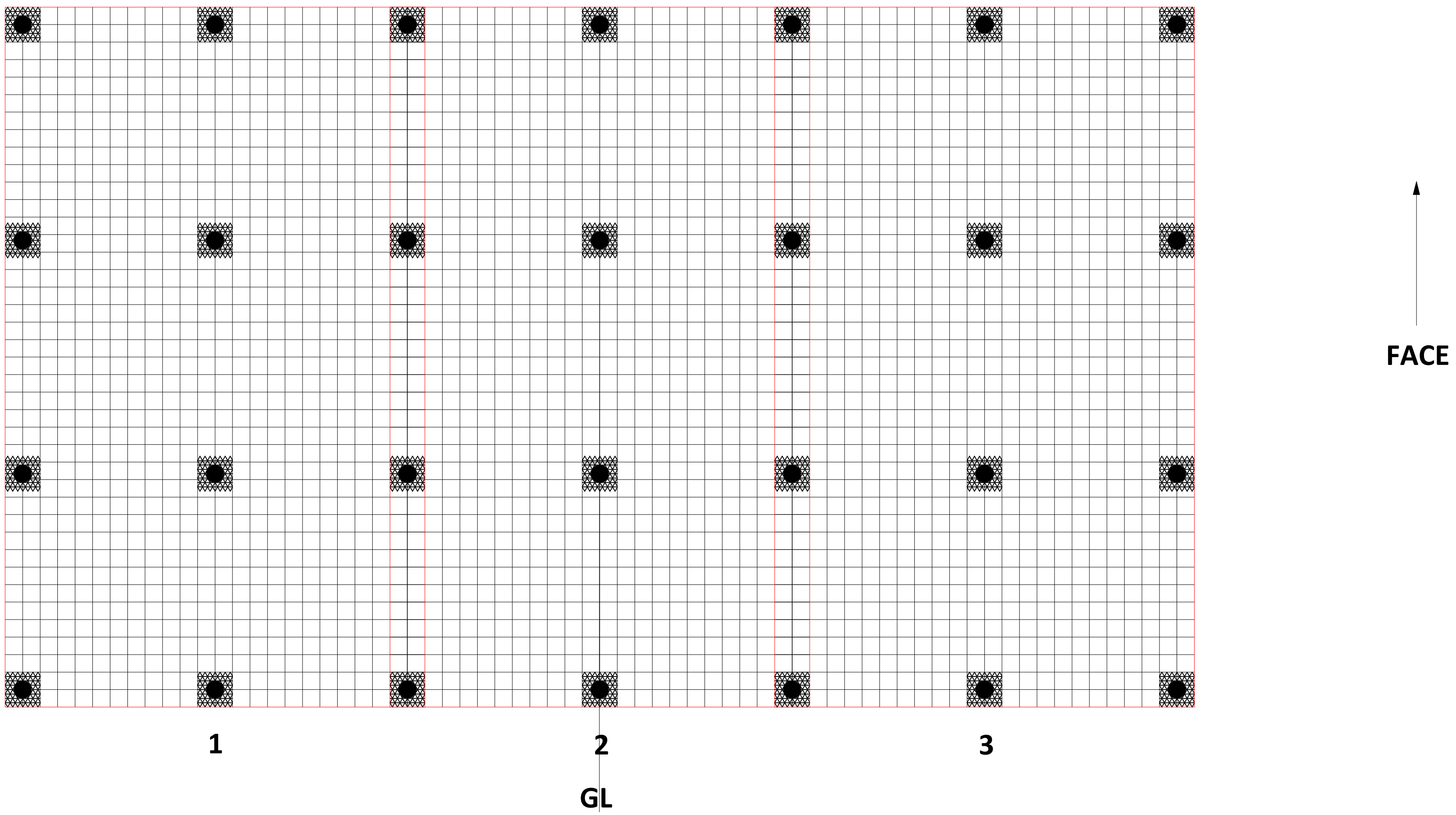
RASP MINE

CBH Resources Limited

GROUND SUPPORT STANDARD
PROFILE C MESH PATTERN

3 SHEETS OF MESH
36 FRICTION BOLTS
STUBBY BOLTS AS REQUIRED

PROFILE: 5.0mH x 5.0mW ARCH
GOOD GROUND CONDITIONS



DO NOT SCALE

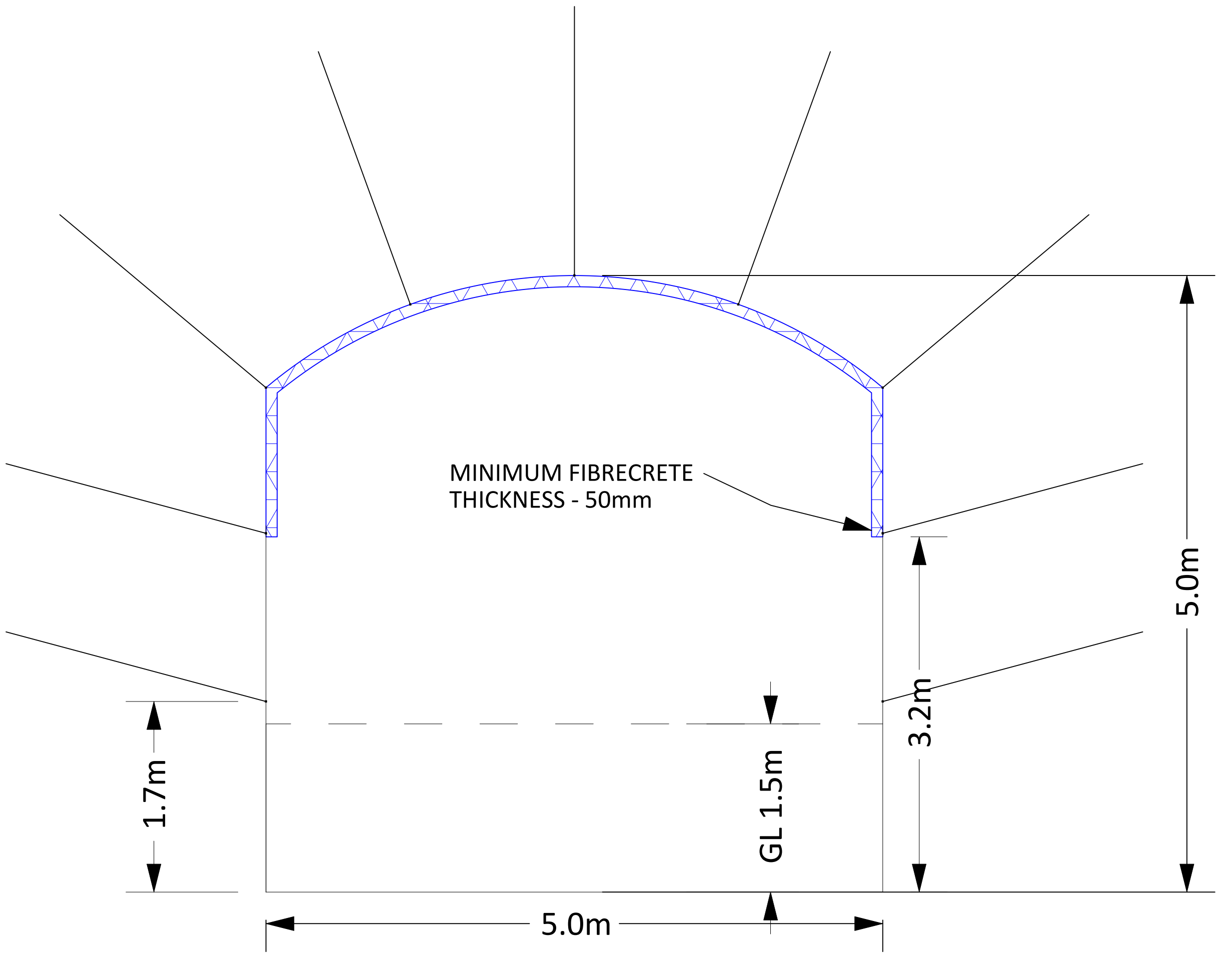
CBH Resources Limited

RASP MINE

GROUND SUPPORT STANDARD
PROFILE C2

PROFILE: 5.0mH x 5.0mW ARCH

GOOD GROUND CONDITIONS



MINIMUM GROUND SUPPORT REQUIREMENTS

- SCALE HEADING WITH JUMBO
- INSTALL EXTRA BOLTS IF REQUIRED

SPECIFICATIONS		
DRILLING DETAILS	HOLE DIAMETER HOLE DEPTH COLLAR TOLERANCE IN RING SPACING ROW SPACING	43.5 - 44.5mm 2.4m 100mm 1.1m 1.3m
FRICTION BOLT	BOLT LENGTH NOMINAL DIAMETER YIELD CAPACITY - MINIMUM	2.4m 46mm 130 KN
FIXTURES	DOMED PLATES STUBBY BOLTS	150mm X 150mm X 5mm 39mm x 0.9m
FIBRECRETE	UCS (28 DAY) MINIMUM TOUGHNESS FIBRE TYPE FIBRE DOSAGE MINIMUM THICKNESS	40 MPa 400 J STEEL 40 KG/M3 50 MM

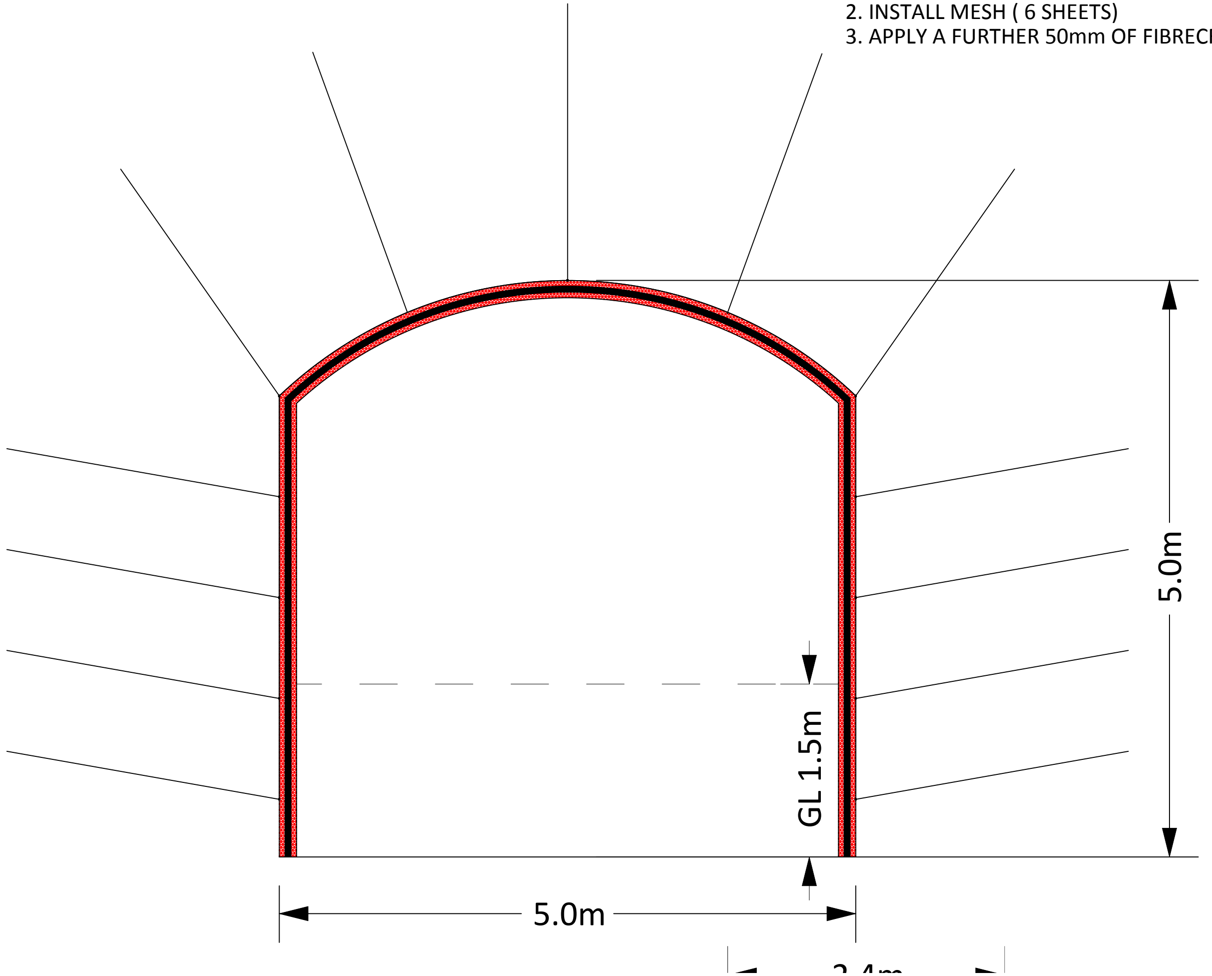
GEOTECHNICAL ENGINEER	UNDERGROUND SUPERINTENDENT	MANAGER MINING	DATE

DO NOT SCALE

CBH Resources Limited

RASP MINE

INSTRUCTIONS
1. FIBRECRETE FLOOR TO FLOOR 25mm
2. INSTALL MESH (6 SHEETS)
3. APPLY A FURTHER 50mm OF FIBRECRETE



GROUND SUPPORT STANDARD
PROFILE D

PROFILE: 5.0mH x 5.0mW ARCH
MLD PILLAR MINING
GOOD GROUND CONDITIONS

MINIMUM GROUND SUPPORT REQUIREMENTS

- SCALE HEADING WITH JUMBO
- INSTALL EXTRA BOLTS IF REQUIRED

SPECIFICATIONS		
DRILLING DETAILS	HOLE DIAMETER HOLE DEPTH COLLAR TOLERANCE IN RING SPACING ROW SPACING	43.5 - 44.5mm 2.4m 100mm 1.1m 1.3m
FRICTION BOLT	BOLT LENGTH NOMINAL DIAMETER YIELD CAPACITY - MINIMUM	2.4m 46mm 130 KN
FIXTURES	DOMED PLATES STUBBY BOLTS	150mm X 150mm X 5mm 39mm x 0.9m
MESH	OVERLAP APERTURE SURFACE PROTECTION SIZE	200mm 100mm SQUARE GALVANISED 4.0m X 2.4m
FIBRECRETE	UCS (28 DAY) MINIMUM TOUGHNESS FIBRE TYPE FIBRE DOSAGE MINIMUM THICKNESS	40 MPa 400 J STEEL 40 KG/M3 50 MM

