Level 3, 22 Delhi Street,
West Perth WA 6005
P +61 8 9462 8400
F +61 8 9321 0520
E mailbox@psm.com.au
www.psm.com.au

Our Ref: PSM3754-037L

5 February 2020

Senior Environmental Advisor
Atlas Iron Pty Ltd
Level 17, 300 Murray Street
PERTH WA 6000
David.Morley@atlasiron.com.au

Attention: David Morley

Dear David,

RE: MIRALGA CREEK - ASSESSMENT OF POTENTIAL MINING ACTIVITIES IMPACT ON THE STRUCTURAL INTEGRITY OF THE CAVES

1. Introduction

This letter presents the results of a qualitative geotechnical assessment undertaken on three bat caves located at Miralga Creek in the Pilbara region, Western Australia. The assessment was requested via email by Heidi Taylor of Atlas Iron Pty Ltd (Atlas) on 07 November 2019 with the principal objective to assess the potential impact of proposed mining activities on the structural integrity of three caves nominated by Atlas. This letter presents a brief background to this work, outlines the data provided, summarises the scope of work undertaken, provides a subjective, qualitative assessment of the caves based on visual site inspections and presents recommendations for managing the potential impacts of mining.

This final version of the letter incorporates feedback from Atlas, received via email on 28 January 2020[1], on the draft letter completed on 8 January 2020[2].

2. Background

PSM understands Atlas is developing their environmental approvals submission for the Miralga Project (Miralga). Miralga involves the development of three mining areas, Sandtrax, Miralga West and Miralga Creek (East). Three bat caves that were assessed (CMRC-13 to 15) are located proximal to the Miralga Creek Pit 02 as shown in Figure 1.

PSM has previously provided advice on the current geotechnical stability of bat caves CMRC-13, 14 and 15 and the associated risks prior to undertaking a laser survey of the caves[3]. As part of this previous assessment, a site visit was undertaken by Mr Duncan Noble and Liam Parsons of PSM on 14 to 16 November 2019. The salient findings from the visit were as follows.

[1] Email from David Morley, Senior Advisor – Approvals, dated 28 January 2020

[2] PSM3754-037l DRAFT Miralga Creek - Assessment of Potential Mining Activities Impact on the Structural Integrity of the Caves dated 8 January 2020

[3] PSM3754-035L Miralga Creek – Geotechnical Assessment of Bat Caves dated 22 November 2019.

- All three caves are situated in highly weathered banded iron and chert formations
- All three caves showed no observed sign of water including past pooling of water or channelling of water
- No loose blocks were observed in CMRC-13 and 14 within the cave profile
- Cave CMRC-13 has a shallow profile with tight, low persistence defects visible in the cave walls
- Two chambers were visible in cave CMRC-15 along with two entrances
- Two adverse blocks were observed in cave CMRC-15 located inside the cave profile
- A shear zone was observed in cave CMRC-15 and is inferred to be associated with a regional scale fault cross cutting Pit 02.

