REPORT

Rasp Mine - Tailings and Waste Rock Management for MOD 6

Submitted to:

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Distribution List

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1.0 INTRODUCTION

Broken Hill Operations Pty Ltd (BHOP) operates the Rasp zinc-lead mine in Broken Hill, NSW (the site). Ore is recovered from an underground mining operation and is processed on surface in the Processing Plant. Tailings from the plant is currently placed in a thickened slurry form into the Blackwood Pit (TSF2) located within the mine lease area. The tailings surface elevation is approaching the final design elevation and BHOP plans to transition tailings storage from TSF2 to the nearby Kintore Pit (TSF3).

This report summarises the work undertaken by Golder Associates Pty Ltd (Golder) under commission by BHOP related to tailings and waste rock management associated with the proposed MOD6 development at the Rasp Mine. The MOD6 development is understood to relate to 5 years of operation at the site (to the end of 2026 when the current Project Approval is due to expire). This report details the proposed development both within the Project Approval timeframe of MOD6 and with an extended period that enables the filling of TSF3.

2.0 BACKGROUND

The Kintore Pit (TSF3) has been identified for life of mine tailings storage once the TSF2 has reached its capacity. TSF3 was chosen as the life of mine tailings storage facility through an assessment and selection process undertaken by BHOP which included an options analysis conducted by Golder (Rasp Mine - Tailings Storage Options Analysis, September 2017). The assessment considered a TSF option that was on-lease (TSF3) and a number of off-lease TSF options. Off-lease TSF options were deemed as not suitable for further assessment considering the large costs associated with clearing a new area, haulage of embankment fill materials and the potential requirement to install a liner system over relatively large tailings storage areas. On-lease TSF results in less land disturbance and in-pit TSF is also considered to be a preferable tailings storage option compared to above ground storages related to risk to outside stakeholders.

Two tailings storage concepts which have been considered for TSF3 include thickened tailings deposition via pipeline, similar to current operations at the TSF2, and the placement of dewatered tailings. Two options were considered for dewatering of the tailings: filtration and solar/air drying. For additional safety, the use of underground waste rock was considered to provide an additional barrier between the tailings, pit floor and walls. Due to factors including site conditions and safety related considerations, the option of a co-disposal dried tailings and waste rock approach is preferred.

The dried tailings and waste rock co-disposal approach is expected to substantially reduce the risk of liquefaction and inrush of tailings from the pit into underground mine workings compared with the option of thickened tailings deposition in TSF3. Accordingly, dried full stream compacted tailings are proposed to be co-disposed with waste rock in TSF3. Tailings will be dried and harvested in TSF2, before transport into TSF3.

3.0 PROPOSED APPROACH FOR TAILINGS AND WASTE ROCK MANAGEMENT

The approach selected by BHOP involves continuing to deposit thickened tailings into TSF2 at a proposed maximum rate of up to 480,000 tonnes per annum (tpa). The tailings deposition rate may vary over time depending on processing plant production, mining operations and variable weather conditions to enable dried tailings harvesting. The tailings slurry is deposited into TSF2 at a solids concentration of approximately 65% by weight[1] which is equivalent to a dry density of approximately 1.15 t/m^3 and a gravimetric moisture content of approximately 53%. The tailings are proposed to be deposited in thin layers into drying bays (cells) to enable the tailings to dry or 'dewater' to a point where the tailings can be excavated, hauled, deposited and compacted in TSF3 using conventional earthmoving equipment. Dried tailings will be transported by truck

[1] Solids concentration = mass of solids / total mass of slurry

and placed in compacted layers within the central part of TSF3. The proposed tailings and waste rock management layout is presented in Figure 1.