GEOTECHNICAL ENGINEER	UNDERGROUND SUPERINTENDENT	MANAGER MINING	DATE

DO NOT SCALE

PLEASE TURN OVER FOR MESH PLAN

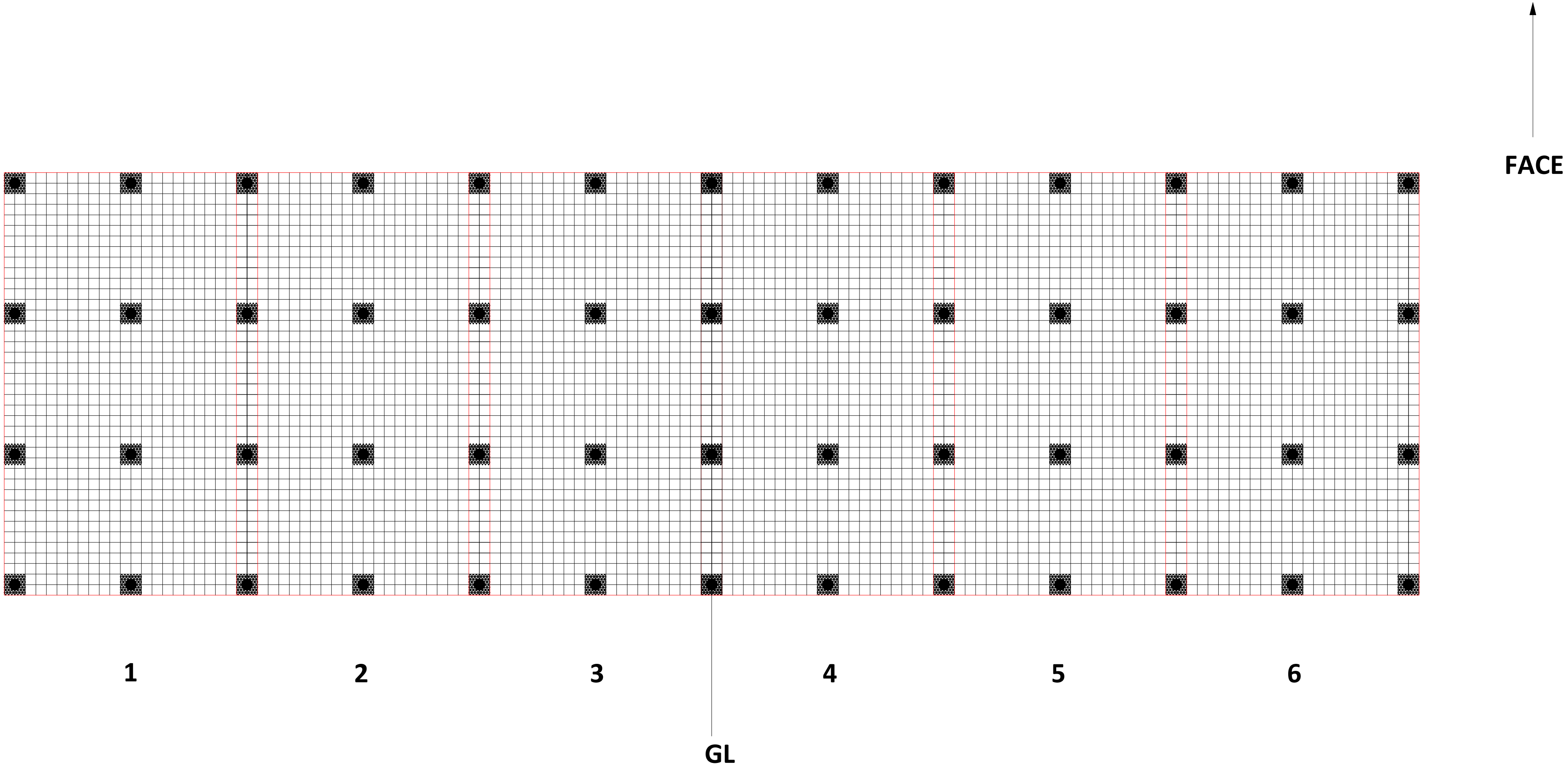
CBH Resources Limited

RASP MINE

GROUND SUPPORT STANDARD
PROFILE D MESH PATTERN

6 SHEETS OF MESH
52 FRICTION BOLTS
STUBBY BOLTS AS REQUIRED

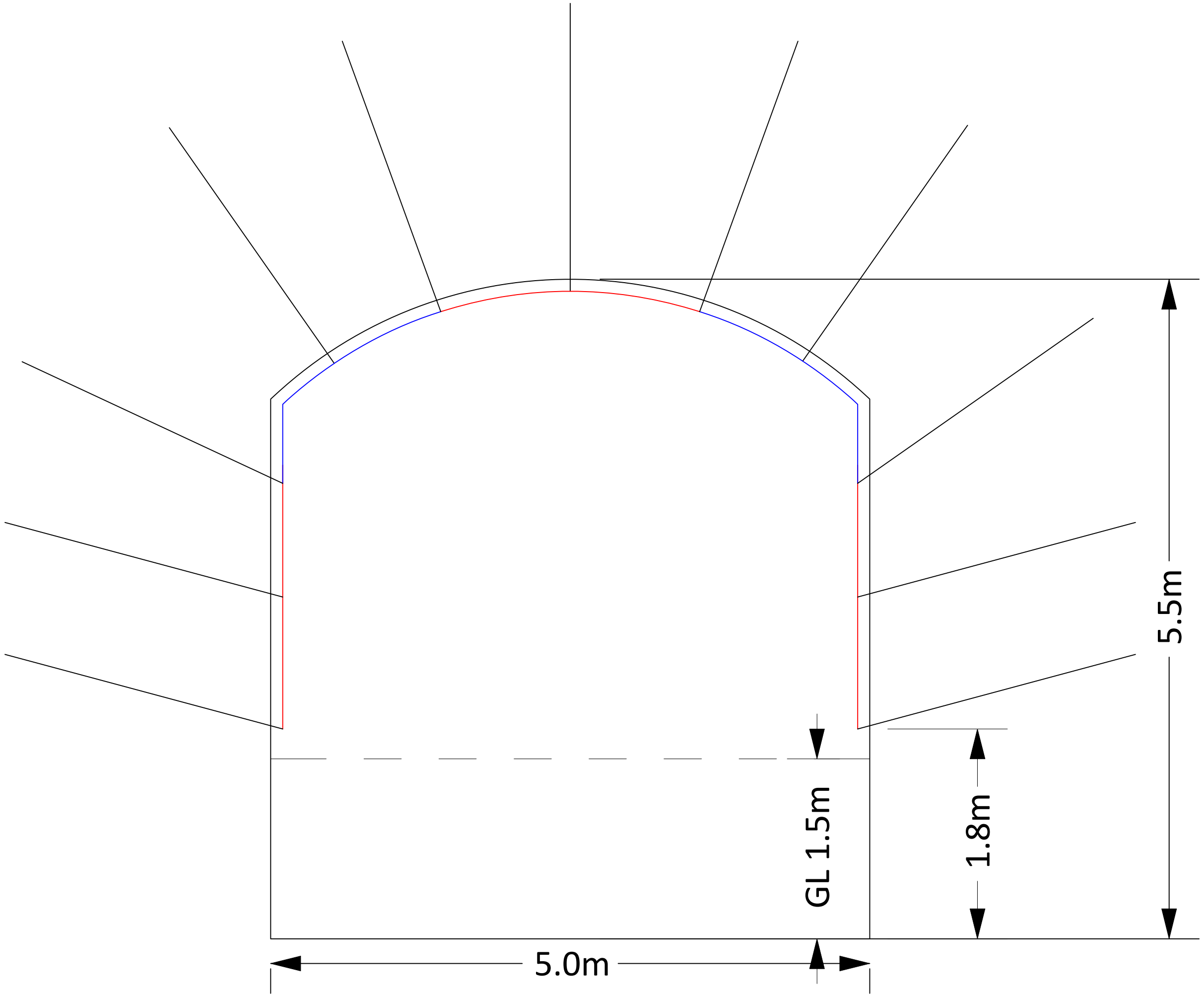
PROFILE: 5.0mH x 5.0mW ARCH
MLD PILLAR MINING



DO NOT SCALE

CBH Resources Limited

RASP MINE



GROUND SUPPORT STANDARD
Profile E

PROFILE: 5.5mH x 5.0mW ARCH

GOOD GROUND CONDITIONS

MINIMUM GROUND SUPPORT REQUIREMENTS

- SCALE HEADING WITH JUMBO
- INSTALL EXTRA BOLTS IF REQUIRED

SPECIFICATIONS		
DRILLING DETAILS	HOLE DIAMETER HOLE DEPTH COLLAR TOLERANCE IN RING SPACING ROW SPACING	43.5 - 44.5mm 2.4m 100mm 1.1m 1.3m
FRICTION BOLT	BOLT LENGTH NOMINAL DIAMETER YIELD CAPACITY - MINIMUM	2.4m 46mm 130 KN
FIXTURES	DOMED PLATES STUBBY BOLTS	150mm X 150mm X 5mm 39mm x 0.9m
MESH	OVERLAP APERTURE SURFACE PROTECTION SIZE	200mm 100mm SQUARE GALVANISED 4.0m X 2.4m

PLEASE TURN OVER FOR MESH PLAN

GEOTECHNICAL ENGINEER	UNDERGROUND SUPERINTENDENT	MANAGER MINING	DATE

DO NOT SCALE

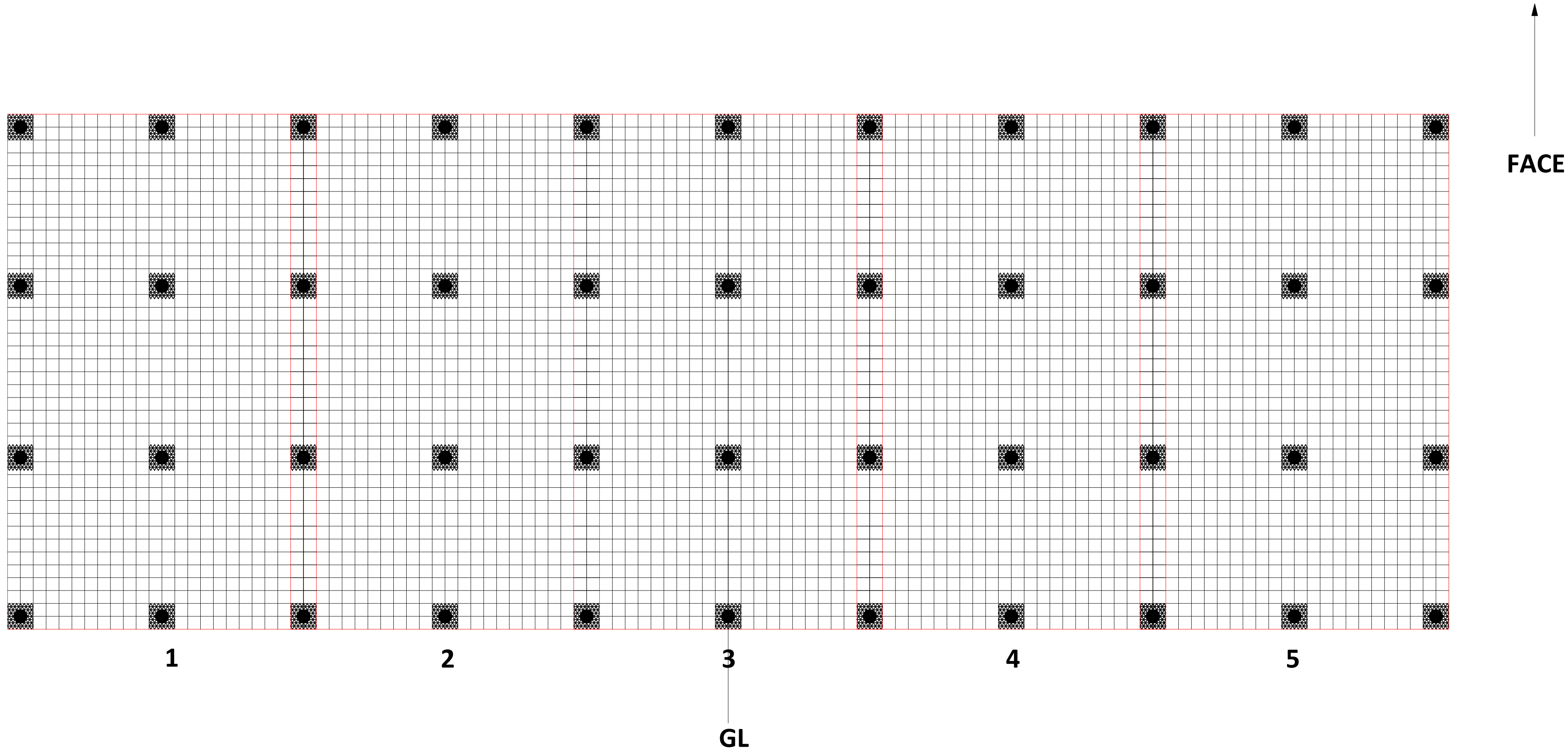
CBH Resources Limited

RASP MINE

GROUND SUPPORT STANDARD
PROFILE E MESH PATTERN

5 SHEETS OF MESH
44 FRICTION BOLTS
STUBBY BOLTS AS REQUIRED

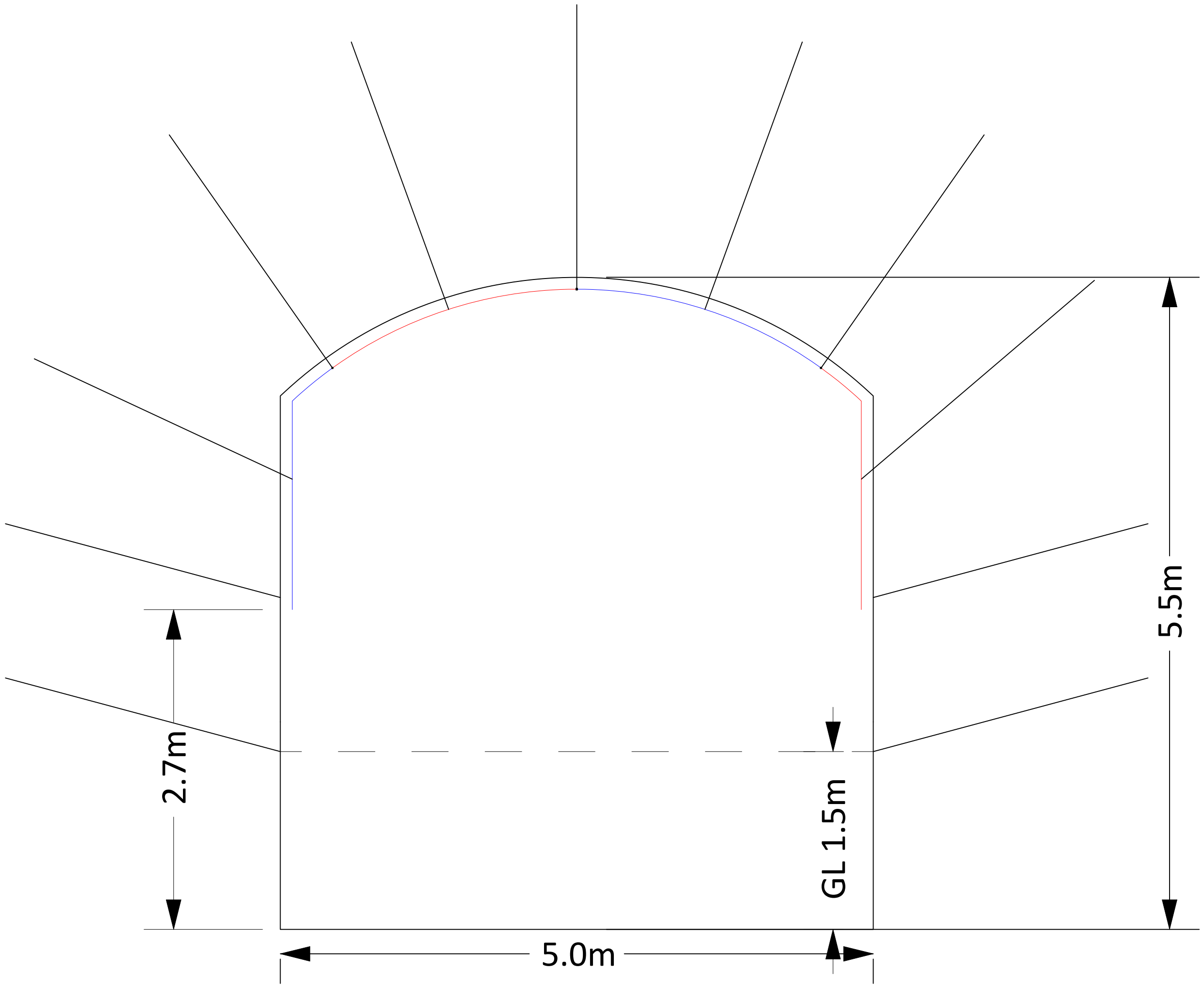
PROFILE: 5.5mH x 5.0mW ARCH
GOOD GROUND CONDITIONS



DO NOT SCALE

CBH Resources Limited

RASP MINE



GROUND SUPPORT STANDARD
Profile F

PROFILE: 5.5mH x 5.0mW ARCH

GOOD GROUND CONDITIONS

MINIMUM GROUND SUPPORT REQUIREMENTS

- SCALE HEADING WITH JUMBO
- INSTALL EXTRA BOLTS IF REQUIRED

SPECIFICATIONS		
DRILLING DETAILS	HOLE DIAMETER HOLE DEPTH COLLAR TOLERANCE IN RING SPACING ROW SPACING	43.5 - 44.5mm 2.4m 100mm 1.1m 1.3m
FRICTION BOLT	BOLT LENGTH NOMINAL DIAMETER YIELD CAPACITY - MINIMUM	2.4m 46mm 130 KN
FIXTURES	DOMED PLATES STUBBY BOLTS	150mm X 150mm X 5mm 39mm x 0.9m
MESH	OVERLAP APERTURE SURFACE PROTECTION SIZE	200mm 100mm SQUARE GALVANISED 4.0m X 2.4m