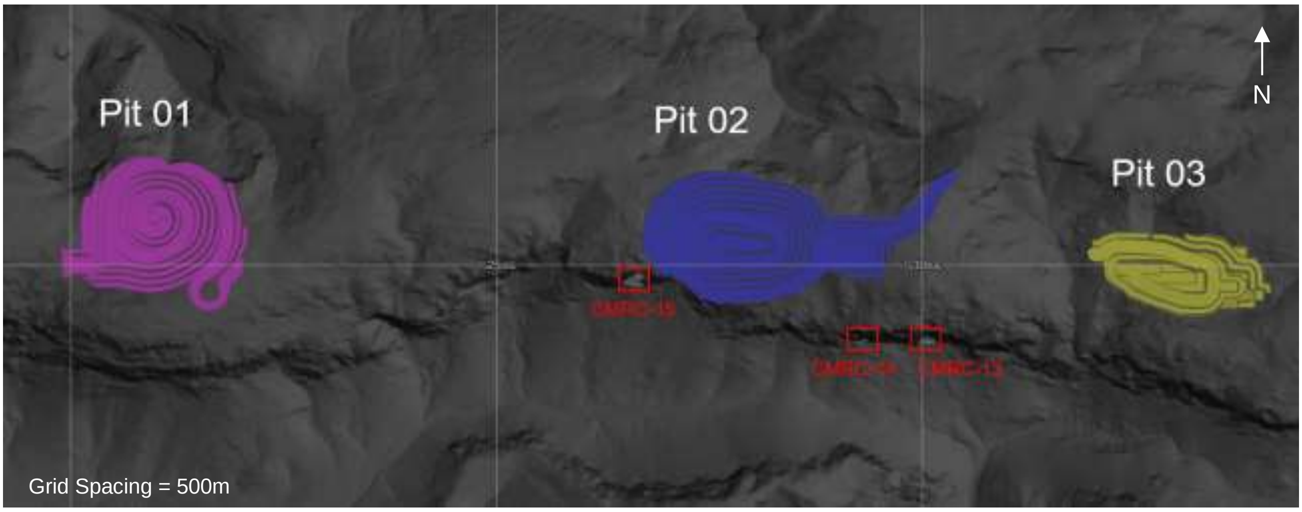


Figure 1: Location of Current Miralga Creek pit designs in relation to assessed caves CMRC-13, CMRC-14 and CMRC-15

Recommendations were provided in the earlier letter (PSM3754-035L) with regard to management of risks during laser survey of the caves.

3. Available Data and Scope of Work

The following data and past reports were supplied by Atlas for this assessment:

- GIS_2537.pdf – Plan of the bat cave and proposed mine operations
- Caves_Miralga_Creek.xls – Coordinates of the three bat caves (CMRC-13 to 15)
- Cave Information.docx – Tabulated information for caves CMRC-13 to 15
- Razorback Cave CA-CO-03 – Memo on the geotechnical assessment of a bat cave at Razorback pit, Corunna Downs
- ABYDOS DSO PROJECT – Geotechnical Assessment – A Geotechnical study for the Abydos Project
- Miralga track.kml – Google Earth path showing access route to caves
- Landsurveys-9180c8- CMRC13, CMRC-14 and CMRC-15 cave scans .las and .dxf.

The scope of work completed for this assessment comprised:

- Review of the available geological, geotechnical and cave information
- Utilisation of the information and observations from the earlier site visit to the cave sites including:
  - Geotechnical conditions of the cave entrance
  - Geotechnical conditions within the cave (as could be achieved with respect to safe access and lighting)
  - Geology and structure observed within the caves and surrounding the caves.

- Reporting of findings in a short letter.

4. Geotechnical Assessment

This section describes the geotechnical condition of each cave as observed during the site inspections which includes an opinion regarding the structural integrity of the cave. Additional observations of the cave conditions were provided in letter PSM3754-035L. Cave dimensions and shapes have been taken from the laser survey results which were completed after the geotechnical inspections.

The term 'hydrated zone' shown in Figures 2, 3 and 4 refers to a zone of weathering below an upper ferricrete layer. The geological processes that have occurred in the hydrated zone can include the dissolution of hematite and martitie and precipitation of goethite. Another term used in the Pilbara to label this zone is the 'hardcap' zone.

4.1 CMCR-13

Cave CMCR-13 is the easternmost of the three caves and is positioned 112 m from the Pit 02 crest, 124 m from the Pit02 base and 40 m from the top of the escarpment, Figure 2. The cave resembles a shallow profile with approximate dimensions 4 mW x 2.5 mD x 3 mH. Rock mass consists of brown to grey-white, high strength (R4), highly to extremely weathered, slightly altered to fresh chert. Bedding was observed to be sub-vertical with wavelengths of 1 – 2 m. Jointing is planar with low persistence and generally of sub-horizontal orientation. Overall the geotechnical conditions appear to be favourable in terms of structural stability.

Cave CMRC-13 is assessed to be of low risk to mine induced structural instability. The distance of the cave from the mine, shallow cave shape and apparent lack of persistent geological structure reduce the potential of mining induced ground vibrations propagating to the cave and reduce the likelihood of structural instability as a result of the vibrations.