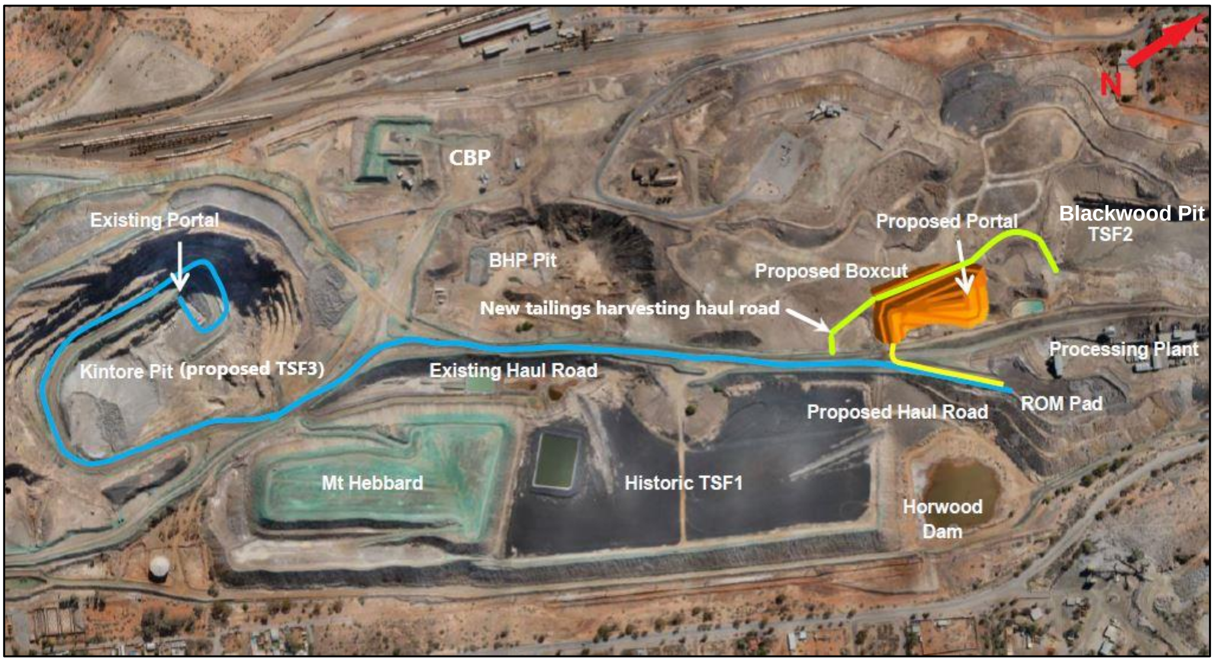


Figure 1: Tailings and Waste Rock Management Layout

Waste rock from mining operations is intended to be co-disposed in TSF3 and placed over the bottom and sides of the pit. The bottom layer of waste rock is proposed to include a seepage drainage network with a robust outlet system through the filled portal decline through an engineered concrete plug to the underground mine workings water management system. To help reduce the risk of the drainage network being impacted by fines from the tailings in the event of upset conditions related to drainage via the portal, additional measures are proposed to be incorporated in TSF3. Additional measures may comprise installation of a riser pipe to enable pumped extraction of seepage collected in the drainage network and/or the installation of a layer of non-woven separation geotextile over the waste rock in the base of the pit and extended up the sides of the rockfill surround to control the risk of potential migration of fines from the tailings into the drainage layer if the bottom of the pit was to become saturated.

Additional waste rock generated from mining activities is also proposed to be used for rehabilitation capping at various locations within the lease area.

Further information regarding proposed tailings and waste rock management is presented in Sections 5.3.2.1, 7.0, 9.0, and 10.0. Information related to amendments to stormwater management practises onsite in response to these amended management practises is presented in Section 11.0.

4.0 KINTORE PIT TSF3 CHARACTERISTICS

4.1 Configuration of Kintore Pit TSF3

The site has been mined for over 135 years leaving the site highly disturbed with a number of heritage buildings and structures within the site. The majority of the site is covered with historic waste rock or tailings material, and there is minimal topsoil and vegetation. TSF3 is located in the western half of the site, as identified on Figure 1.