PLEASE TURN OVER FOR MESH PLAN

GEOTECHNICAL ENGINEER	UNDERGROUND SUPERINTENDENT	MANAGER MINING	DATE

DO NOT SCALE

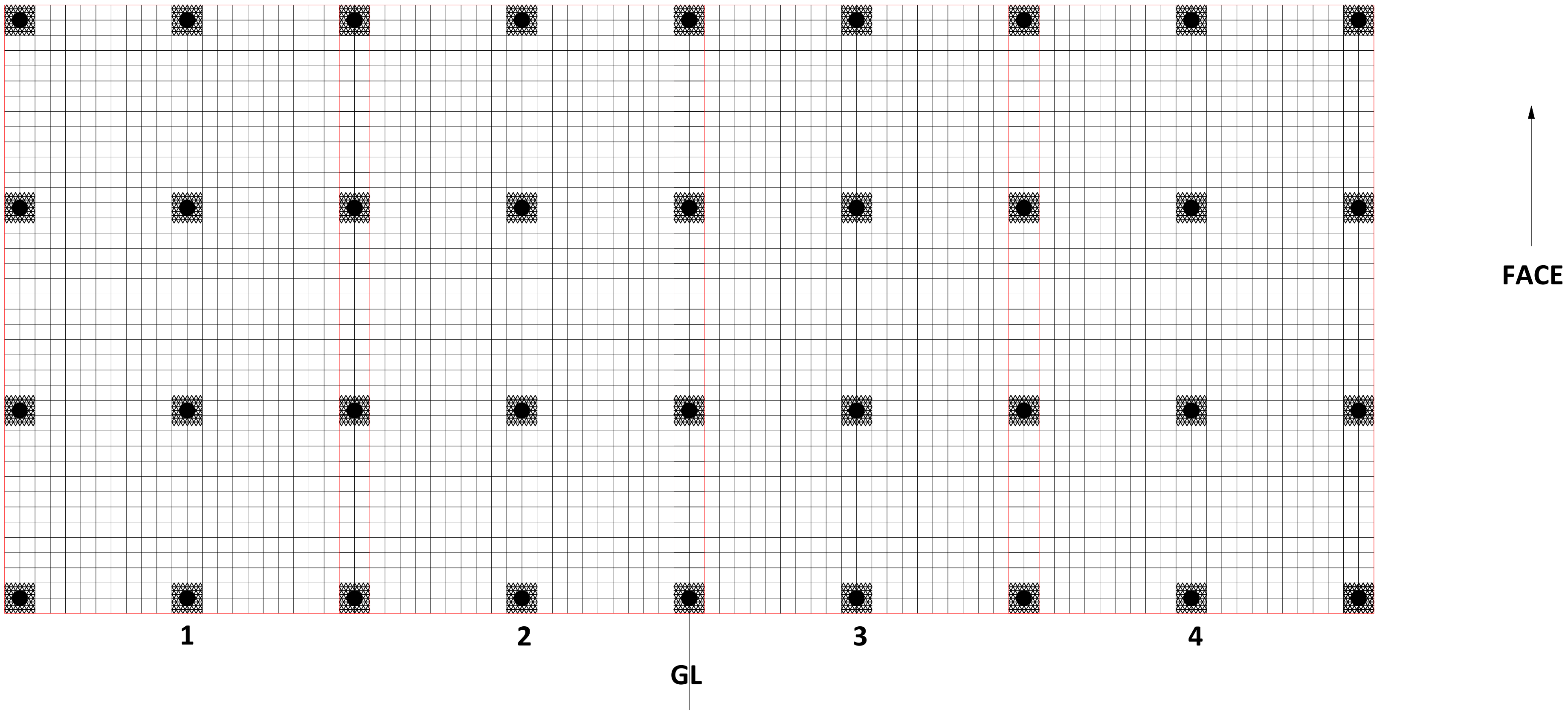
CBH Resources Limited

RASP MINE

GROUND SUPPORT STANDARD
PROFILE F MESH PATTERN

4 SHEETS OF MESH
44 FRICTION BOLTS
STUBBY BOLTS AS REQUIRED

PROFILE: 5.5mH x 5.0mW ARCH



DO NOT SCALE

Appendix B2

Standard Intersection Cable Bolt Designs

CBH Resources Limited

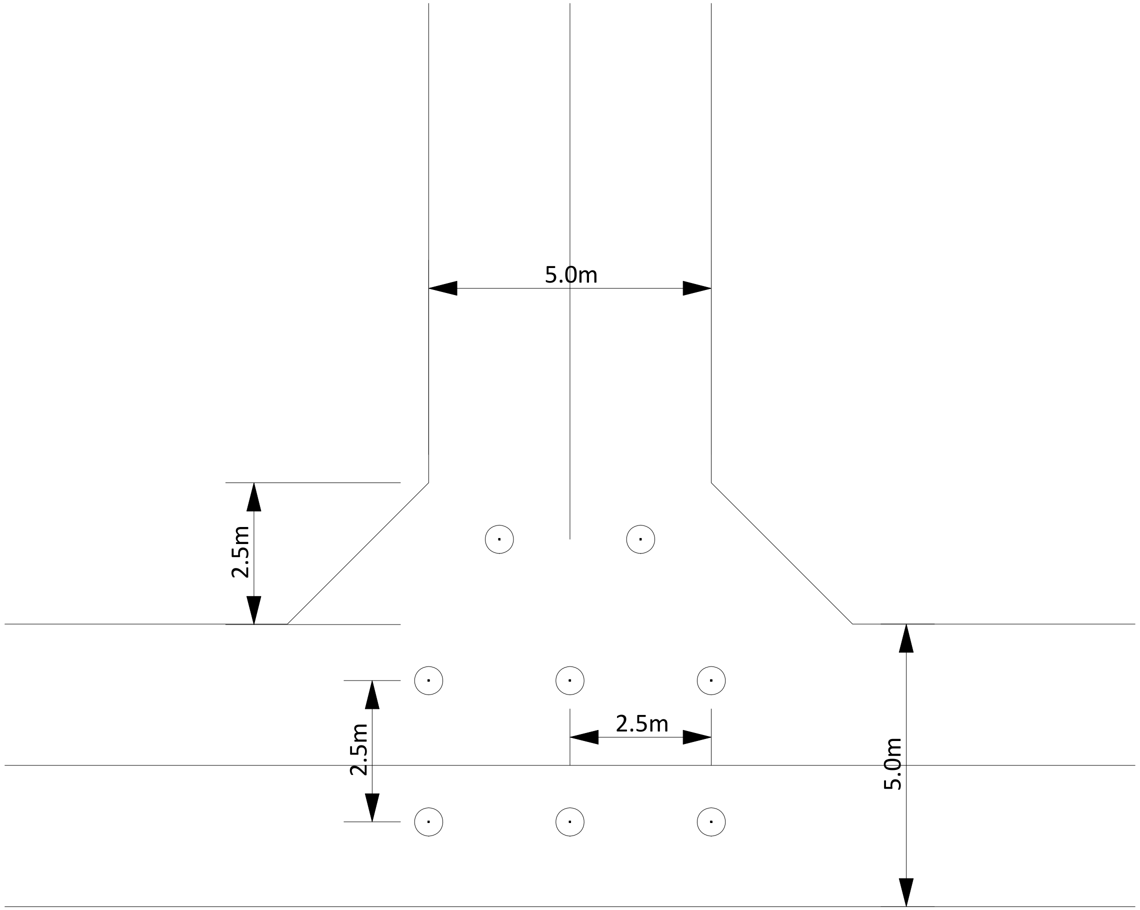
RASP MINE

GROUND SUPPORT STANDARD

INTERSECTION CABLE BOLT DESIGN

5m X 5m INTERSECTION, 2.5m FILLETS

3 - WAY INTERSECTION



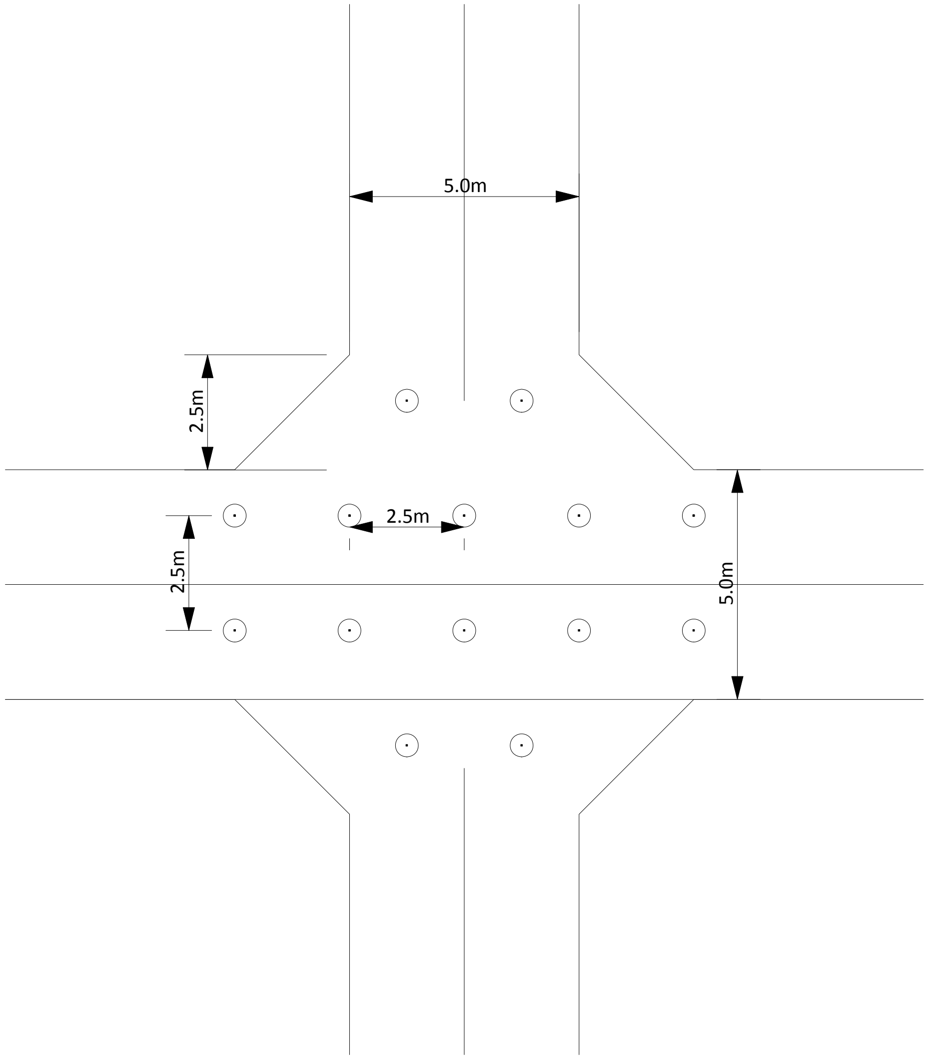
SPECIFICATIONS	
TYPE LENGTH SPACING	TWIN STRAND BULBED 6m OR AS PER DESIGN 2.5m X 2.5m OR AS PER DESIGN
CABLE TYPE	
CAPACITY BULBS GROUT WATER CEMENT RATIO CEMENT TYPE	25T PER STRAND BULB EVERY 1/2m FULL COLUMN GROUT 0.3 TO 0.4 NORMAL PORTLAND CEMENT
PLATES	
MINIMUM THICKNESS MINIMUM DIAMETER	7.0 MM 150 MM

GEOTECHNICAL ENGINEER	UNDERGROUND SUPERINTENDENT	MANAGER MINING	DATE

DO NOT SCALE

CBH Resources Limited

RASP MINE



GROUND SUPPORT STANDARD

INTERSECTION CABLE BOLT DESIGN

5m X 5m INTERSECTION, 2.5m FILLETS

4 - WAY INTERSECTION

SPECIFICATIONS	
TYPE LENGTH SPACING	TWIN STRAND BULBED 6m OR AS PER DESIGN 2.5m X 2.5m OR AS PER DESIGN
CABLE TYPE	
CAPACITY BULBS GROUT WATER CEMENT RATIO CEMENT TYPE	25T PER STRAND BULB EVERY 1/2m FULL COLUMN GROUT 0.3 TO 0.4 NORMAL PORTLAND CEMENT
PLATES	
MINIMUM THICKNESS MINIMUM DIAMETER	7.0 MM 150 MM

GEOTECHNICAL ENGINEER	UNDERGROUND SUPERINTENDENT	MANAGER MINING	DATE

DO NOT SCALE

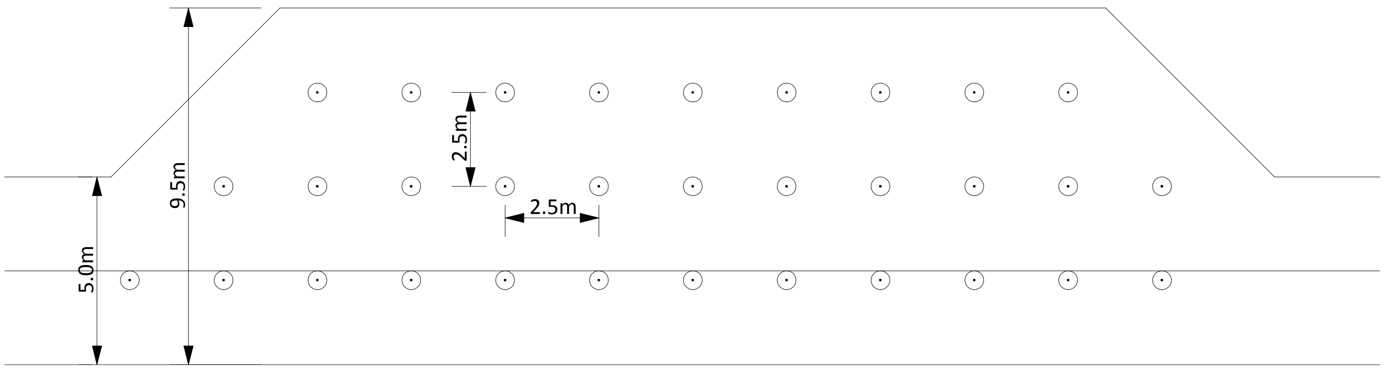
CBH Resources Limited

RASP MINE

GROUND SUPPORT STANDARD

DECLINE PASSING BAY CABLE BOLT DESIGN

9.5m WIDE, 4.5m FILLETS



SPECIFICATIONS	
TYPE LENGTH SPACING	TWIN STRAND BULBED 6m OR AS PER DESIGN 2.5m X 2.5m OR AS PER DESIGN
CABLE TYPE	
CAPACITY BULBS GROUT WATER CEMENT RATIO CEMENT TYPE	25T PER STRAND BULB EVERY 1/2m FULL COLUMN GROUT 0.3 TO 0.4 NORMAL PORTLAND CEMENT
PLATES	
MINIMUM THICKNESS MINIMUM DIAMETER	7.0 MM 150 MM

GEOTECHNICAL ENGINEER	UNDERGROUND SUPERINTENDENT	MANAGER MINING	DATE

DO NOT SCALE

Appendix B3

Ground support materials supplier specifications

Appendix B Ground Support Designs for stope crowns and hangingwall exposures

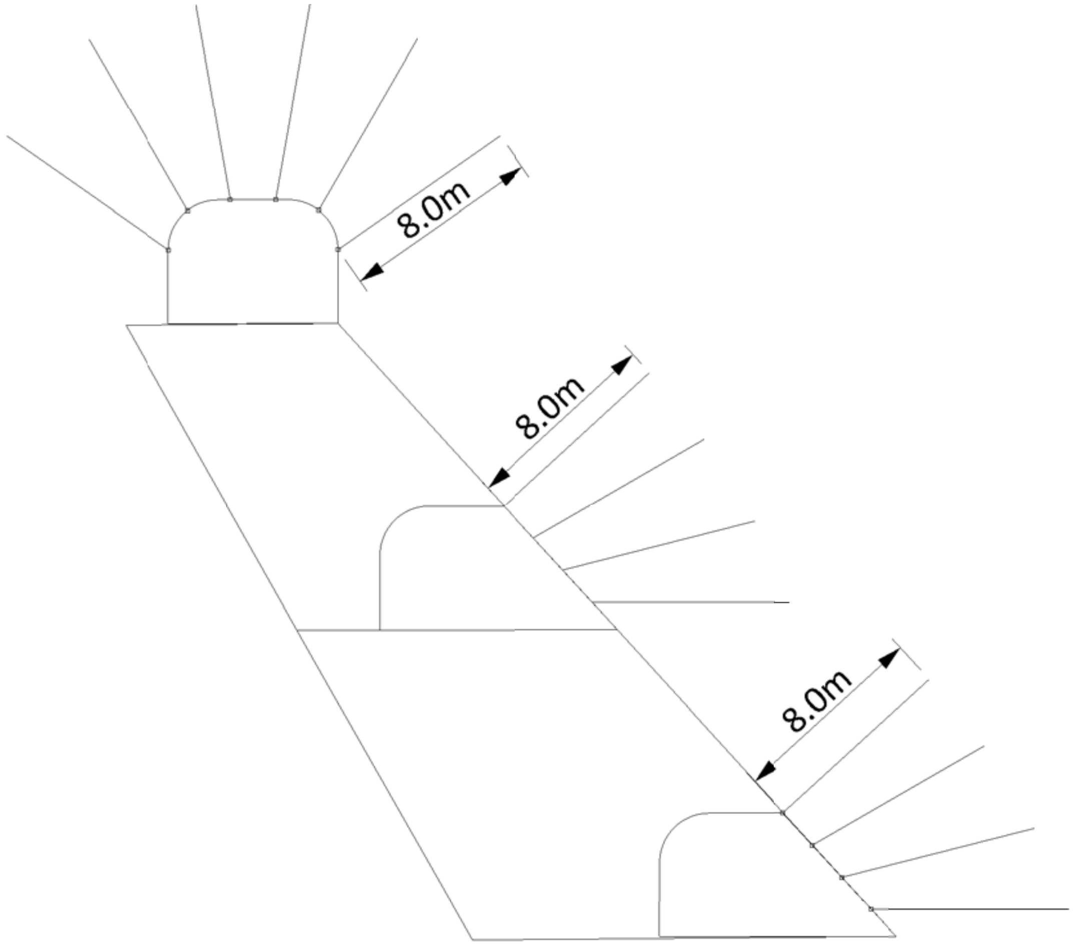
RASP MINE - ZINC LODES

CBH Resources Limited

GROUND SUPPORT STANDARD

DEVELOPMENT CABLE BOLT DESIGN

SHANTY BACK PROFILE
OR SIMILAR
BENCH STOPING SECTION



SPECIFICATIONS	
TYPE LENGTH RING SPACING	TWIN STRAND BULBED 8m OR AS PER DESIGN 2.0m
CABLE TYPE	
CAPACITY BULBS GROUT WATER CEMENT RATIO CEMENT TYPE	25T PER STRAND BULB EVERY 1/2m FULL COLUMN GROUT 0.3 TO 0.4 NORMAL PORTLAND CEMENT
PLATES	
MINIMUM THICKNESS MINIMUM DIAMETER	7.0 MM 150 MM