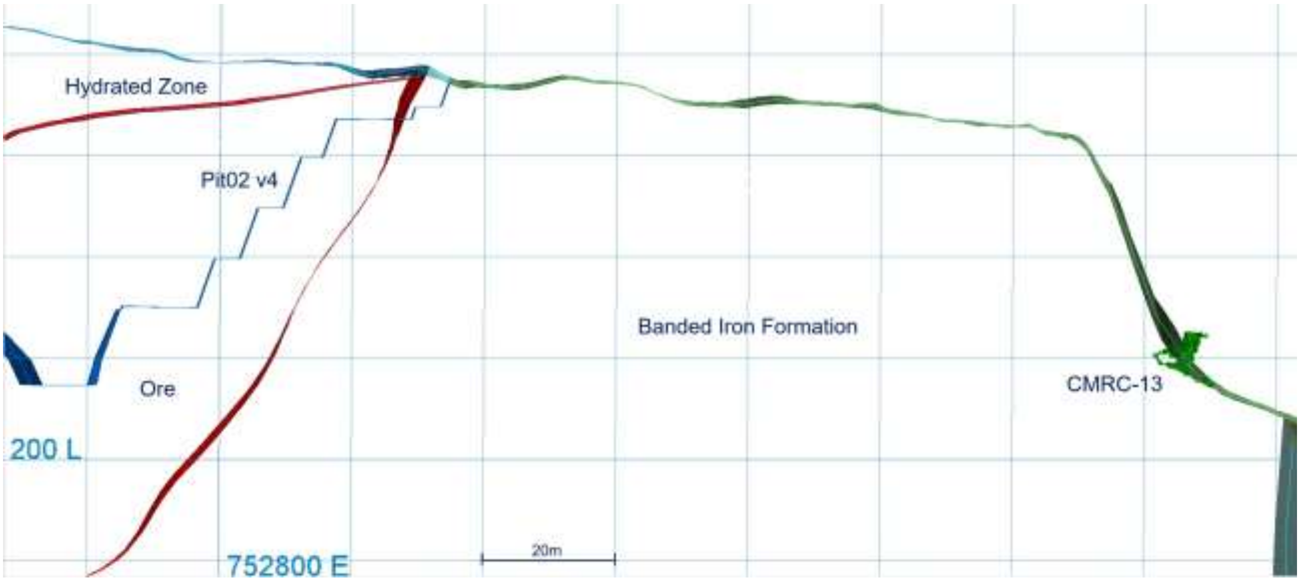


Figure 2: NW-SE cross-section illustrating CMRC-13 location relative to the Pit 02 southeastern pit wall

4.2 CMCR-14

Cave CMCR-14 is situated about 85 m from the Pit 02 crest, 120 m from the Pit 02 base and 31 m from the top of the escarpment, Figure 3. The cave resembles a deep and narrow, arched profile with approximate dimensions 15 mW x 20 mD x 4 mH. The rock material consists of highly weathered brown to grey-white, high strength chert. Bedding is poorly defined to completely overprinted by weathering with no partings observed. No consistent joint sets were recorded, or any other persistent defects observed which could connect the cave to the current pit design. Overall the geotechnical conditions are considered to be favourable in terms of structural stability.

Cave CMRC-14 is assessed to be of low risk to mine induced structural instability. The cave distance from the mine and lack of persistent geological structure reduces the potential of mining induced vibration propagating to the cave and reduces the likelihood of structural instability as a result of the vibrations.