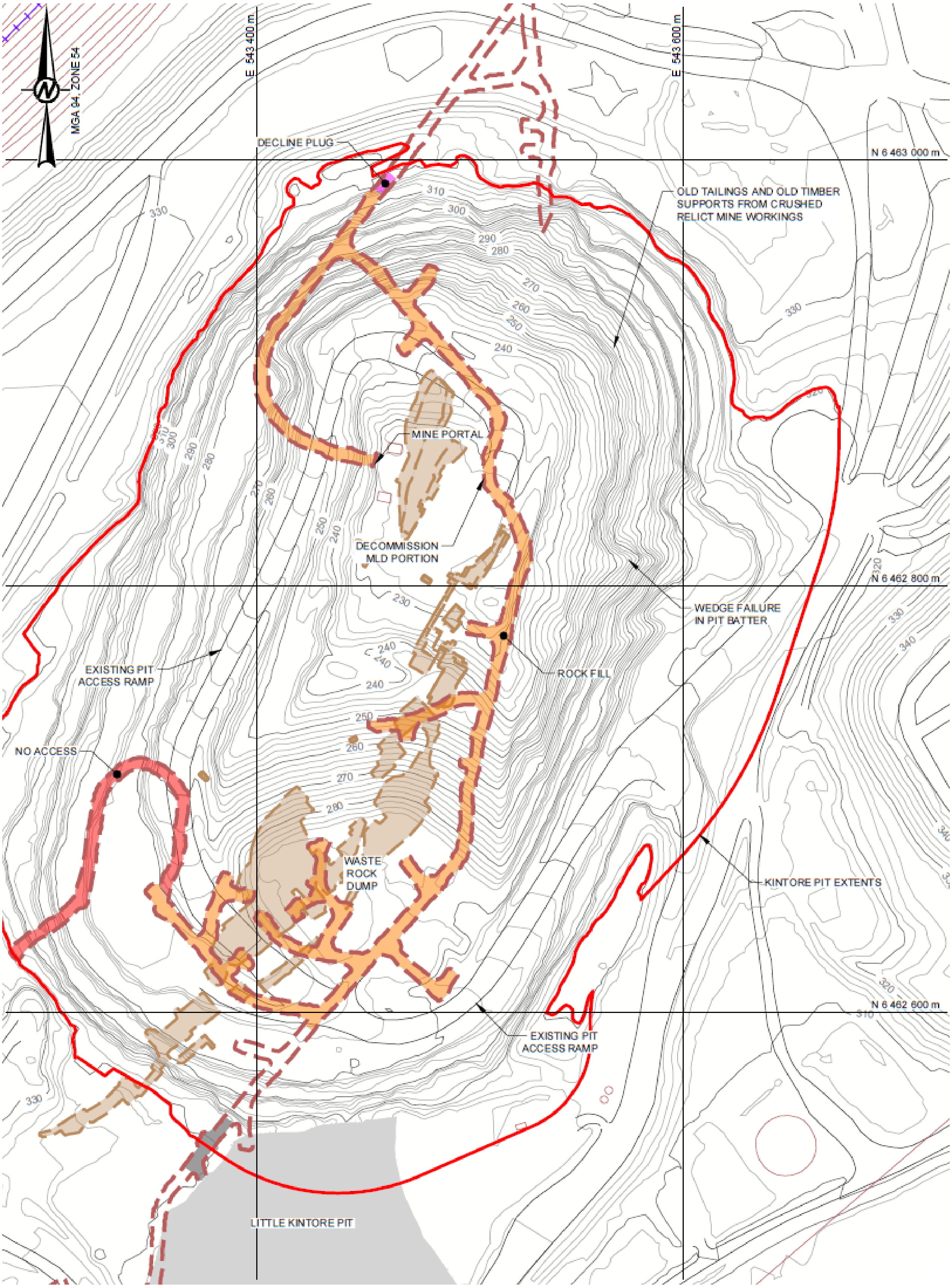


Figure 2: Extent of waste rock filling in Old Workings

TSF3 is approximately 110 m deep (RL 210 to RL 320) on the southern perimeter and approximately 480 m wide (north to south) and 360 m long (east to west). Pit wall excavations have exposed tailings within an old storage facility in the northern batter of the pit, as well as old timber supports from crushed relict mine workings. Adits and shafts to old workings are present in the batters on each side of the pit, including reportedly behind and below a waste rock stockpile against the southern pit face.

A slope wedge failure has occurred in the eastern batter of the pit where the intersection of discontinuity planes in the rock slope has day-lighted in the batter slope. Failure of the wedge is understood to have occurred in approximately 2014 following a period of heavy rainfall.

Access to the current underground workings is by a decline and access ramp tunnel system with the decline portal located at the base of the pit and into the toe of the western batter slope. The lower slopes around and within the decline portal have been supported by a combination of resin bolts, split sets, cable bolts and fibre reinforced shotcrete. A plan of the decline and access ramps in the TSF3 area is presented in Figure 2. This shows the decline branching at about 160 m length with one ramp continuing to the northern mine workings and one turning back under the pit floor and connecting to the southern mine workings.

BHOP has advised crown pillars separating the pit floor from the old workings were removed either during open pit mining or by previous underground remnant mining.

The current Main Lode Drive (MLD) and old mine workings are located below the pit floor with a minimum rock cover thickness reported by BHOP to the old workings of approximately 10 m and to the MLD of approximately 15 m. It is understood that once current mining operations are completed future access to the MLD will not be required and prior to commencement of tailings / waste rock disposal into the pit, the MLD will be filled with waste material to the extent shown on Figure 2 and barricaded to prevent access.