GEOTECHNICAL ENGINEER	UNDERGROUND SUPERINTENDENT	MANAGER MINING	DATE

DO NOT SCALE

Appendix C Laboratory Test Results

Trilab
Soil Rock Calibration

Brisbane
346A Bilsen Road,
Geebung
QLD 4034
Ph: +61 7 3265 5656

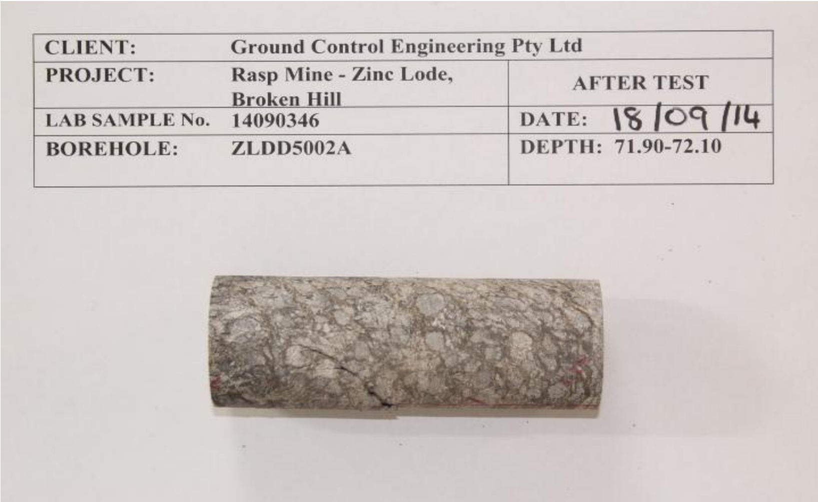
Perth
2 Kimmer Place,
Queens Park
WA 6107
Ph: +61 8 9258 8323

UNIAXIAL COMPRESSIVE STRENGTH TEST REPORT

Test Method: AS 4133.4.2.1

Client	Ground Control Engineering Pty Ltd	**Report No.**	14090346-UCS
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	18/09/2014
		Report Date	19/09/2014

Sample No.	14090346
Client ID	ZLDD5002A
Depth (m)	71.90-72.10
Description	MW R3
Wet Density (t/m^3)	2.78
Moisture Content (%)	0.3
Specimen Length (mm)	129.4
Specimen Diameter (mm)	47.7
Mode of Failure	Shear
Test Duration (Min:Sec)	7:36



UCS (MPa)	17.8

NOTES/REMARKS:
Stored and tested as received
Sample/s supplied by the client
Test Apparatus - Kelba 1000 kN Load Cell
Photo not to scale

Authorised Signatory

C. Channon

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STRENGTH OF ROCK MATERIAL IN TRIAXIAL COMPRESSION

ASTM D7012-13

Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures

Method A : Triaxial Compressive Strength of Undrained Rock Core Specimens Without Pore Pressure Measurements

Client	Ground Control Engineering Pty Ltd	**Report No.**	14090347-HOK
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	18/09/2014
		Report Date	19/09/2014
Client ID	ZLDD5036	**Depth (m)**	25.75-26.00
Description	SW R4		
Sample Type	Single Individual Rock Core Specimen		

Sample Details

Average Sample Diameter (mm)	47.3	Moisture Content (%)	0.1
Sample Height (mm)	112	Wet Density (t/m^3)	3.06
Duration of Test (min)	8.20	Dry Density (t/m^3)	3.06
Rate of Loading (MPa/min)	3.87	Bedding (^{o})	40
Mode of Failure	Shear	Test Apparatus	Kelba 1000 kN Load Cell

Intact Test Results

Confining Pressure (MPa)	1.0	2.0	5.0	
Peak Axial Stress (MPa)	61.9	68.7	*	
# Axial Strain (με)	8792	9525	*	
Youngs Modulus (GPa)	16.0	10.6	*	

Residual Test Results

Confining Pressure (MPa)	5.0	2.0	1.0	
Residual Axial Stress (MPa)	31.2	26.3	24.9	
# Axial Strain (με)	15942	19233	21058	

 # Axial Strain values should be used as a guide only as the axial strain indicated above is calculated from axial ram displacement and as such are not true sample strain values.

Notes/Remarks: * Sample failed catastrophically after stage 2

Sample/s supplied by client Tested as received

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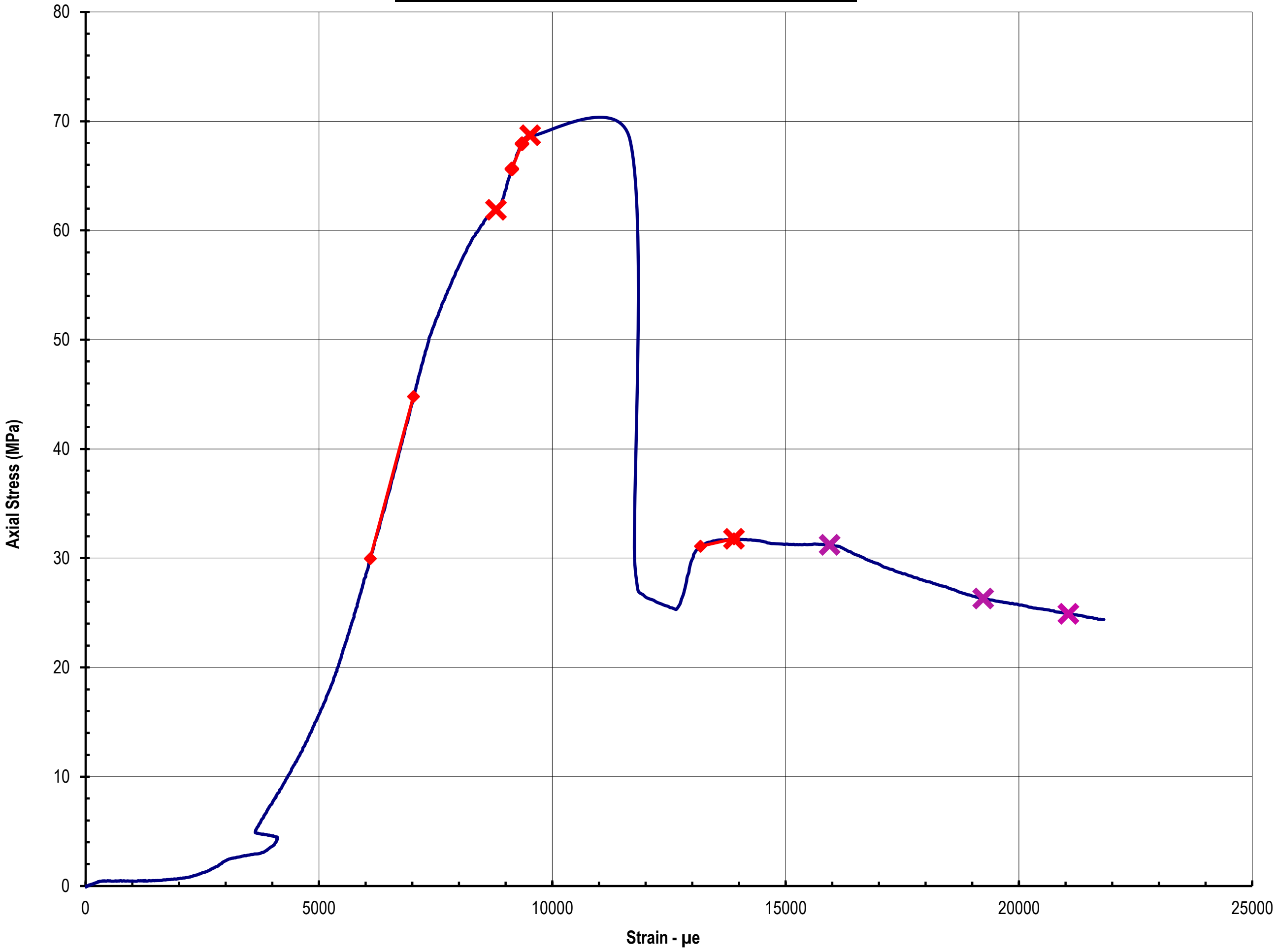
		Report Date	19/09/2014
Client ID	ZLDD5036	**Depth (m)**	25.75-26.00
Description	SW R4		
Sample Type	Single Individual Rock Core Specimen		

Axial Stress vs Axial Strain Plots



Refer to Note on Page 1

Notes/Remarks: * Sample failed catastrophically after stage 2

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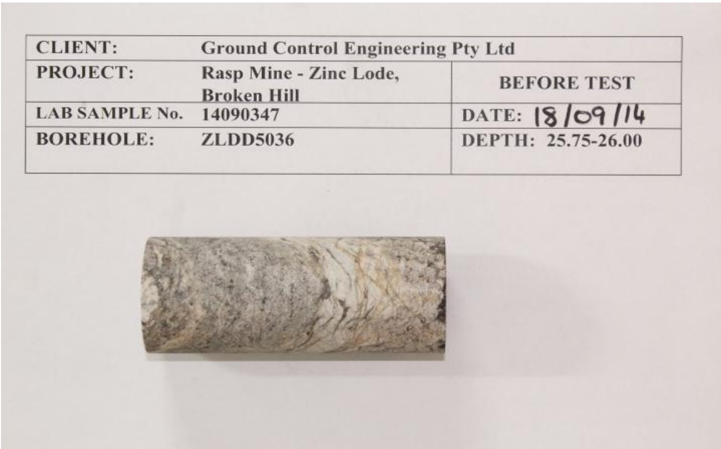
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	18/09/2014
		Report Date	19/09/2014
Client ID	ZLDD5036	**Depth (m)**	25.75-26.00
Description	SW R4		
Sample Type	Single Individual Rock Core Specimen		

Before Test Photograph



After Test Photograph

Notes/Remarks: * Sample failed catastrophically after stage 2

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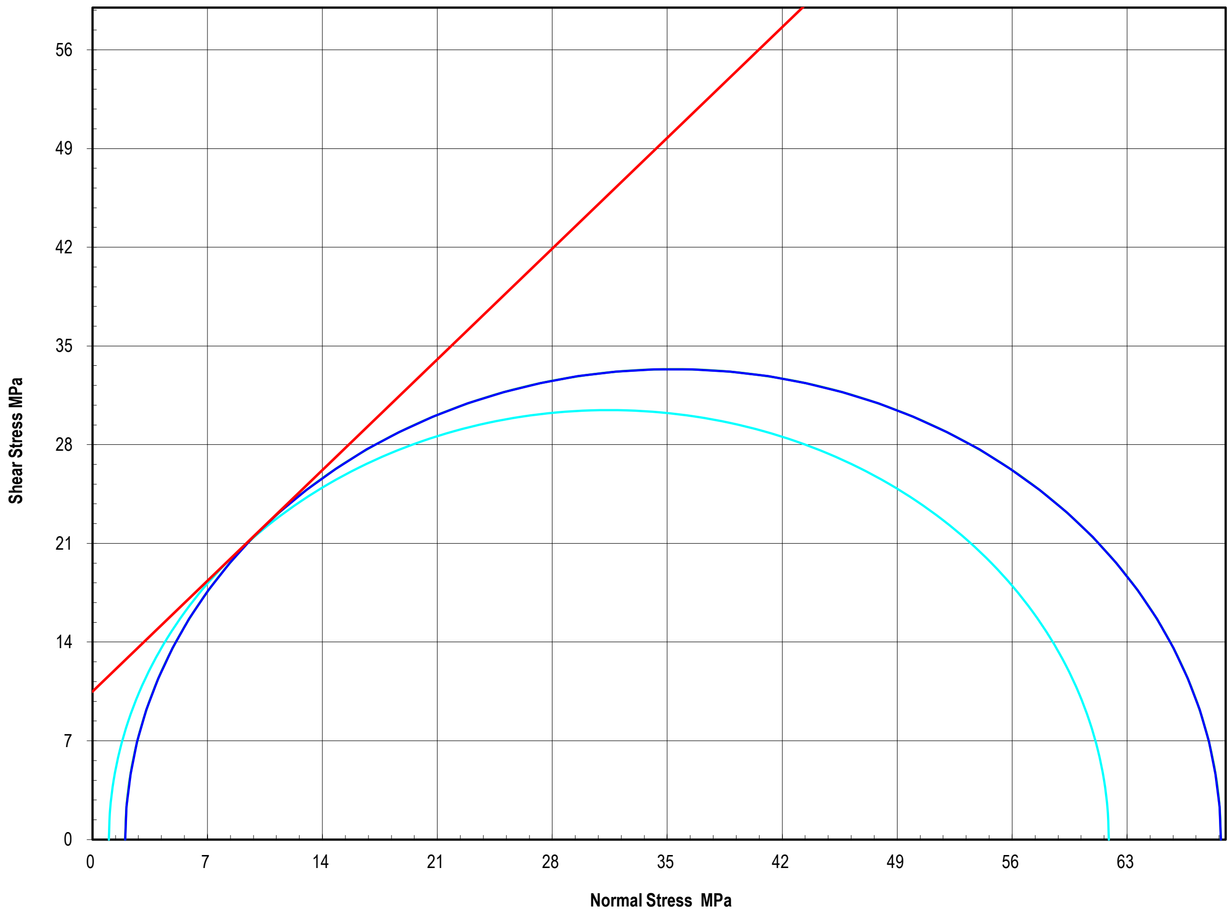
Client	Ground Control Engineering Pty Ltd	**Report No.**	14090347-HOK
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	18/09/2014
		Report Date	19/09/2014
Client ID	ZLDD5036	**Depth (m)**	25.75-26.00
Description	SW R4		
Sample Type	Single Individual Rock Core Specimen		

Peak Stress Mohr Circle Plot



Estimated Peak Envelope	
Angle	48.3 °
Cohesion	10.47 MPa
Correlation	1.0000

Notes/Remarks: * Stage 3 not used in envelope calculations

Sample/s supplied by client   Tested as received   Graph not to scale

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Method A : Triaxial Compressive Strength of Undrained Rock Core Specimens Without Pore Pressure Measurements

Client	Ground Control Engineering Pty Ltd	**Report No.**	14090347-HOK
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	18/09/2014
		Report Date	19/09/2014
Client ID	ZLDD5036	**Depth (m)**	25.75-26.00
Description	SW R4		
Sample Type	Single Individual Rock Core Specimen		

Residual Stress Mohr Circle Plot

Estimated Residual Envelope	
Angle	13.3 °
Cohesion	9.19 MPa
Correlation	0.9984

Notes/Remarks:

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UNIAXIAL COMPRESSIVE STRENGTH TEST REPORT

Test Method: AS 4133.4.2.1

Client	Ground Control Engineering Pty Ltd	**Report No.**	14090348-UCS
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	17/09/2014
		Report Date	18/09/2014

Sample No.	14090348
Client ID	ZLDD5036
Depth (m)	91.20-91.40
Description	SW R4
Wet Density (t/m^3)	2.98
Moisture Content (%)	0.1
Specimen Length (mm)	131.3
Specimen Diameter (mm)	47.3
Mode of Failure	Conical
Test Duration (Min:Sec)	12:36

UCS (MPa)	60.8

NOTES/REMARKS:

Stored and tested as received

Sample/s supplied by the client

Test Apparatus - Kelba 1000 kN Load Cell

Photo not to scale

Page: 1 of 1 REP02701

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UNIAXIAL COMPRESSIVE STRENGTH & DEFORMATION TEST REPORT

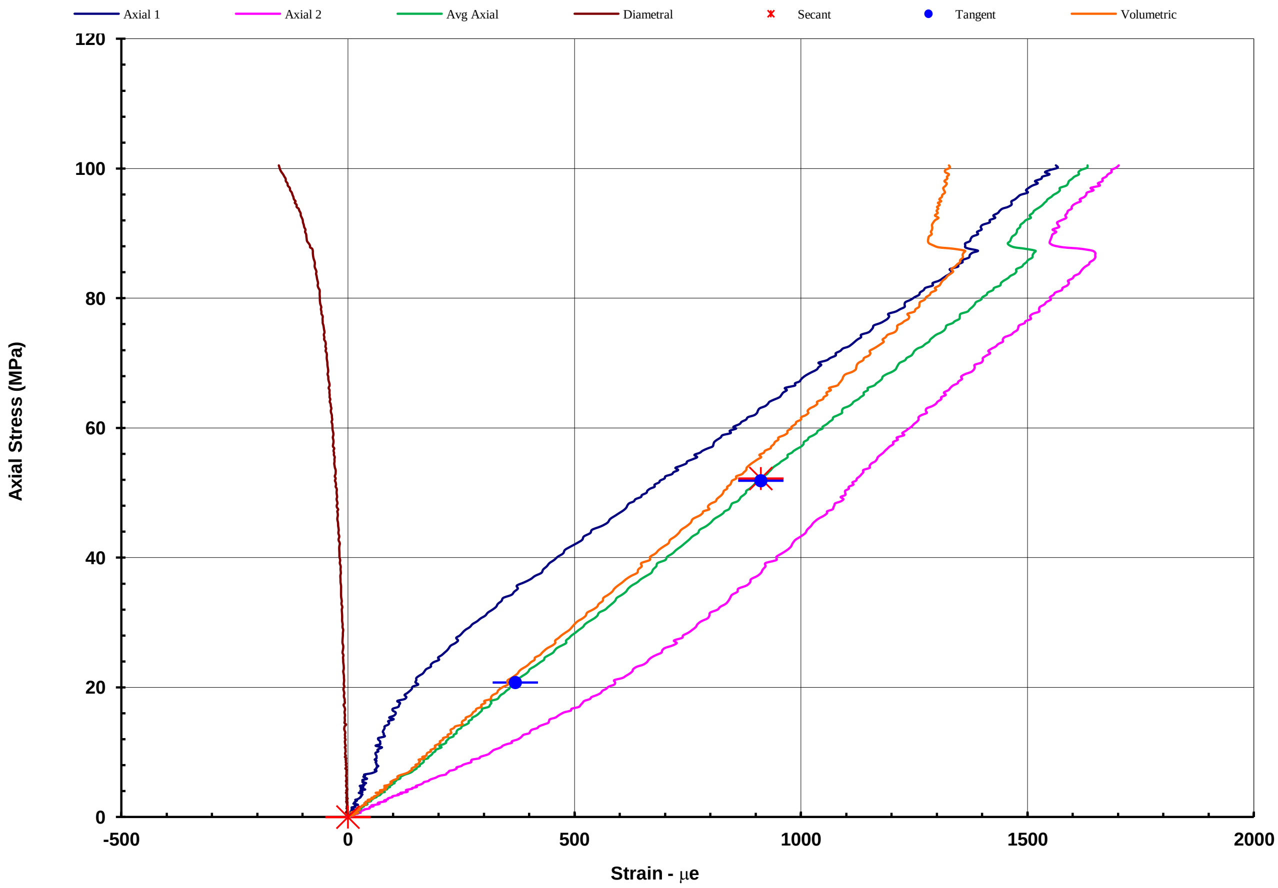
Test Method: AS 4133.4.3.1

Client	Ground Control Engineering Pty Ltd	**Report No.**	14090349-MOD
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	18/09/2014
		Report Date	19/09/2014
Client ID	ZLDD5017	**Depth (m)**	86.90-87.15
Description	SW R4		
Sample Type	Single Individual Rock Core Specimen		

Uniaxial Compressive Strength 103 MPa

	Young's Modulus	Poisson Ratio	
Tangent	57.4 GPa	0.030	from 20 % to 50 % of Max UCS
Secant	57.3 GPa	0.031	from 0 % to 50 % of Max UCS

Axial Stress vs Strain Plots



Notes/Remarks:

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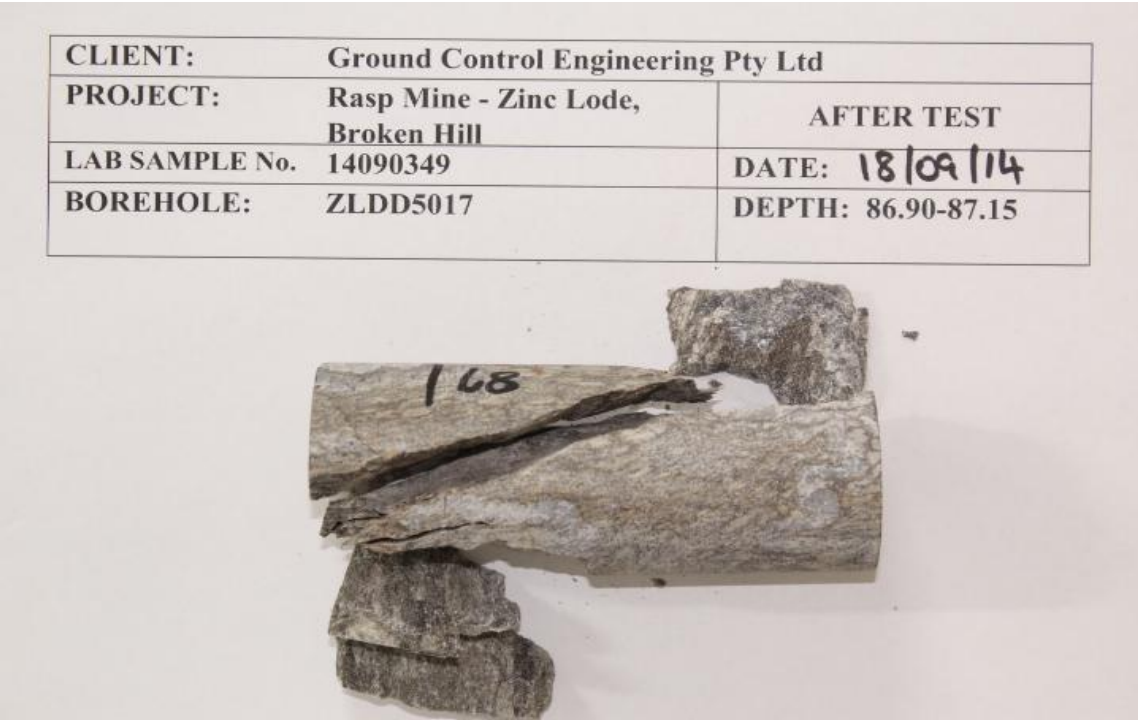
UNIAXIAL COMPRESSIVE STRENGTH & DEFORMATION TEST REPORT

Test Method: AS 4133.4.3.1

Client	Ground Control Engineering Pty Ltd	**Report No.**	14090349-MOD
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	18/09/2014
		Report Date	19/09/2014
Client ID	ZLDD5017	**Depth (m)**	86.90-87.15
Description	SW R4		
Sample Type	Single Individual Rock Core Specimen		

Uniaxial Compressive Strength 103 MPa

Average Sample Diameter (mm)	47.3	Moisture Content (%)	0.1
Sample Height (mm)	131.5	Wet Density (t/m^3)	2.92
Duration of Test (min)	3.17	Dry Density (t/m^3)	2.91
Rate of Loading (MPa/min)	32.58	Bedding (°)	Nil
Mode of Failure	Shear	Test Apparatus	Kelba 1000kN Load Cell



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UNIAXIAL COMPRESSIVE STRENGTH & DEFORMATION TEST REPORT

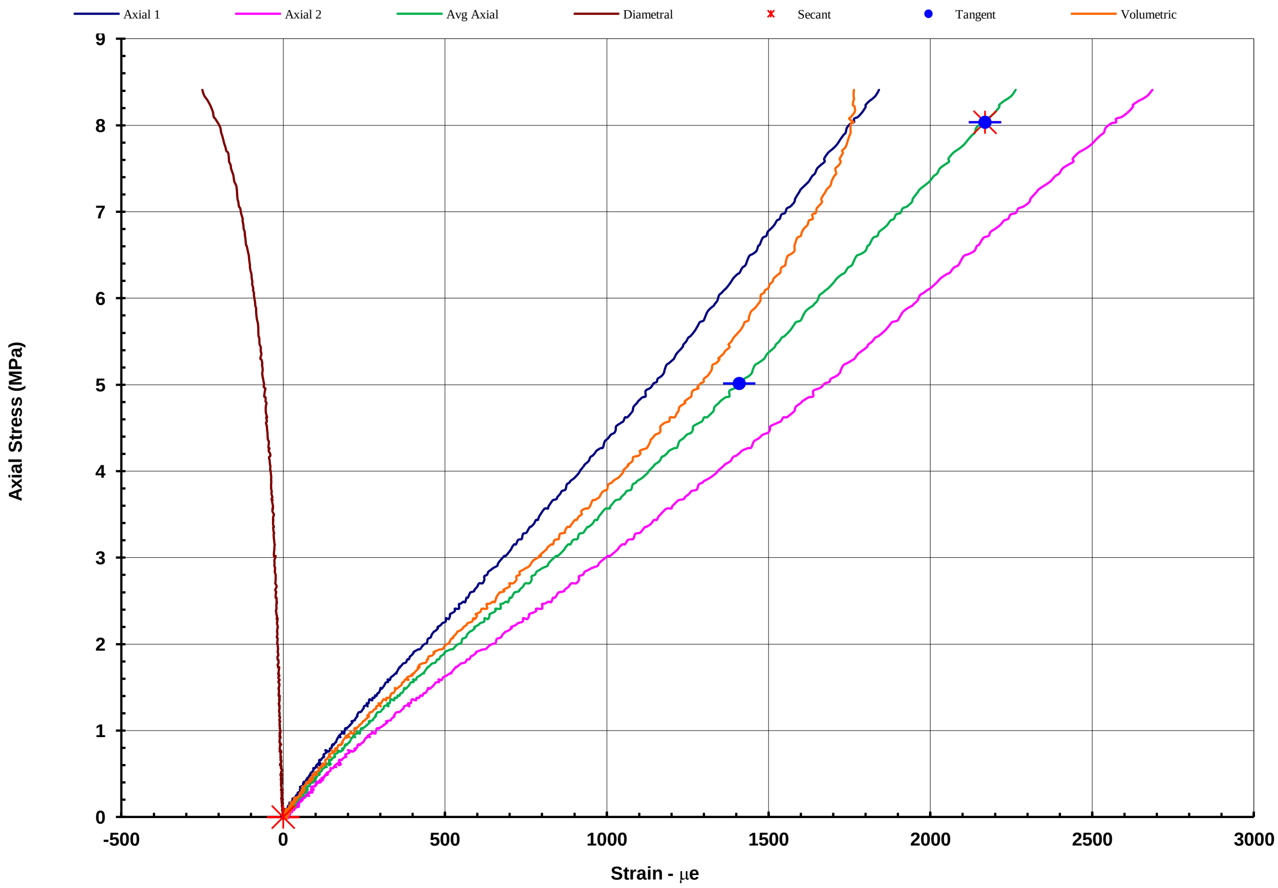
Test Method: AS 4133.4.3.1

Client	Ground Control Engineering Pty Ltd	**Report No.**	14090350-MOD
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	17/09/2014
		Report Date	18/09/2014
Client ID	ZLDD5034	**Depth (m)**	14.00-14.30
Description	MW R3		
Sample Type	Single Individual Rock Core Specimen		

Uniaxial Compressive Strength 16.0 MPa

	Young's Modulus	Poisson Ratio	
Tangent	3.98 GPa	0.094	from 31 % to 50 % of Max UCS
Secant	3.70 GPa	0.094	from 0 % to 50 % of Max UCS

Axial Stress vs Strain Plots



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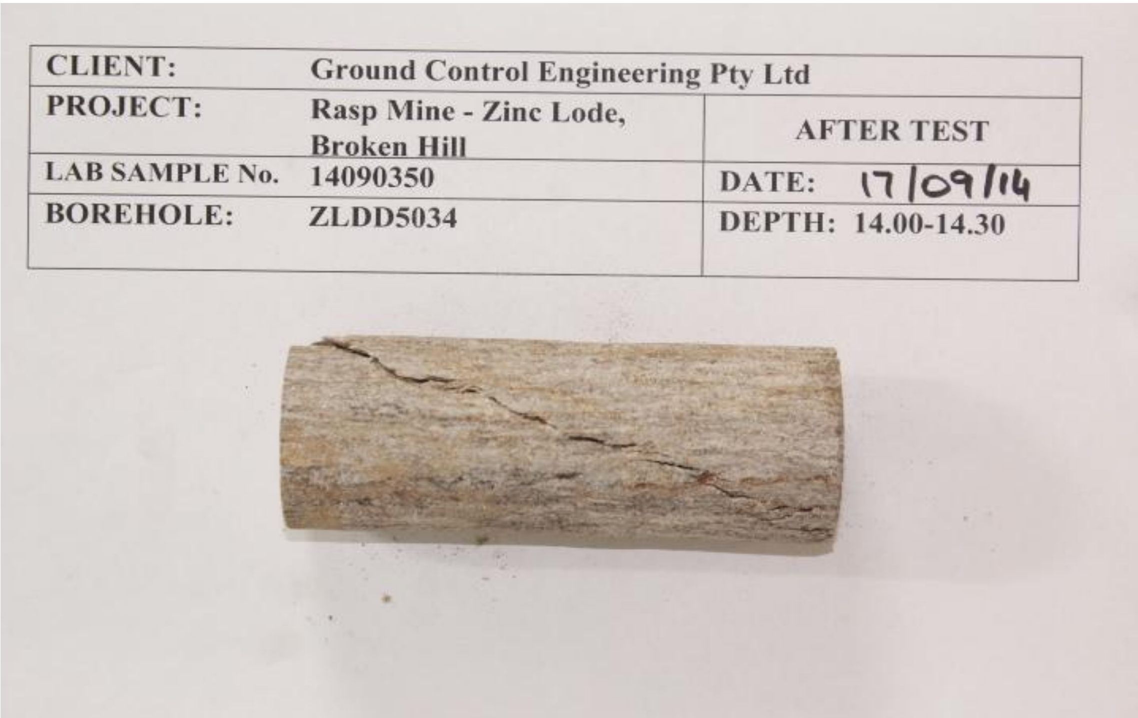
UNIAXIAL COMPRESSIVE STRENGTH & DEFORMATION TEST REPORT

Test Method: AS 4133.4.3.1

Client	Ground Control Engineering Pty Ltd	**Report No.**	14090350-MOD
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	17/09/2014
		Report Date	18/09/2014
Client ID	ZLDD5034	**Depth (m)**	14.00-14.30
Description	MW R3		
Sample Type	Single Individual Rock Core Specimen		

Uniaxial Compressive Strength 16.0 MPa

Average Sample Diameter (mm)	47.0	Moisture Content (%)	0.6
Sample Height (mm)	130.7	Wet Density (t/m^3)	2.64
Duration of Test (min)	6.03	Dry Density (t/m^3)	2.63
Rate of Loading (MPa/min)	2.66	Bedding (°)	90
Mode of Failure	Shear	Test Apparatus	Kelba 1000kN Load Cell



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UNIAXIAL COMPRESSIVE STRENGTH TEST REPORT

Test Method: AS 4133.4.2.1

Client	Ground Control Engineering Pty Ltd	**Report No.**	14090351-UCS
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	18/09/2014
		Report Date	19/09/2014

Sample No.	14090351
Client ID	ZLDD5034
Depth (m)	29.30-29.60
Description	MW R4
Wet Density (t/m^3)	2.95
Moisture Content (%)	0.1
Specimen Length (mm)	130.9
Specimen Diameter (mm)	47.1
Mode of Failure	Conical
Test Duration (Min:Sec)	12:40

UCS (MPa)	98.0

NOTES/REMARKS:
Stored and tested as received
Sample/s supplied by the client
Test Apparatus - Kelba 1000 kN Load Cell
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UNIAXIAL COMPRESSIVE STRENGTH TEST REPORT

Test Method: AS 4133.4.2.1

Client	Ground Control Engineering Pty Ltd	**Report No.**	14090352-UCS
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	17/09/2014
		Report Date	18/09/2014

Sample No.	14090352
Client ID	ZLDD5032
Depth (m)	83.70-84.00
Description	SW R4
Wet Density (t/m^3)	3.22
Moisture Content (%)	0.0
Specimen Length (mm)	130.3
Specimen Diameter (mm)	47.1
Mode of Failure	Conical
Test Duration (Min:Sec)	8:38

UCS (MPa)	83.1

NOTES/REMARKS:
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UNIAXIAL COMPRESSIVE STRENGTH TEST REPORT

Test Method: AS 4133.4.2.1

Client	Ground Control Engineering Pty Ltd	**Report No.**	14090353-UCS
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	18/09/2014
		Report Date	19/09/2014

Sample No.	14090353
Client ID	ZLDD5009
Depth (m)	30.80-31.00
Description	MW R3
Wet Density (t/m^3)	2.96
Moisture Content (%)	0.3
Specimen Length (mm)	129.3
Specimen Diameter (mm)	47.5
Mode of Failure	Shear
Test Duration (Min:Sec)	5:53

UCS (MPa)	34.1

NOTES/REMARKS:
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Test Apparatus - Kelba 1000 kN Load Cell
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STRENGTH OF ROCK MATERIAL IN TRIAXIAL COMPRESSION

ASTM D7012-13

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Method A : Triaxial Compressive Strength of Undrained Rock Core Specimens Without Pore Pressure Measurements

Client	Ground Control Engineering Pty Ltd	**Report No.**	14090354-HOK
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	18/09/2014
		Report Date	19/09/2014
Client ID	ZLDD5022	**Depth (m)**	62.90-63.15
Description	SW R4		
Sample Type	Single Individual Rock Core Specimen		

Sample Details

Average Sample Diameter (mm)	47.5	Moisture Content (%)	0.0
Sample Height (mm)	111.8	Wet Density (t/m^3)	3.02
Duration of Test (min)	18.47	Dry Density (t/m^3)	3.01
Rate of Loading (MPa/min)	9.74	Bedding (^{o})	Nil
Mode of Failure	End Splitting	Test Apparatus	Kelba 1000 kN Load Cell

Intact Test Results

Confining Pressure (MPa)	2.0	5.0	10.0	
Peak Axial Stress (MPa)	105	143	180	
# Axial Strain (µe)	10179	12782	15215	
Youngs Modulus (GPa)	14.9	16.1	18.9	

Residual Test Results

Confining Pressure (MPa)	10.0	5.0	2.0	
Residual Axial Stress (MPa)	80.6	45.3	25.8	
# Axial Strain (µe)	16497	19064	21255	

 # Axial Strain values should be used as a guide only as the axial strain indicated above is calculated from axial ram displacement and as such are not true sample strain values.