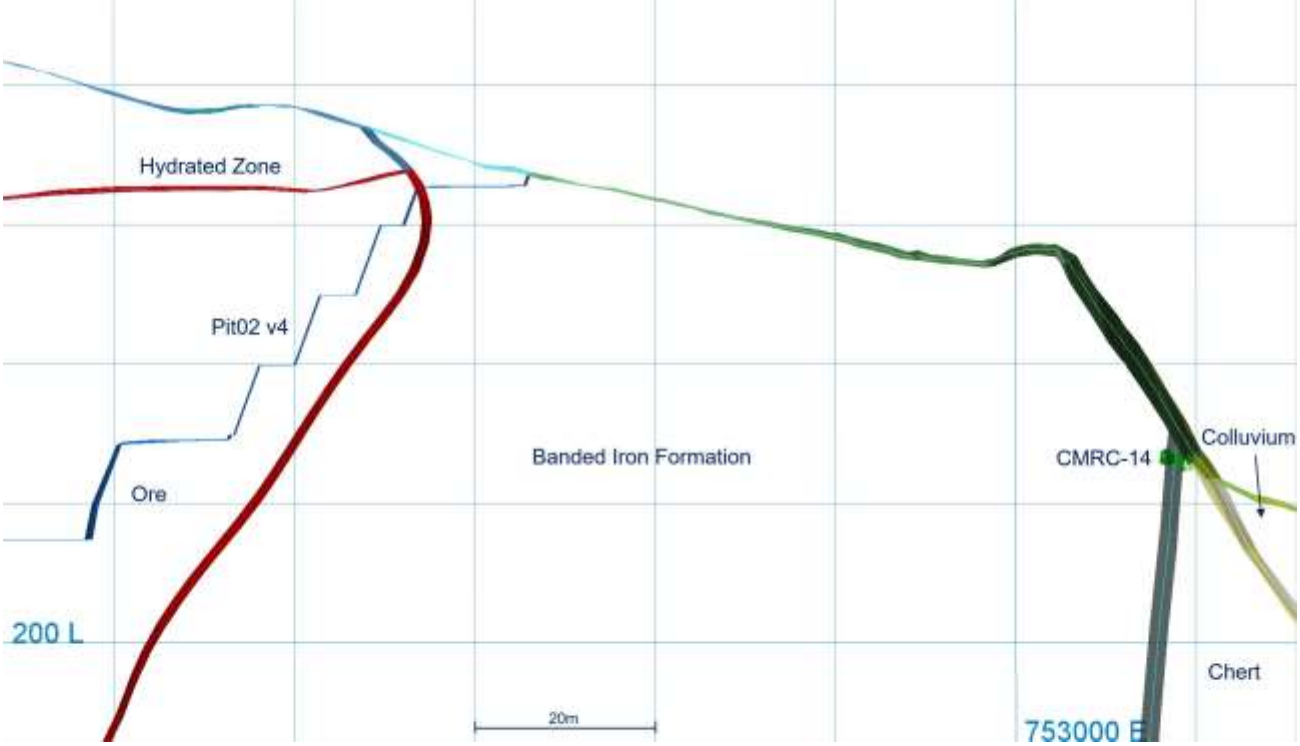


Figure 3: NW-SE cross-section illustrating CMRC-14 location relative to the Pit 02 southeastern pit wall

4.3 CMCR-15

Cave CMCR-15 is the westernmost of the three caves and is positioned about 25 m from the Pit 02 crest, 60 m from Pit 02 base and 20 m from the top of the escarpment, Figure 4. The cave consists of two main caverns, the first is approximately 15 mW x 3 mH x 10 mD. The second cavern has approximate dimensions of 6 mW x 3 mH x 3 mD. The second cavern is accessible to the rear and the right of the main cavern where it appears to abruptly steepen to the north. The overall cave resembles an elongated profile trending in the north-easterly direction, Figure 5. CMRC-15 has two entrances, the main entrance located on the south side of the cave with a secondary entrance located at the south-western end of the cave.

A shear zone was mapped at the rear with a of the cave with dip/strike of 69°/064° towards SE. This shear zone is assessed to be associated with a regional scale geological structure due to its close proximity and similar strike to the regional scale structure. The regional scale geological structure is shown in the Carlindie 1;100,000 scale geological map[4] to intersect Pit 02 and is projected along a north-eastern strike length to be in excess of 800 m and within 10 m of CMRC-15, Figure 6. It is possible the shear observed in CMRC-15 is a subsidiary fault splay of this regional scale fault. The shape and elongation of the cave profile along the strike direction of the shear and regional fault suggests the cave originated as a weathering and erosional feature associated with the fault. The presence of the structure presents a plane of weakness that increases the likelihood of roof or sidewall instability of the cave.

The overall assessment of the structural integrity of Cave CMRC-15 is potential for significant instability of the roof or side wall at the rear of the cave adjacent to the mapped shear zone. Outside of the zone of influence of the shear zone, the remainder of the cave is less likely to experience significant instability of the roof or side wall. This assessment places Cave CMRC-15 at a higher risk of mine induced structural instability compared

[4] State of Western Australia (Department of Mines, Industry Regulations and Safety), 2012, *Carlindie*, Australia, 1:100,000 Geological series, Sheet 2756, Perth.

to caves CMRC-13 and 14. As such control measures are recommended to manage the risk of structural instability due to mining induced vibrations in CMCR-15.

The potential impacts and qualitative likelihood of instability events in cave CMR-15 arising from mining activities are summarised as follows:

- Falling or collapse of observed hanging blocks – more likely
- Partial or complete collapse of cave – less likely
- Collapse forming a new entrance at surface or pit – less likely.

Note this qualitative, subjective impact assessment is contingent on the implementation of appropriate blasting practices to mitigate the risk to cave CMRC-15.