BHOP prepared a contour plan of the TSF3 which also shows the location of the decline and underlying MLD, and has provided various reports related to the estimated extent of the historic mine workings. Collapsed old mine workings are located in the north-eastern pit sidewall, with a collapsed stope noted to be partially filled with tailings at an elevation of approximately RL 275 m.

A waste rock stockpile has been formed on the southern floor of the pit. The volume of the stockpile based on comparison of topographical surveys before placement (January 2000) and the April 2016 survey after placement is approximately 450,000 m^3. Additional waste rock has been placed on the stockpile since the 2016 survey. A north-south section through the pit is shown in Figure 3. The pit sidewalls have been formed as a series of batters with generally small benches with overall average sidewall slopes of about 40°.

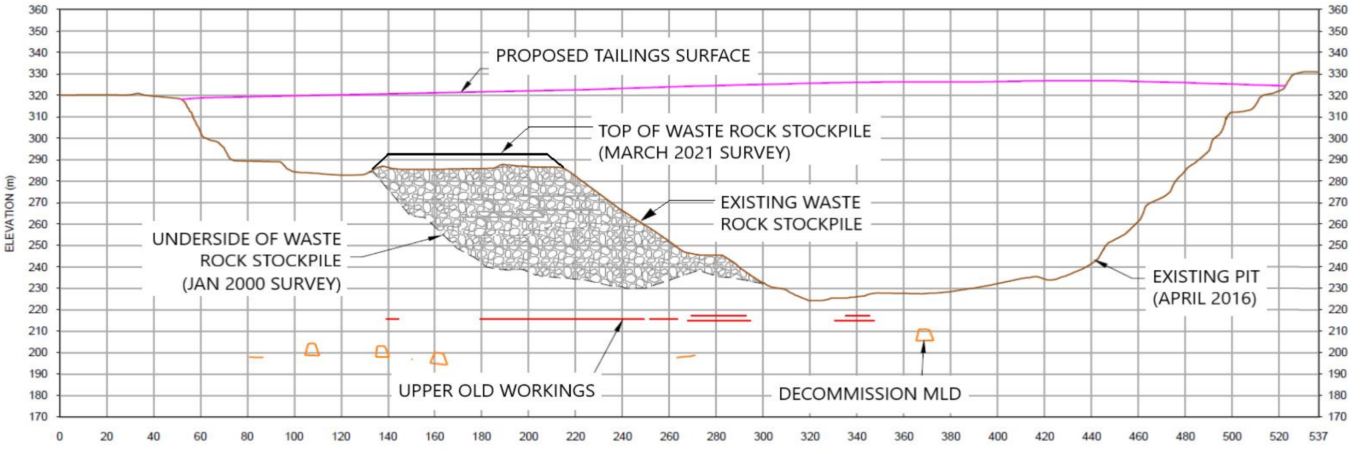


Figure 3: North-South section through the Kintore Pit TSF3

4.2 Capacity and Service Life

Kintore Pit TSF3 has a relatively small footprint in the bottom of the pit, increasing substantially above RL 280 m. As described in Section 3.0 the proposed strategy for tailings deposition in the pit comprises placement of engineered fill in the form of dried tailings and waste rock in the pit to reduce the risk of inrush into the old and current underground mine workings below and adjacent to the pit. The intent is to dry the tailings to a moisture content that allows the tailings to be trafficked for excavation, haulage, spreading and compaction.

The pit footprint at RL 250 m is approximately 2 hectares (20,000 m^2), with the bottom of the pit being approximately 0.48 hectares (4,800 m^2). The rate of tailings placement in these relatively small footprint areas needs to be limited to enable placement, compaction and potentially some drying to manage occasional rainfall in the pit.

Based on a 480,000 tpa tailings production rate as nominated by BHOP and 146,000 tpa of waste rock co-deposition strategy, described in Section 7.2.1, the TSF3 has capacity to store tailings produced for the proposed MOD6 development life (5 years with an estimated 2,320,000 m^3 capacity to approximately RL 285 m AHD). However, the total pit capacity from the bridging layer to natural ground level (approximately RL 320 m AHD) is estimated to be approximately 4,305,000 m^3 which equates to approximately 13 years of filling at the nominated production rates.

5.0 TAILINGS AND WASTE ROCK PROPERTIES

5.1 Tailings Properties

Dried full stream tailings are intended to be deposited and stored as engineered fill in TSF3. Golder undertook laboratory testing on tailings samples provided by BHOP as presented in APPENDIX D. The results of the testing are summarised in the following subsections.