Notes/Remarks:

Sample/s supplied by client   Tested as received

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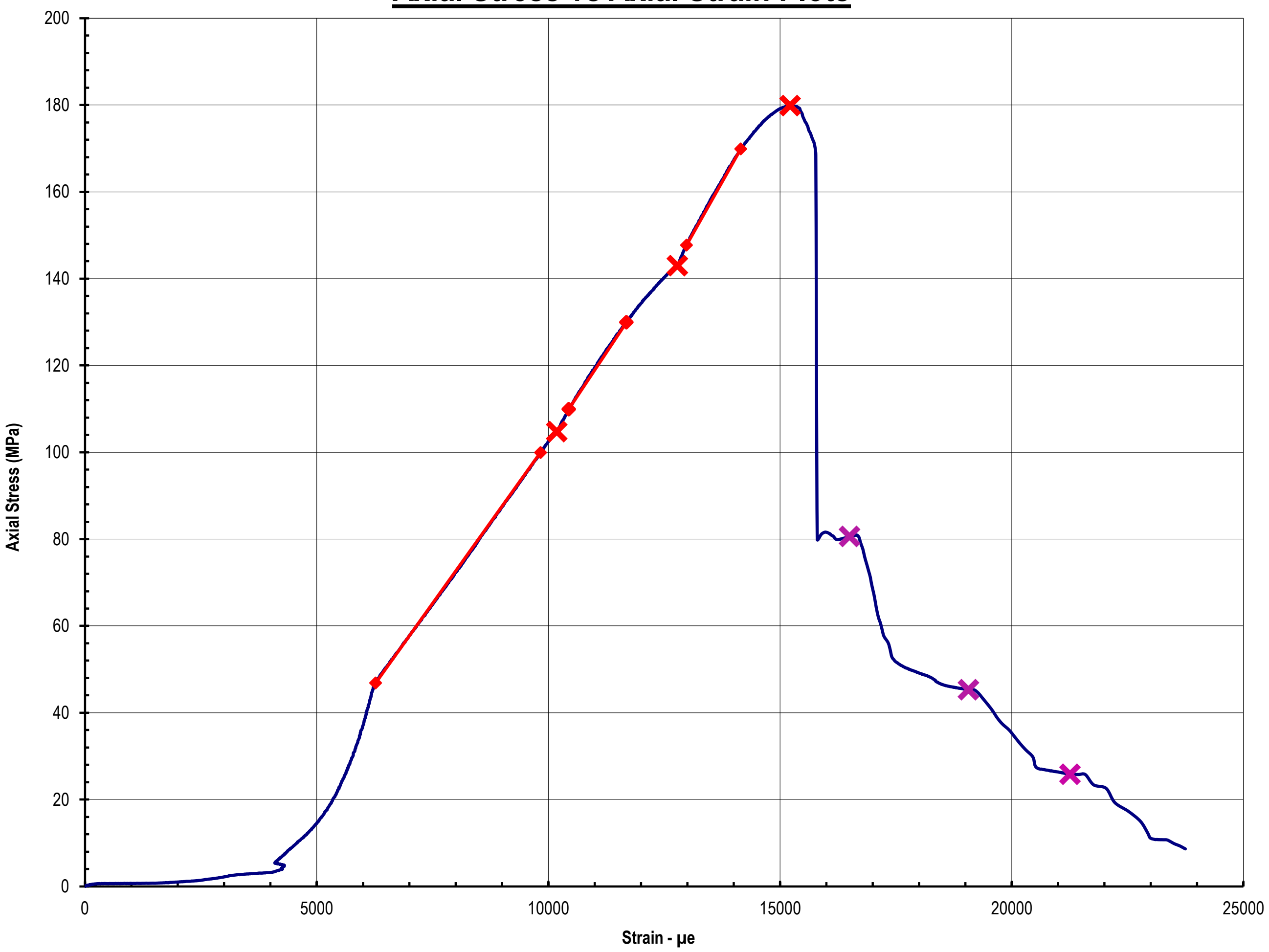
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	18/09/2014
		Report Date	19/09/2014
Client ID	ZLDD5022	**Depth (m)**	62.90-63.15
Description	SW R4		
Sample Type	Single Individual Rock Core Specimen		

Axial Stress vs Axial Strain Plots



X Peak Value
X Residual Value

Refer to Note on Page 1

Notes/Remarks:

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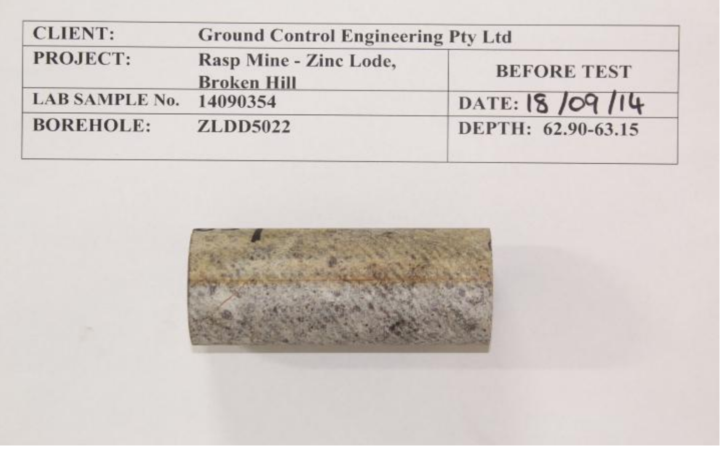
Method A : Triaxial Compressive Strength of Undrained Rock Core Specimens Without Pore Pressure Measurements

Client	Ground Control Engineering Pty Ltd	**Report No.**	14090354-HOK
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	18/09/2014
		Report Date	19/09/2014
Client ID	ZLDD5022	**Depth (m)**	62.90-63.15
Description	SW R4		
Sample Type	Single Individual Rock Core Specimen		

Before Test Photograph



After Test Photograph

Notes/Remarks:

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STRENGTH OF ROCK MATERIAL IN TRIAXIAL COMPRESSION

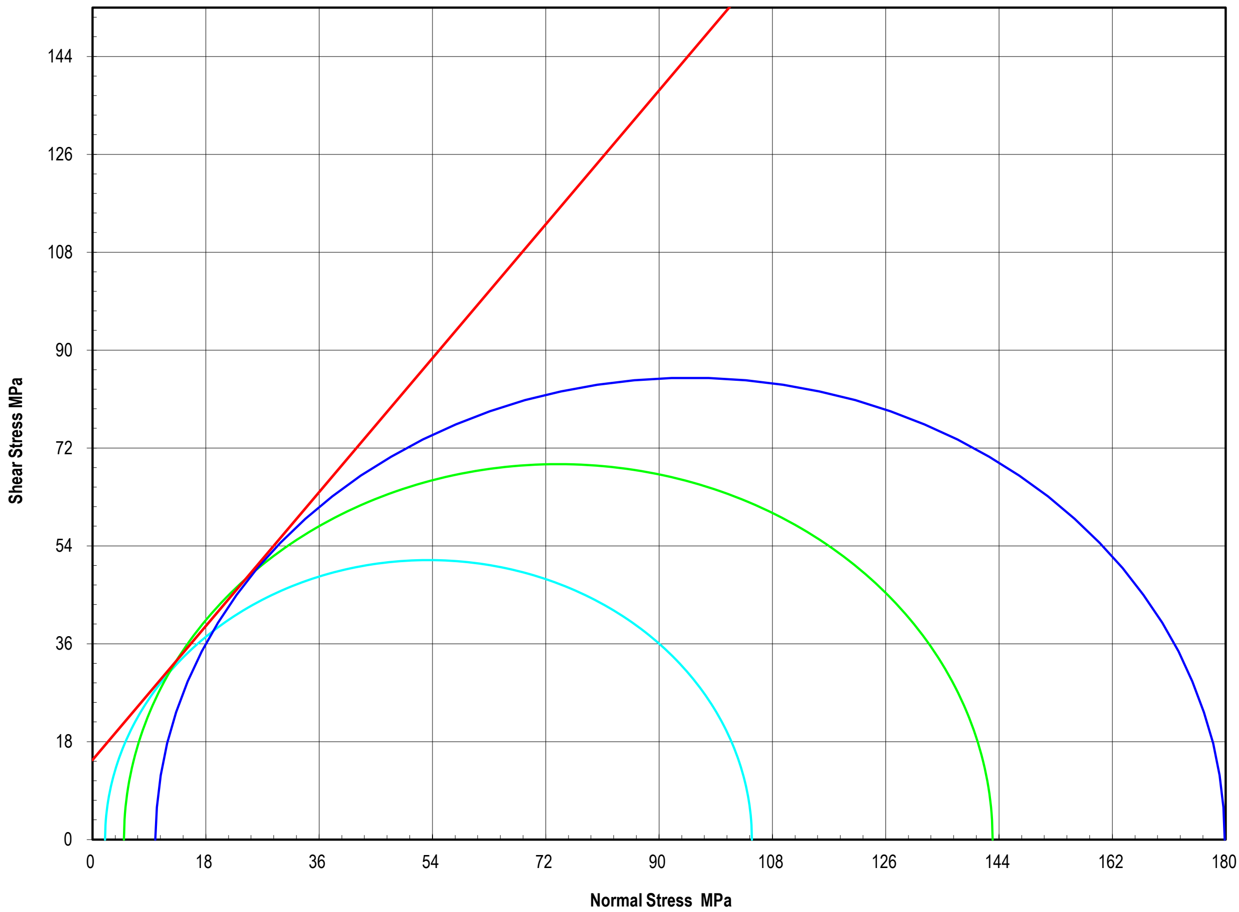
ASTM D7012-13

Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures

Method A : Triaxial Compressive Strength of Undrained Rock Core Specimens Without Pore Pressure Measurements

Client	Ground Control Engineering Pty Ltd	**Report No.**	14090354-HOK
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	18/09/2014
		Report Date	19/09/2014
Client ID	ZLDD5022	**Depth (m)**	62.90-63.15
Description	SW R4		
Sample Type	Single Individual Rock Core Specimen		

Peak Stress Mohr Circle Plot



Estimated Peak Envelope	
Angle	53.8 °
Cohesion	14.59 MPa
Correlation	0.9994

Notes/Remarks:

Sample/s supplied by client | Tested as received | Graph not to scale

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Authorised Signatory
C. Channon

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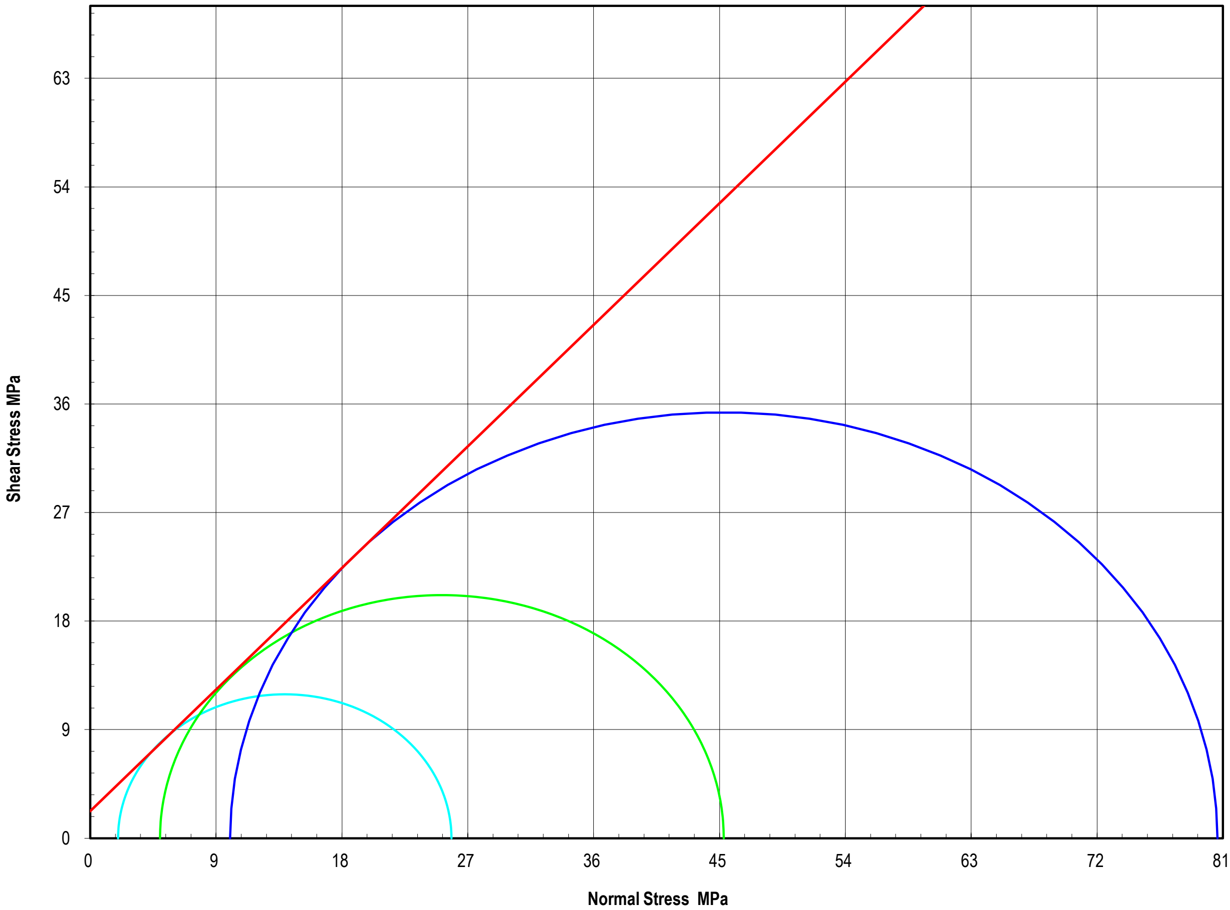
Client	Ground Control Engineering Pty Ltd	**Report No.**	14090354-HOK
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	18/09/2014
		Report Date	19/09/2014
Client ID	ZLDD5022	**Depth (m)**	62.90-63.15
Description	SW R4		
Sample Type	Single Individual Rock Core Specimen		

Residual Stress Mohr Circle Plot



Estimated Residual Envelope	
Angle	48.2 °
Cohesion	2.22 MPa
Correlation	1.0000

Notes/Remarks:

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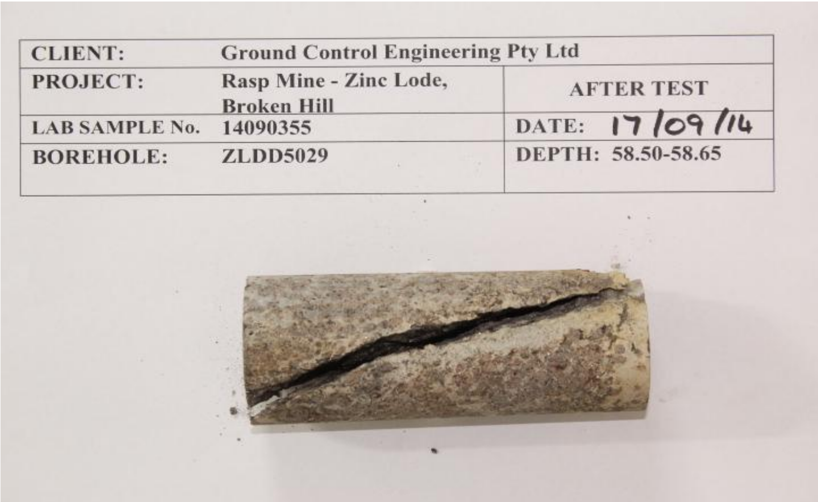
UNIAXIAL COMPRESSIVE STRENGTH TEST REPORT

Test Method: AS 4133.4.2.1

Client	Ground Control Engineering Pty Ltd	**Report No.**	14090355-UCS
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	17/09/2014
		Report Date	18/09/2014

Sample No.	14090355
Client ID	ZLDD5029
Depth (m)	58.50-58.65
Description	MW R4
Wet Density (t/m^3)	3.33
Moisture Content (%)	0.1
Specimen Length (mm)	131.2
Specimen Diameter (mm)	47.4
Mode of Failure	Shear
Test Duration (Min:Sec)	5:51



UCS (MPa)	35.2

NOTES/REMARKS:

Stored and tested as received

Sample/s supplied by the client

Test Apparatus - Kelba 1000 kN Load Cell

Photo not to scale

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UNIAXIAL COMPRESSIVE STRENGTH & DEFORMATION TEST REPORT

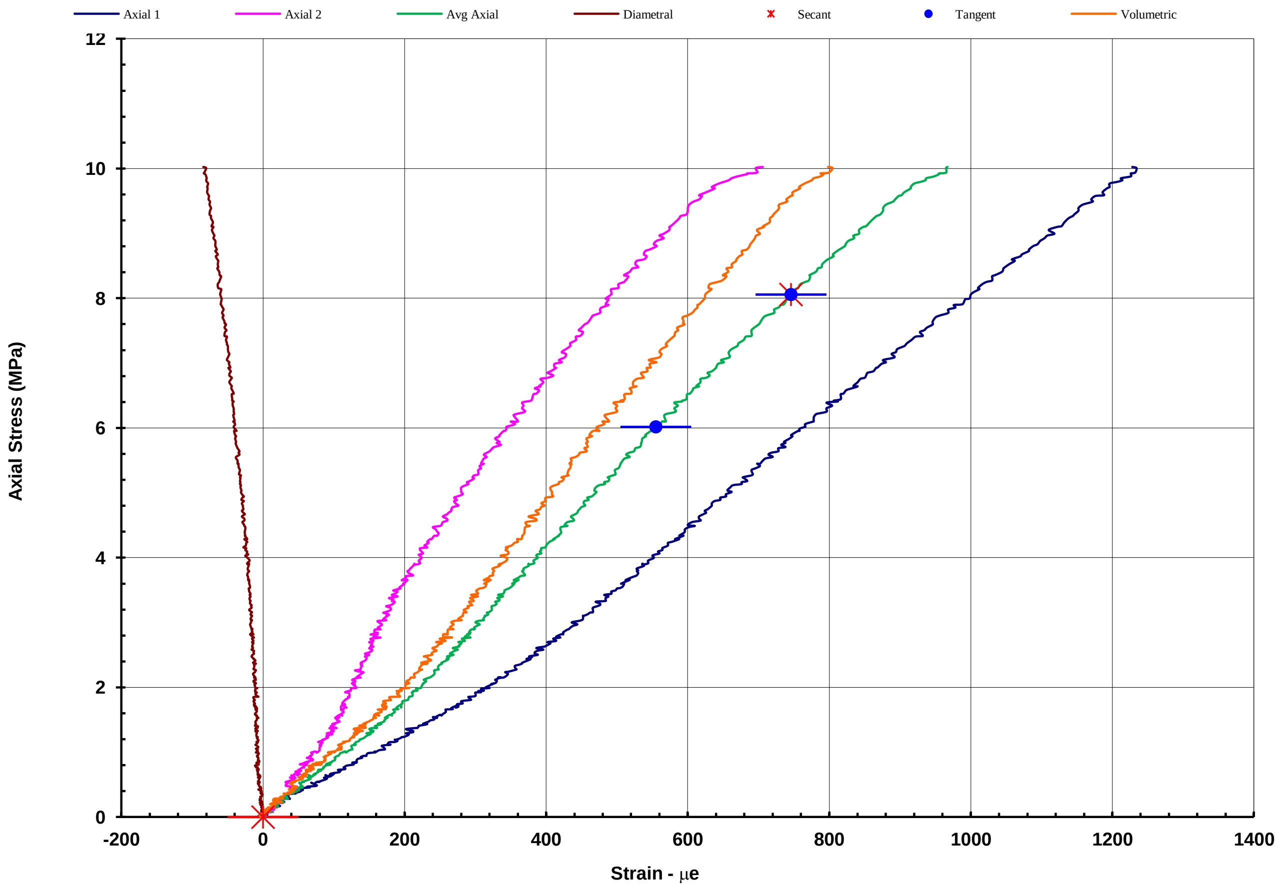
Test Method: AS 4133.4.3.1

Client	Ground Control Engineering Pty Ltd	**Report No.**	14090356-MOD
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	18/09/2014
		Report Date	19/09/2014
Client ID	ZLDD5001	**Depth (m)**	33.20-33.40
Description	SW R3		
Sample Type	Single Individual Rock Core Specimen		

Uniaxial Compressive Strength 18.2 MPa

	Young's Modulus	Poisson Ratio	
Tangent	10.7 GPa	0.081	from 33 % to 44 % of Max UCS
Secant	10.8 GPa	0.081	from 0 % to 44 % of Max UCS

Axial Stress vs Strain Plots



Notes/Remarks:

Sample/s supplied by client   Graph not to scale   Tested as received.

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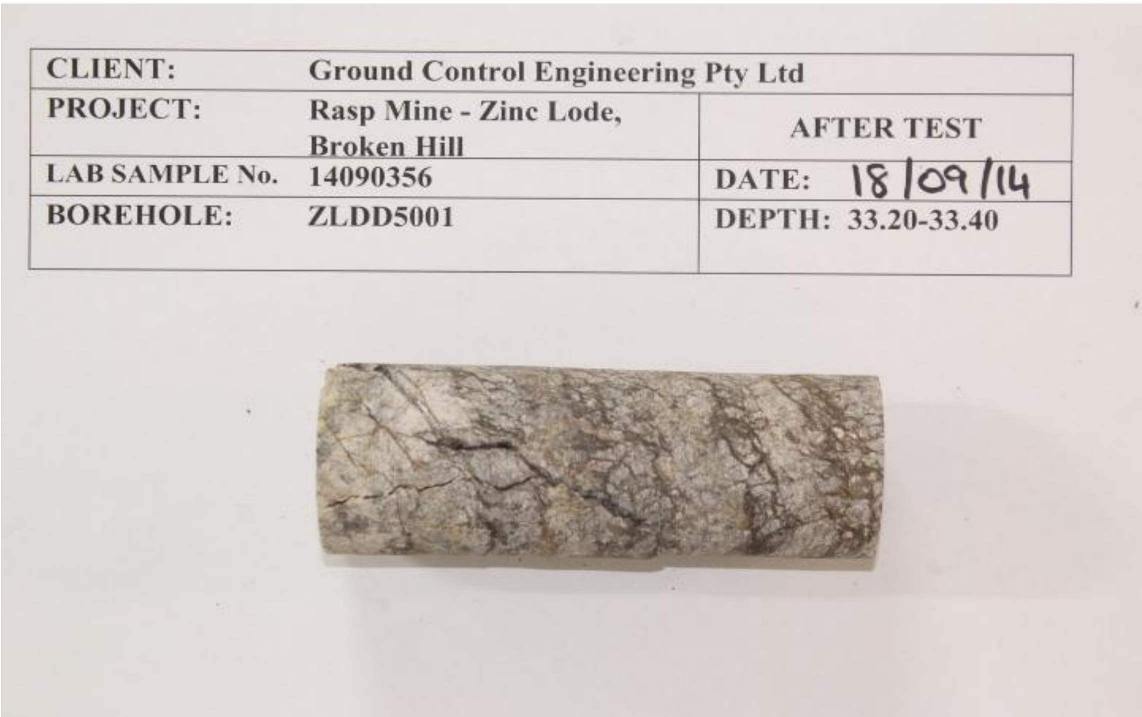
UNIAXIAL COMPRESSIVE STRENGTH & DEFORMATION TEST REPORT

Test Method: AS 4133.4.3.1

Client	Ground Control Engineering Pty Ltd	**Report No.**	14090356-MOD
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	18/09/2014
		Report Date	19/09/2014
Client ID	ZLDD5001	**Depth (m)**	33.20-33.40
Description	SW R3		
Sample Type	Single Individual Rock Core Specimen		

Uniaxial Compressive Strength 18.2 MPa

Average Sample Diameter (mm)	46.8	Moisture Content (%)	0.5
Sample Height (mm)	131.0	Wet Density (t/m^3)	2.71
Duration of Test (min)	6.60	Dry Density (t/m^3)	2.70
Rate of Loading (MPa/min)	2.76	Bedding (°)	Nil
Mode of Failure	Shear	Test Apparatus	Kelba 1000kN Load Cell



Notes/Remarks:

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UNIAXIAL COMPRESSIVE STRENGTH & DEFORMATION TEST REPORT

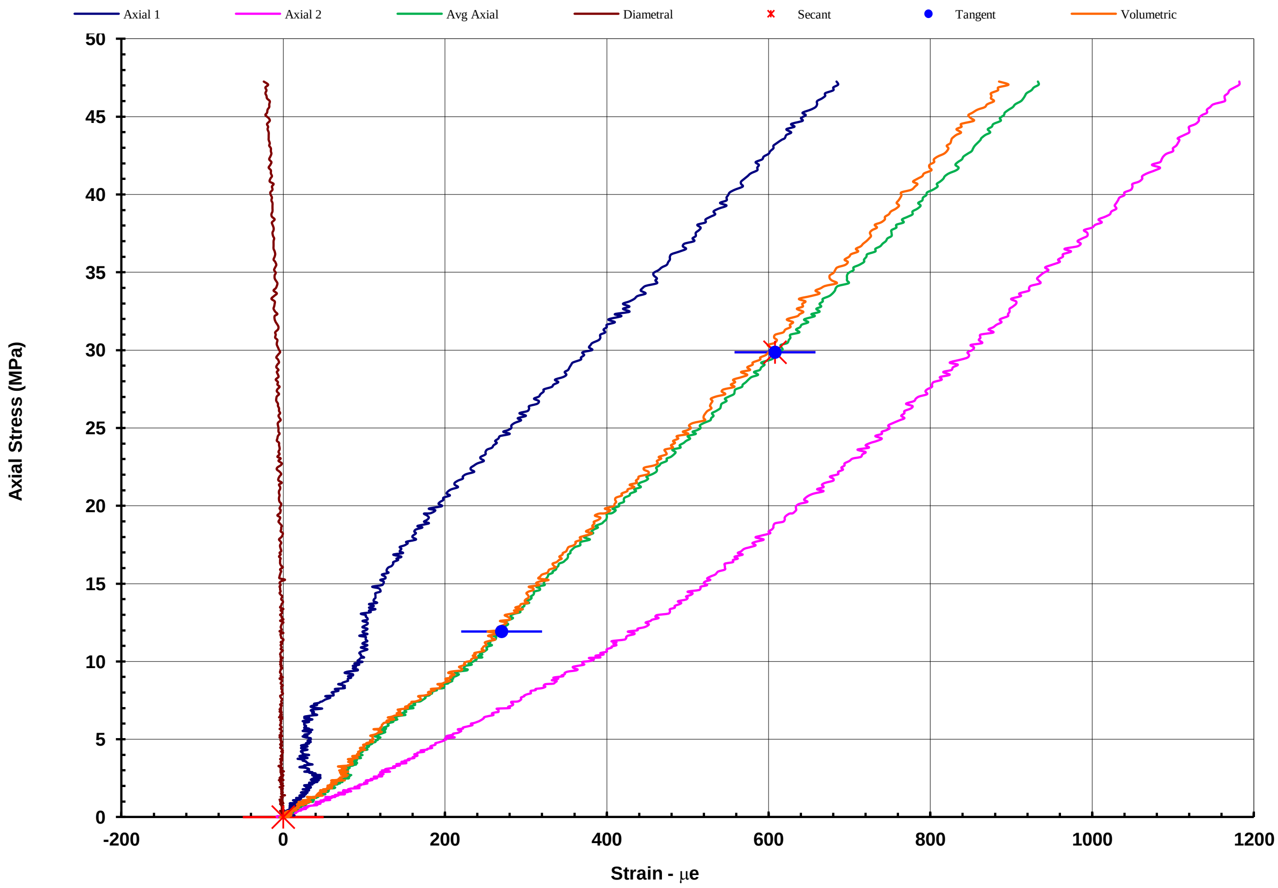
Test Method: AS 4133.4.3.1

Client	Ground Control Engineering Pty Ltd	**Report No.**	14090357-MOD
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	17/09/2014
		Report Date	18/09/2014
Client ID	ZLDD5001	**Depth (m)**	70.40-70.60
Description	SW R4		
Sample Type	Single Individual Rock Core Specimen		

Uniaxial Compressive Strength 59.4 MPa

	Young's Modulus	Poisson Ratio	
Tangent	53.1 GPa	0.007	from 20 % to 50 % of Max UCS
Secant	49.1 GPa	0.007	from 0 % to 50 % of Max UCS

Axial Stress vs Strain Plots



Notes/Remarks:

Sample/s supplied by client   Graph not to scale   Tested as received.   **Page 1 of 2** REP03603

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UNIAXIAL COMPRESSIVE STRENGTH & DEFORMATION TEST REPORT

Test Method: AS 4133.4.3.1

Client	Ground Control Engineering Pty Ltd	**Report No.**	14090357-MOD
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	17/09/2014
		Report Date	18/09/2014
Client ID	ZLDD5001	**Depth (m)**	70.40-70.60
Description	SW R4		
Sample Type	Single Individual Rock Core Specimen		

Uniaxial Compressive Strength 59.4 MPa

Average Sample Diameter (mm)	47.5	Moisture Content (%)	0.1
Sample Height (mm)	130.6	Wet Density (t/m^3)	3.01
Duration of Test (min)	5.57	Dry Density (t/m^3)	3.01
Rate of Loading (MPa/min)	10.68	Bedding (°)	Nil
Mode of Failure	Shear	Test Apparatus	Kelba 1000kN Load Cell

Notes/Remarks:

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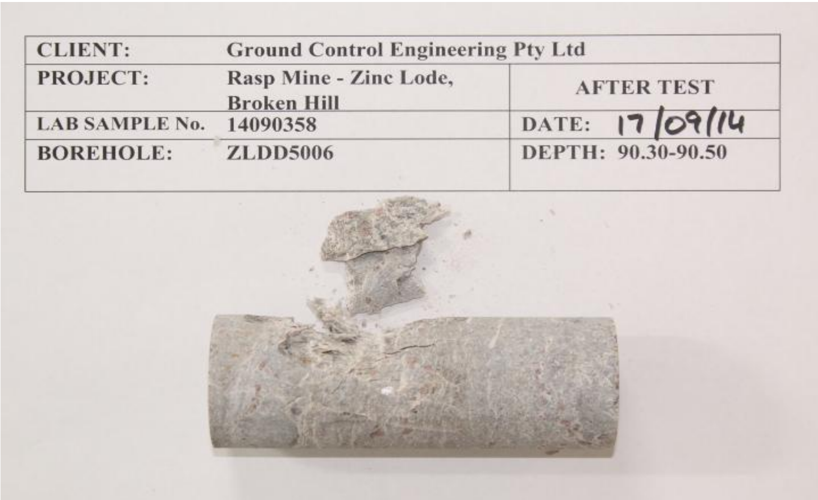
UNIAXIAL COMPRESSIVE STRENGTH TEST REPORT

Test Method: AS 4133.4.2.1

Client	Ground Control Engineering Pty Ltd	**Report No.**	14090358-UCS
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	17/09/2014
		Report Date	19/09/2014

Sample No.	14090358
Client ID	ZLDD5006
Depth (m)	90.30-90.50
Description	SW R5
Wet Density (t/m^3)	2.68
Moisture Content (%)	0.0
Specimen Length (mm)	131.3
Specimen Diameter (mm)	47.3
Mode of Failure	Shear
Test Duration (Min:Sec)	9:17



UCS (MPa)	88.4

NOTES/REMARKS:
Stored and tested as received
Sample/s supplied by the client
Test Apparatus - Kelba 1000 kN Load Cell

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UNIAXIAL COMPRESSIVE STRENGTH TEST REPORT

Test Method: AS 4133.4.2.1

Client	Ground Control Engineering Pty Ltd	**Report No.**	14090359-UCS
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	17/09/2014
		Report Date	18/09/2014

Sample No.	14090359
Client ID	ZLDD5003
Depth (m)	62.00-62.20
Description	SW R4
Wet Density (t/m^3)	3.10
Moisture Content (%)	0.0
Specimen Length (mm)	130.9
Specimen Diameter (mm)	47.5
Mode of Failure	Conical
Test Duration (Min:Sec)	13:33

UCS (MPa)	95.7

NOTES/REMARKS:
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Test Apparatus - Kelba 1000 kN Load Cell

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STRENGTH OF ROCK MATERIAL IN TRIAXIAL COMPRESSION

ASTM D7012-13

Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures

Method A : Triaxial Compressive Strength of Undrained Rock Core Specimens Without Pore Pressure Measurements

Client	Ground Control Engineering Pty Ltd	**Report No.**	14090360-HOK
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	18/09/2014
		Report Date	19/09/2014
Client ID	ZLDD5004	**Depth (m)**	95.40-95.60
Description	SW R3		
Sample Type	Single Individual Rock Core Specimen		

Sample Details

Average Sample Diameter (mm)	47.4	Moisture Content (%)	0.1
Sample Height (mm)	110.7	Wet Density (t/m^3)	2.97
Duration of Test (min)	10.73	Dry Density (t/m^3)	2.96
Rate of Loading (MPa/min)	8.24	Bedding (^{o})	Nil
Mode of Failure	Shear	Test Apparatus	Kelba 1000 kN Load Cell

Intact Test Results

Confining Pressure (MPa)	5.0	10.0	20.0	
Peak Axial Stress (MPa)	138	159	*	
# Axial Strain (με)	10912	12638	*	
Youngs Modulus (GPa)	17.7	16.3	*	

Residual Test Results

Confining Pressure (MPa)	*	*	*	
Residual Axial Stress (MPa)	*	*	*	
# Axial Strain (με)	*	*	*	

 # Axial Strain values should be used as a guide only as the axial strain indicated above is calculated from axial ram displacement and as such are not true sample strain values.