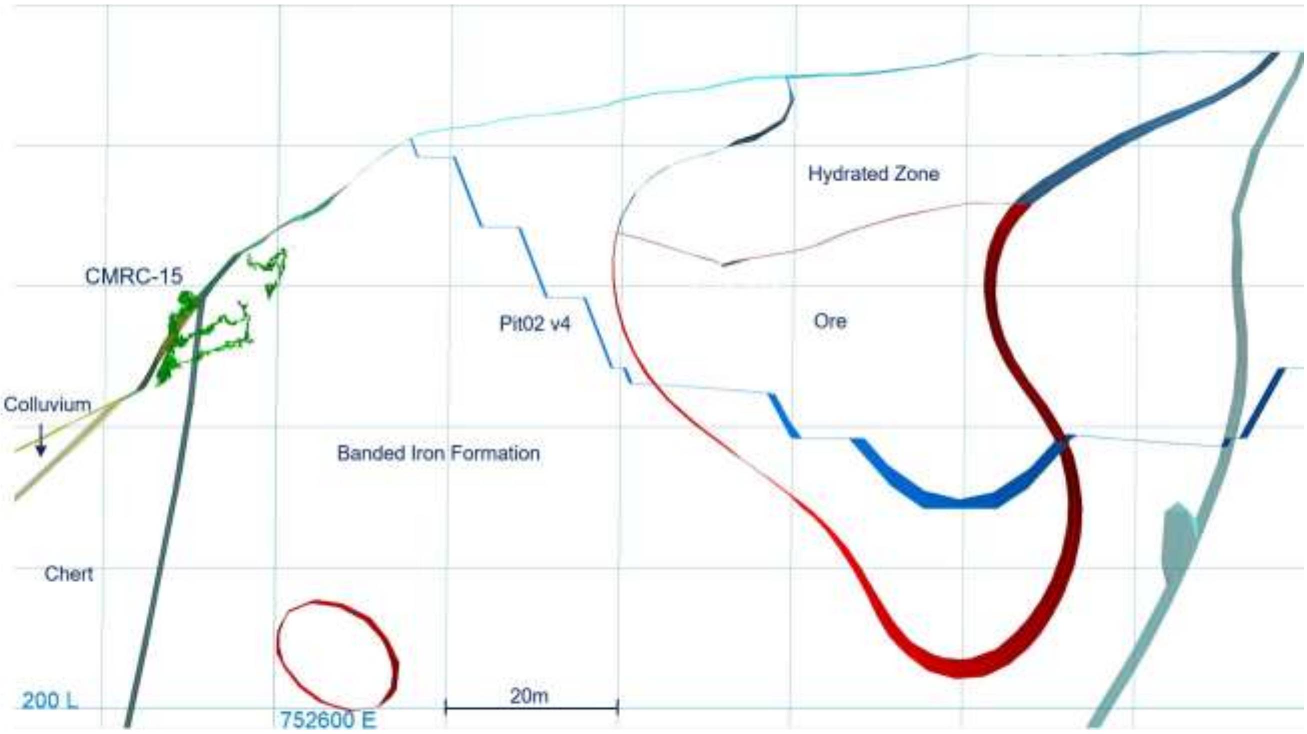


Figure 4: SW-NE Cross-section illustrating the proximity of CMRC-15 to the Pit 02 southwestern pit wall