5.1.1 Classification Testing

The results of index testing are summarised in Table 1. Based on the results, the full stream tailings is classified as a non-plastic silt[2] in accordance with Australian soil classification system (AS 1726:2017).

Table 1: Index test summary

Sample ID	SG	Liquid Limit (LL) (%)	Plasticity Index (PI) (%)	Shrinkage Limit (%)	Fines Content (%)
Full Stream Tailings	3.04	22	0	0	45

[2] Applying the universal soil classification system (USCS), the Tails Cyclone Feed would be classified as a Silty Sand.

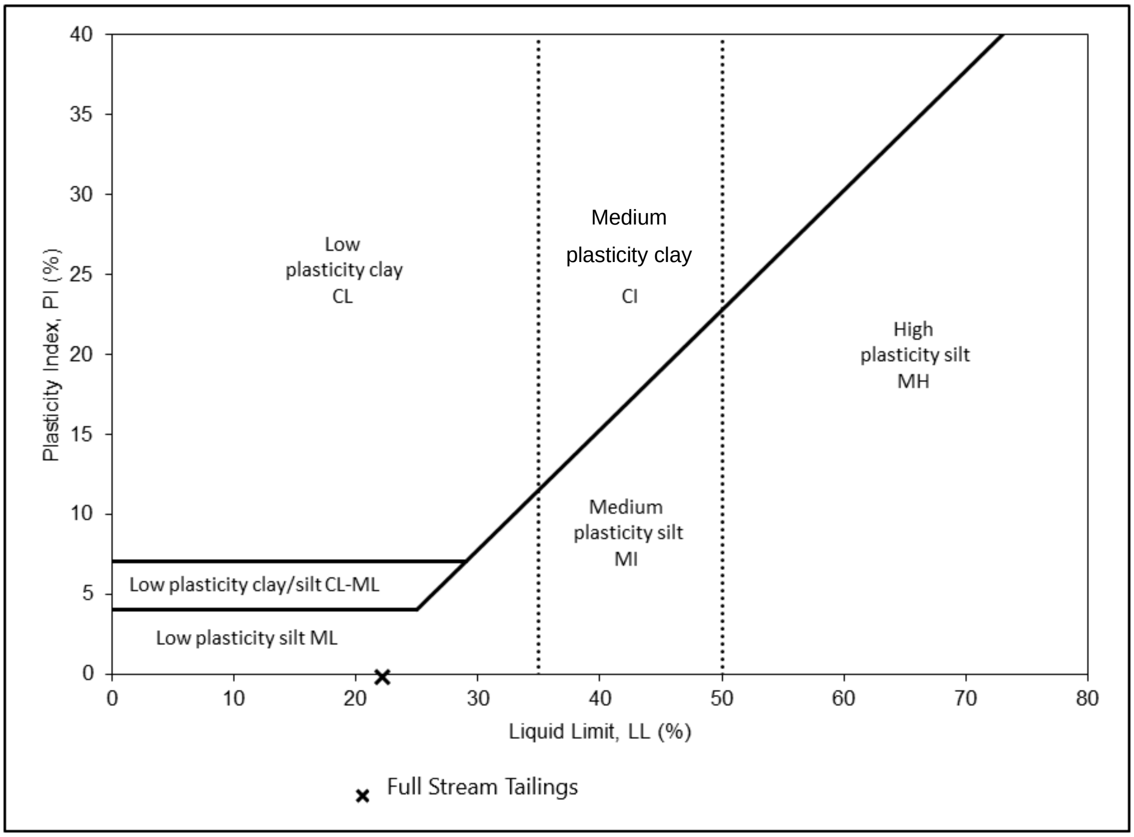


Figure 4: Soil classification based on Atterberg limits

5.1.2 Compaction Testing

The results of compaction testing undertaken on tailings samples are summarised in Table 2.

Table 2: Compaction testing summary

Sample ID	Optimum Water Content (%)	Standard Maximum Dry Density (SMDD) (t/m^3)
Full Stream Tailings	10.0	1.98

5.1.3 Critical State Testing

The critical state line (CSL) is a useful concept to understand geomechanical behaviour of materials. Generally, materials that are looser than the CSL exhibit contractive behaviour during shearing, while those denser than the CSL exhibit dilation. Further, significantly dilative materials are unlikely to exhibit static liquefaction, which occurs when contractive materials are loaded (often under drained conditions) to a shear stress ratio that allows contractive undrained shearing to be triggered. Once the CSL is established, material behaviour can be investigated based on the concept of a state parameter (ψ) (Jefferies and Been, 2015). The state parameter is the void ratio difference between the current state of the soil (i.e. prior to shearing) and the critical void ratio at the same mean effective stress. Typically, a material is regarded at risk of contractive behaviour when the state parameter is greater than -0.05. To reduce the potential for liquefaction or shear-related strength loss, it is desirable for a material to maintain a $\psi<-0.05$ over the operational life of a facility.