Notes/Remarks: * Sample failed catastrophically after stage 2

Sample/s supplied by client Tested as received

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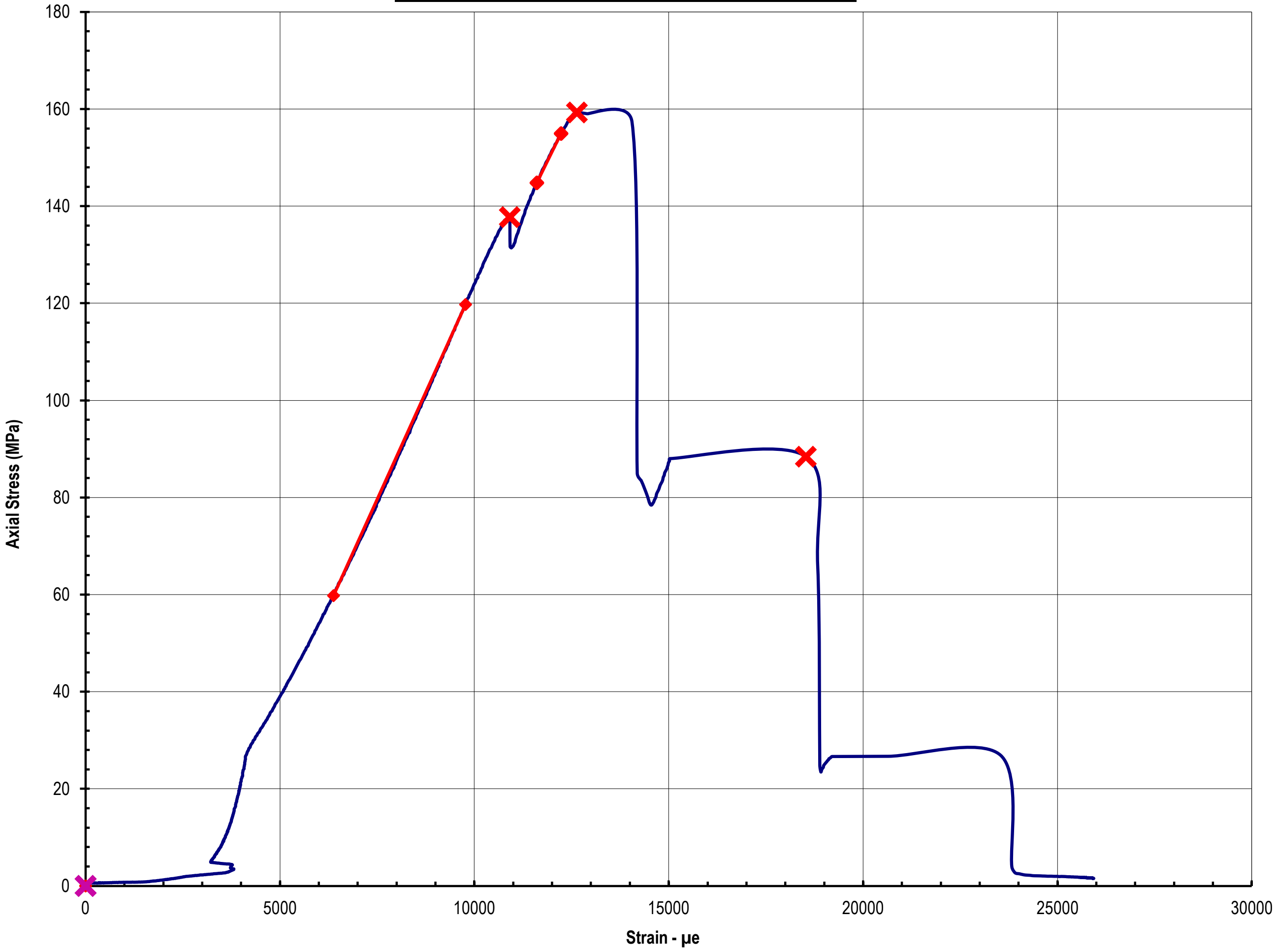
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	18/09/2014
		Report Date	19/09/2014
Client ID	ZLDD5004	**Depth (m)**	95.40-95.60
Description	SW R3		
Sample Type	Single Individual Rock Core Specimen		

Axial Stress vs Axial Strain Plots



X Peak Value
X Residual Value

Refer to Note on Page 1

Notes/Remarks: * Sample failed catastrophically after stage 2

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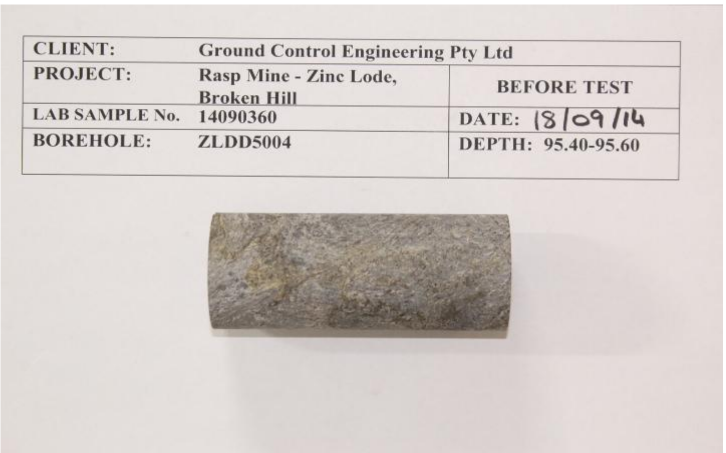
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	18/09/2014
		Report Date	19/09/2014
Client ID	ZLDD5004	**Depth (m)**	95.40-95.60
Description	SW R3		
Sample Type	Single Individual Rock Core Specimen		

Before Test Photograph



After Test Photograph

Notes/Remarks: * Sample failed catastrophically after stage 2

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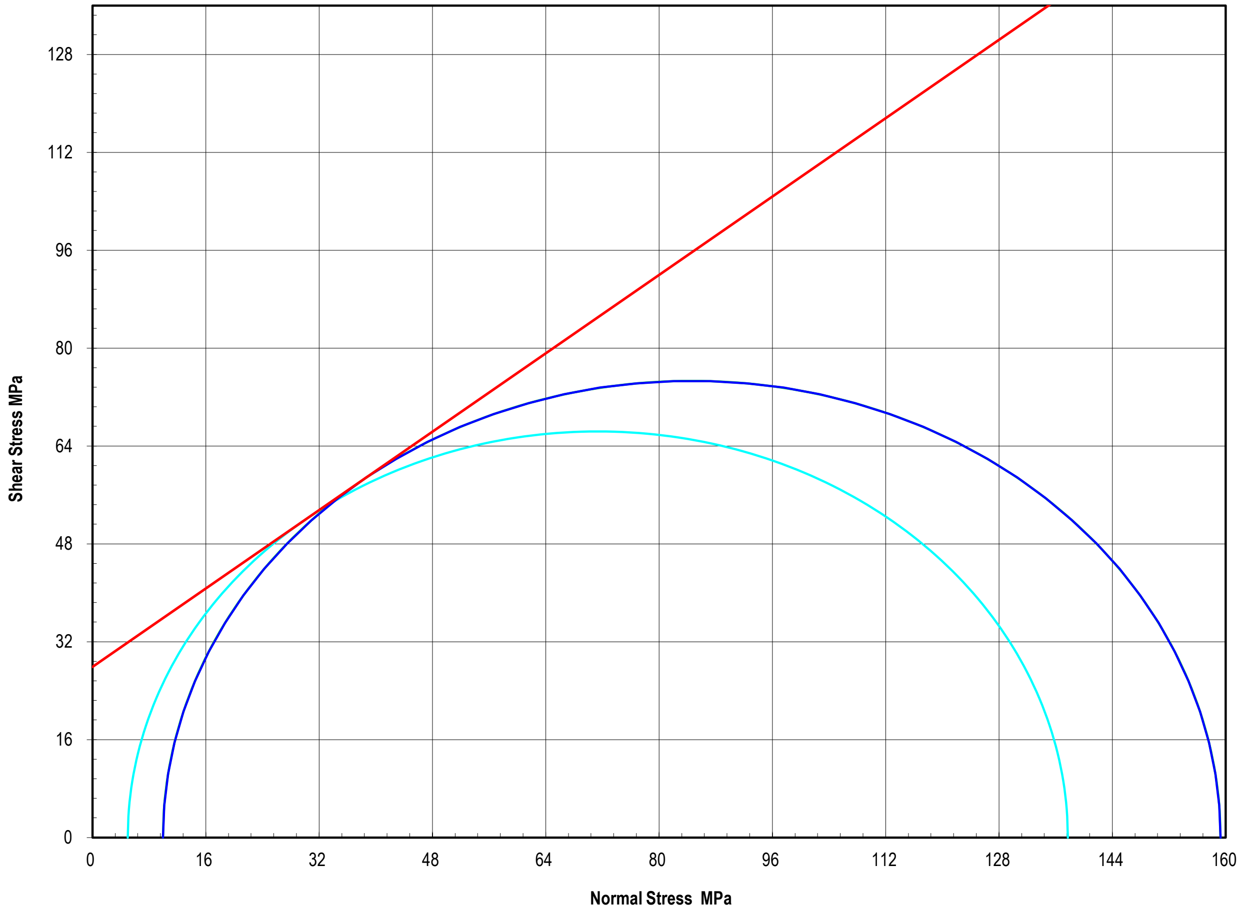
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	18/09/2014
		Report Date	19/09/2014
Client ID	ZLDD5004	**Depth (m)**	95.40-95.60
Description	SW R3		
Sample Type	Single Individual Rock Core Specimen		

Peak Stress Mohr Circle Plot



Estimated Peak Envelope	
Angle	38.7 °
Cohesion	27.87 MPa
Correlation	1.0000

Notes/Remarks: * Stage 3 not used in envelope calculations

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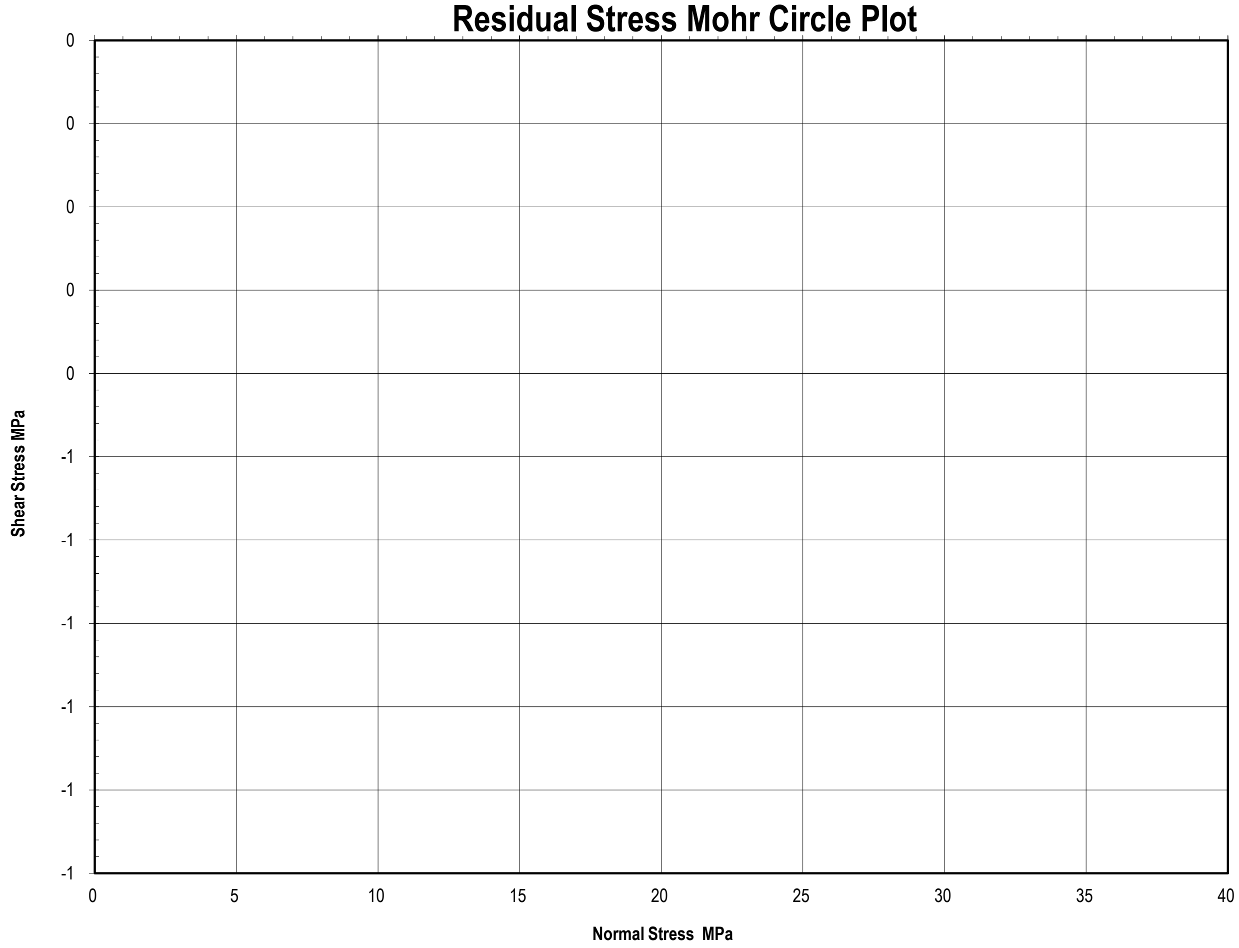
Project	Rasp Mine - Zinc Lode, Broken Hill	**Test Date**	18/09/2014
		Report Date	19/09/2014
Client ID	ZLDD5004	**Depth (m)**	95.40-95.60
Description	SW R3		
Sample Type	Single Individual Rock Core Specimen		

Residual Stress Mohr Circle Plot



Estimated Residual Envelope		
Angle	#	°
Cohesion	#	MPa
Correlation	#	

Notes/Remarks: * Stage 3 not used in envelope calculations

Sample/s supplied by client Tested as received Graph not to scale

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DOCUMENT INFORMATION

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Distribution	PDF to client for review and comment

DOCUMENT CHANGE CONTROL

Version	Description of changes/amendments	Author(s)	Date
V01	Draft report for internal review	D Sidea C Tucker	2/10/14
V02	Draft report incorporating V. Sulicich recommendations.	C.Tucker	6/10/14
V03	Final draft, Section 8.2 added	D Sidea C Tucker	15/10/14

DOCUMENT REVIEW AND SIGN OFF

Version	Reviewer	Position	Signature	Date
V01	D Dickson	Principal Geotechnical Engineer		
V02	D Dickson	Principal Geotechnical Engineer		
V03	D Dickson	Principal Geotechnical Engineer		

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