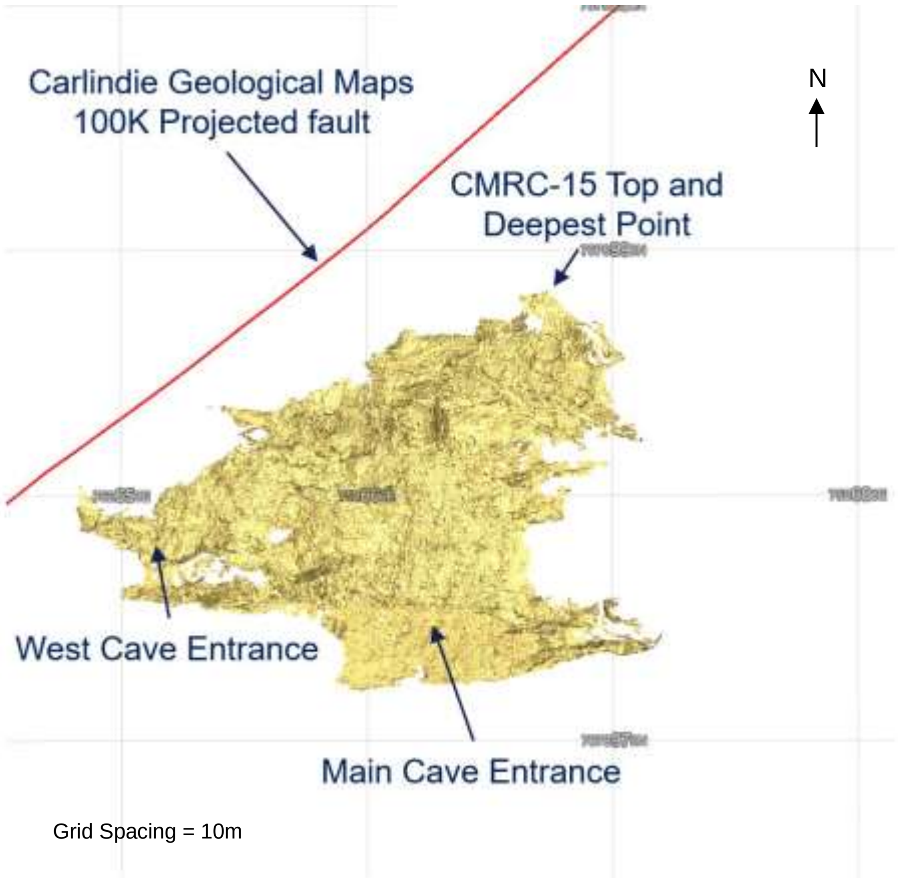


Figure 5: Plan view of the cave CMRC-15 scan showing the proximity of the cave to the Carlindie Geological Map 100K projected fault

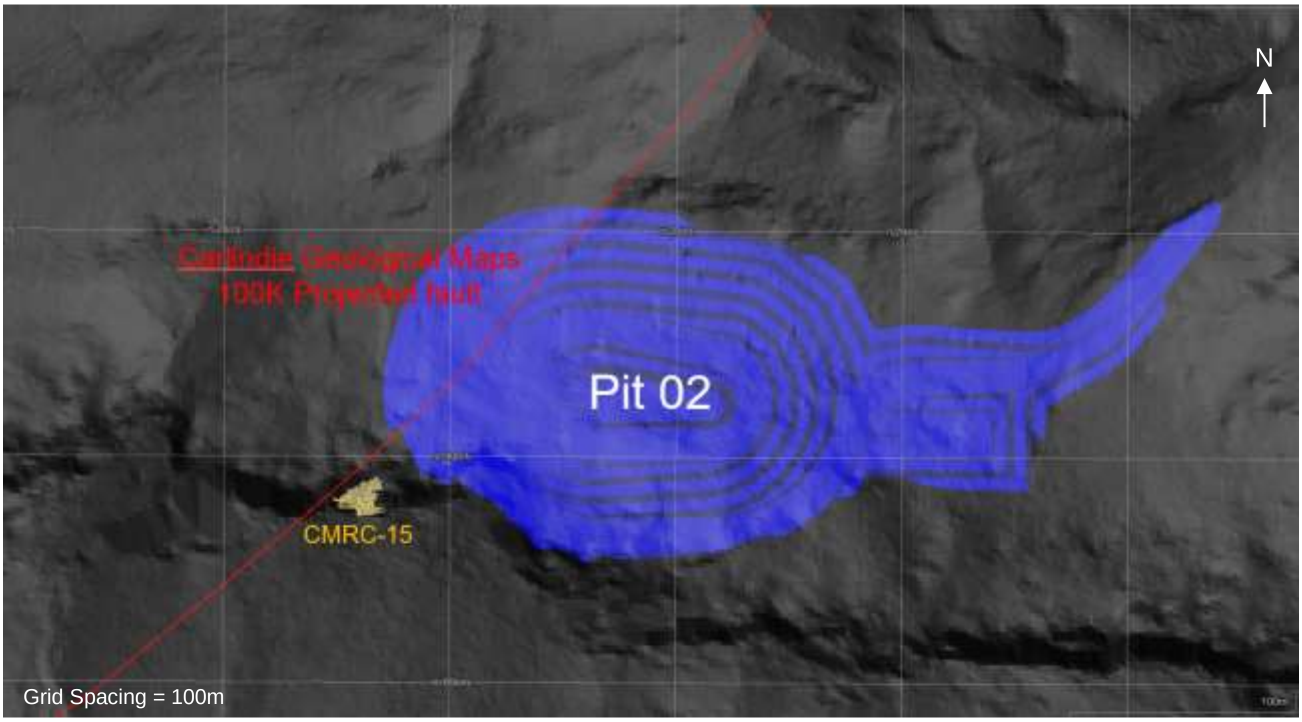


Figure 6: Plan view of Carlindie Geological Map 100K projected fault intersection of cave CMRC-15 scan and Pit 02

5. Conclusions and Recommendations

In conclusion, caves CMCR-13 and 14 are assessed to have a low risk while CMRC 15 is considered to have an elevated risk of structural instability due to proposed mining activities. As such, it is recommended management strategies and controls are implemented to reduce the risk to tolerable levels for cave CMCR-15.

Measures and controls that Atlas can consider, to monitor and mitigate the cave structural integrity include:

- Monitoring of cave CMRC-15 during the initial stages of mining, which we understand will commence in the north-eastern corner of the mine and progress westward towards CMRC-15:
  - This will allow the cave structural stability and vibrations to be progressively monitored as mining approaches the projected fault and cave
  - We understand that Atlas has previously undertaken monitoring of an environmentally significant cave (MD-AN-2) at their Mt Dove operations and recommend similar monitoring methodologies be applied to CMRC-15.
- Obtaining internal/external blasting advice to identify techniques or methodologies to mitigate the effects of blasting vibration on cave CMRC-15
- Undertaking regular pit mapping to identify and assess geological structures of similar orientation to the mapped shear and regional structure that could impact on the structural integrity of the bat cave.

For mine planning and design guidance purposes, the following commentary is provided:

- In general, the greater the distance between the pit and cave, the lower the risk of mining impacting on cave CMRC-15 which can be achieved by modifying the pit design; the disadvantage is the likely sterilisation of ore
- However, it may be possible to sufficiently reduce the risk, while maintaining the current design, by adopting suitable modified blasting practices in this quadrant of the pit with the disadvantage of increasing mining costs
- The best outcome may include a cost benefit analysis of a combination of changes to the pit design and adoption of modified blasting practices to minimise the sterilisation of ore and limit the increases to mining costs.

To take this assessment to the next level some form of numerical modelling of the cave stability conditions would be required. The objective of the modelling would be to quantitatively assess the current stability of the cave and simulate the blast vibrations and stress changes to the rock mass due to mining to help predict the quantitative impacts on the cave.

6. Closure

We trust this letter meets your requirements. As mentioned above, if furthermore detailed advice is required, this may require undertaking numerical analyses / modelling of the proposed pit design, cave and blasting.

If you have any questions, please do not hesitate to contact the undersigned.

For and on behalf of
PELLS SULLIVAN MEYNINK

LIAM PARSONS
ENGINEERING GEOLOGIST

MARK EGGERS
CHIEF ENGINEERING GEOLOGIST

Encl. Appendix A – Location Plan

Glossary:

Alteration - involves the modification and replacement of the original minerals in a rock with a new suite of minerals with different chemistry.

Bedding parting - A parting lineation is a sedimentary structure commonly found on the surface of parallel-laminated sandstones or siltstones.

BIF - Banded Iron Formation: A distinctive type of rock often found in primordial sedimentary rocks.

Dip - the acute angle that a rock surface makes with a horizontal plane

Dip Direction - The bearing the Dip is declined in.

Escarpment - A transition zone between different physiogeographic provinces that involves an elevation differential, characterized by a cliff or steep slope.

Hydrated Zone – A secondary mineralised zone formed by surface weathered processes.

Joint - A discrete discontinuity surface without evidence of displacement.

Mineralisation - The hydrothermal deposition of economically important metals in the formation of ore bodies or "lodes"

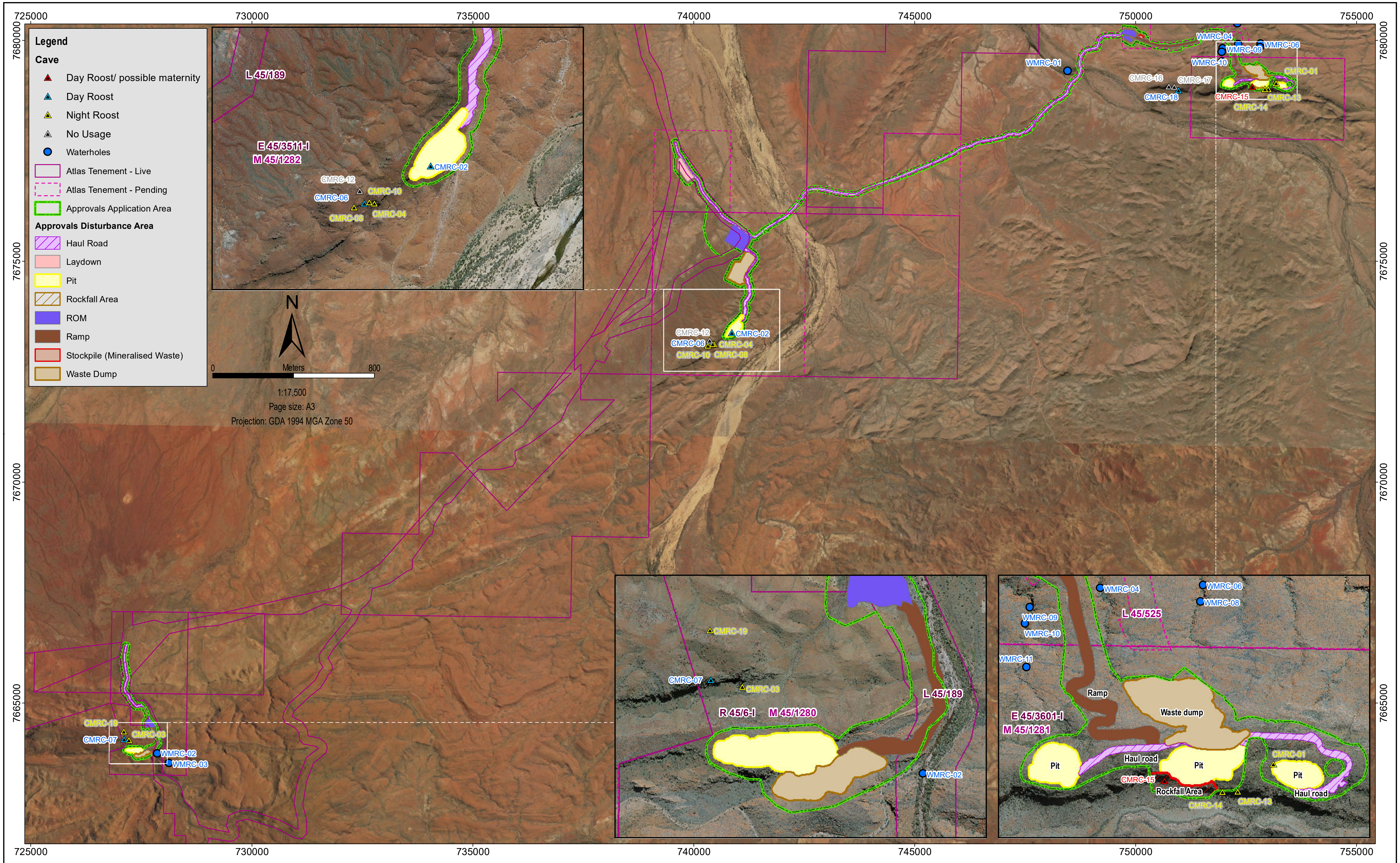
Strike - is the direction of the line formed by the intersection of a rock surface with a horizontal plane.

Talus - A collection of broken rock fragments at the base of crags, mountain cliffs, volcanoes or valley shoulders that has accumulated through periodic rockfall from adjacent cliff faces. Landforms associated with these materials are often called talus deposits.

Vein - A mineral filling of a fracture or other crack within a rock in a sheet-like or tabular shape.

Waviness - is the measurement of the more widely spaced component of surface texture associated with structural defects or bedding.

Appendix A
Location Plan



ATLAS

File Name: GIS_2537.mxd

Date: 01.11.2019

Author: Drew.Smith

Document Number : (QDMS number only)

Source & Notes:

Disclaimer: This figure has been produced for internal review only and may contain inconsistencies or omissions. It is not intended for publication.

FOR INTERNAL USE ONLY

Indicative Cave Locations

Figure No:

1

DRAFT

MIRALGA CREEK *Atlas*