The results of triaxial testing undertaken on tailings samples are presented as follows:

- The results are summarised in Table 3.
- The state diagram for Full Stream Tailings is presented in Figure 5.
- The stress paths and critical frictional angle are presented in Figure 6.
- A plot of the CSL is shown in Figure 7.

Table 3: Summary of triaxial testing results

Triaxial ID	Test Type	CSL Parameters		K	Undrained Strength		Critical Friction Angle Φ_c (°)
		Γ	Λ		Peak Su/σ'v	Residual Su/σ'v	
TX1-1000 kPa	CID	0.9474 (1.214)*	0.044 (0.086)*	1.00	-	-	33.8
TX2-100 kPa	CID			0.96	-	-	38.9
TX3-300 kPa	CID			0.99	-	-	36.4
TX4-300 kPa	CIU			0.99	0.21 (ψ=0.066)	0.12	34.6

Note: * Values in parentheses indicate CSL parameters for vertical effective stress (σ'v) > 590 kPa.

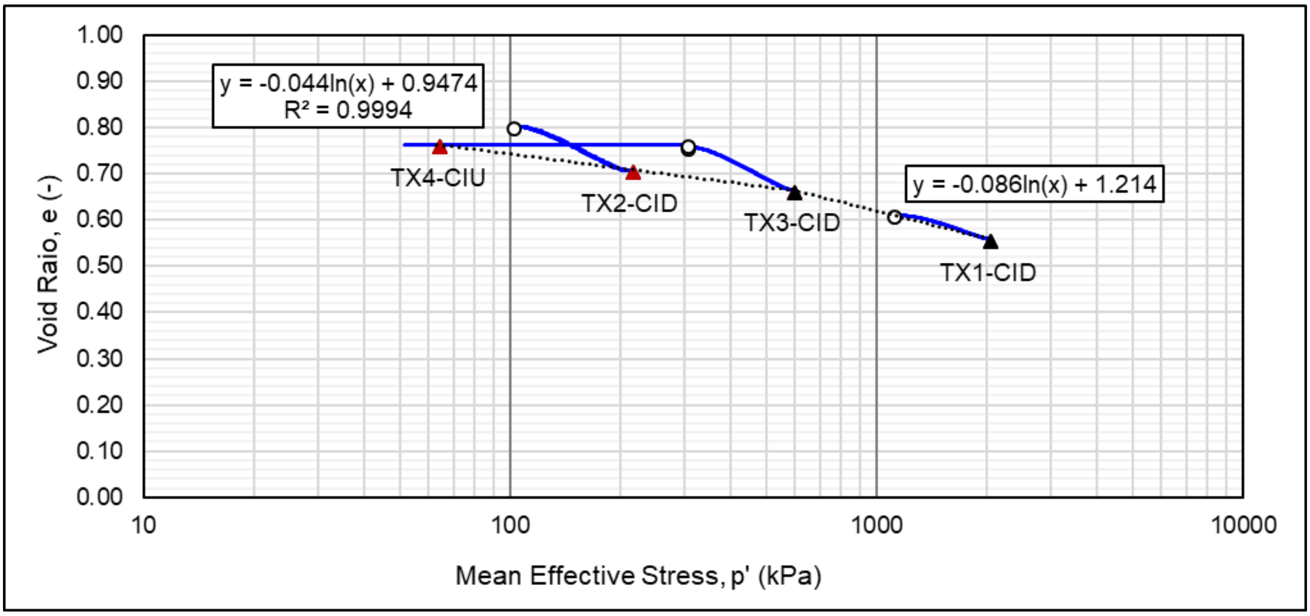


Figure 5: Critical state line for full stream tailings

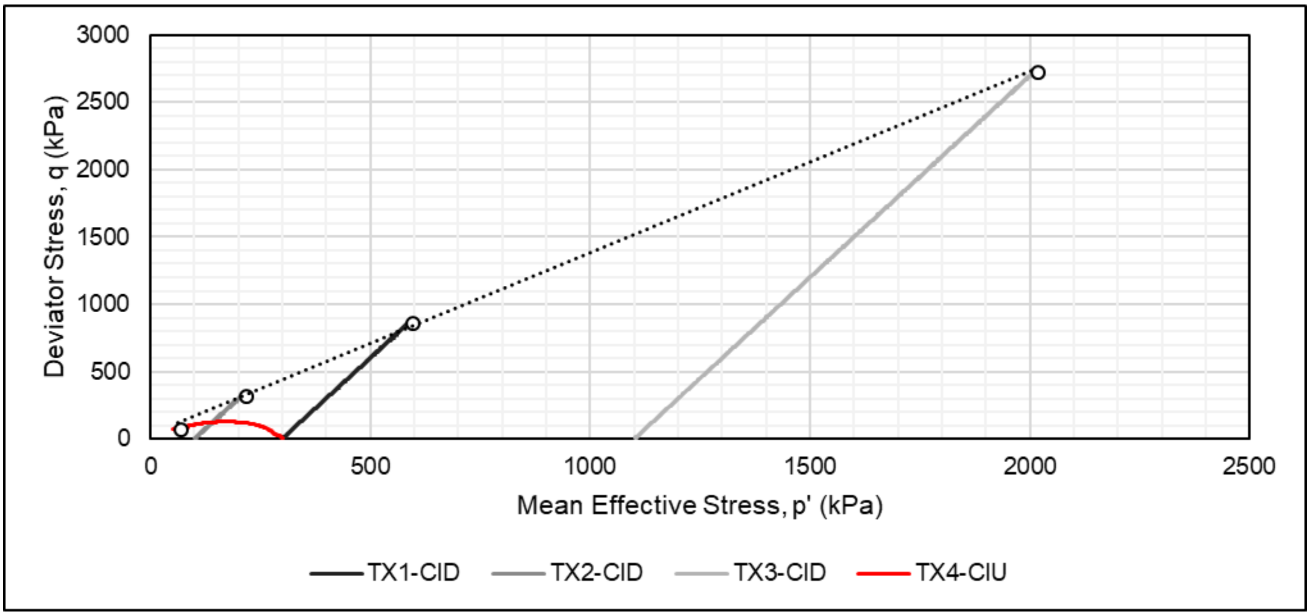


Figure 6: Cambridge plot and critical friction angle for full stream tailings

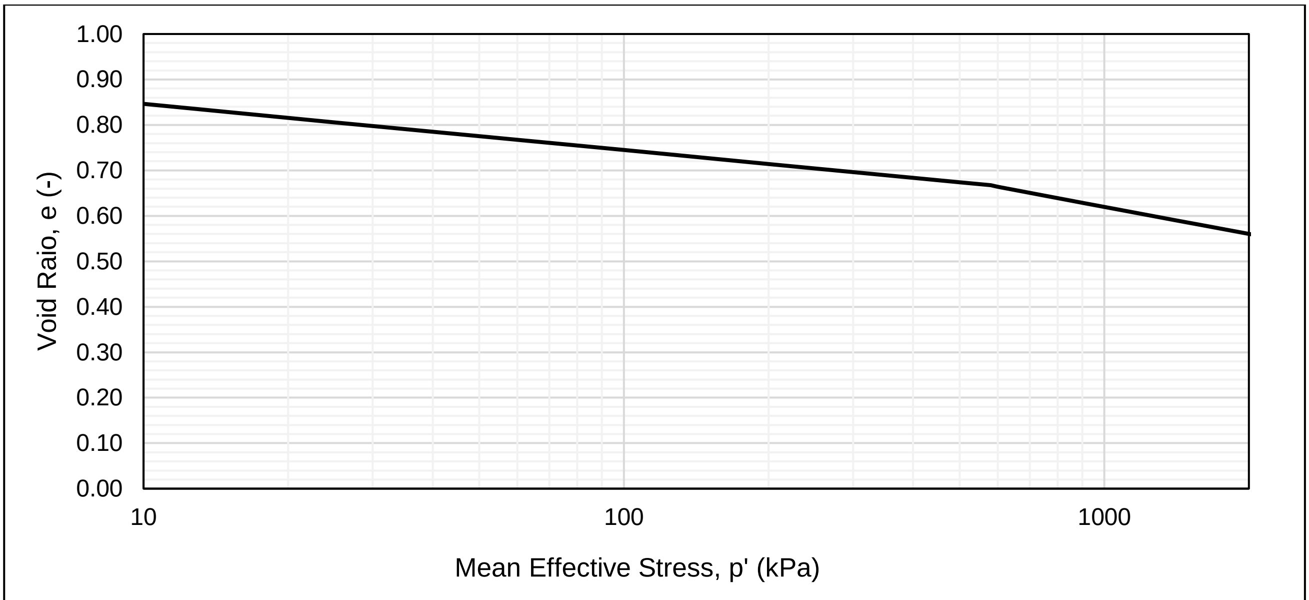


Figure 7: CSL from Full Stream Tailings

The results of the critical state testing indicate:

- The slope of the critical state line is consistent to a stress of approximately 600 kPa. From this stress, the CSL seems to curve from the conventional semi-logarithmic representation. It is noted that several materials present curvature of the CSL (e.g. Jefferies and Been 2015, Verdugo 1992) and the natural logarithmic trend representation is more a convenient engineering approximation rather than an intrinsic material property.
- The slope of the CSL and its location in the e-p' space is the result of a combination of factors, such as the particle size uniformity, fine content, plasticity and particle shape. For example, a material with a

uniform gradation has been observed to produce steeper and higher CSLs than materials that are well-graded, despite having similar fines content (e.g. Jefferies and Been, 2015).

- The critical friction angle inferred from the CID and CIU triaxial testing varies between 34° and 39°, which is typical of silt tailings.
- The peak and residual consolidated undrained shear strength ratios from CIU triaxial compression was 0.21 and 0.12, respectively, at ψ of approximately +0.07. A material with higher state parameter could exhibit lower peak and residual strengths than inferred from this study. Generally, a minimum residual strength for loose contractive soils of 0.05 times the effective stress or less has been reported by several studies of liquefaction case related failures (e.g. Olson and Stark, 2002, Robertson, 2010, Jefferies and Been, 2015).
- Depending on the achieved void ratio during placement and after being subsequently compressed by overlying layers (and hence density) the tailings may potentially become liquefiable when exposed to high confining pressure (refer to Section 5.3 for further discussion).

5.2 Waste Rock Properties

A waste rock study was undertaken in 2017 by Pacific Environment Ltd (PEL) for PA 07_0018 MOD4, Waste Rock Classification, March 2017. The PEL report indicates that the bulk of waste rock is composed of Garnet Pelite and Psammopelite, then Garnet Spotted Psammopelite with very minor quantities of dolerite (DOL) and Garnet Quartzite present. All of these rock types are described as hard and competent units with the exception of Garnet Pelite 1 and 2, which is noted as a softer rock type that has been more susceptible to accommodating shearing. Conversely, DOL1 and DOL2 is rated as extremely hard rock with very high uniaxial compressive strength (UCS).

PEL found that the moisture content of waste rock samples was very low. Moisture content has a significant effect on rock strength, lower moisture contents are typically linked to increased rock strength which will impact how much weathering of the rock may occur over time.

PEL also found that the waste rock samples showed a consistent trend with a low proportion of small particle sizes. Laboratory reports showed that 4 of the 5 samples had 1% of the sample passing a 75 µm sieve; while one sample had 2% passing the 75 µm sieve. Significant volumes of dust are reportedly unlikely to be generated from particle sizes greater than 75 µm.

A report titled ‘Long Term Geochemical Degradation Assessment for Waste Rock MOD6 Waste Rock Management, Rasp Mine’ by Environmental Resources Management Australia Pty Ltd, dated 16 March 2021, found that the potential for acidic drainage from waste rock is expected to be low and that a site inspection by the author of this report found no surface evidence of acid drainage.

5.3 Liquefaction and Inrush

Underground mining operations are currently located to the north and south-west of the TSF3 and the operational areas are accessed via a decline through a portal at the base of the TSF3. The operational areas are also connected by a mine access tunnel (MLD) that joins the decline and passes below the base of the TSF3. Historic mine plans show that shallow mine workings underlie the TSF3 base, with numerous old vertical shafts located within the footprint of the pit.

Following an externally facilitated risk assessment workshop held at the mine, it was agreed that the underground mine workings need to be isolated from potential inrush from the proposed TSF3. From the risk assessment workshop it was also agreed that the tailings deposition operation in TSF3 would involve a dewatered tailings considered suitable for placement as an engineered fill to reduce the risk of liquefaction and inrush of tailings from the pit. The tailings deposition operation in the pit would be an earthworks operation, with dewatered tailings to be placed and compacted in TSF3. The use of dewatered tailings with geotechnical properties considered suitable for placement as engineered fill was the key tailings mitigation risk reduction measure to be implemented for tailings operation in TSF3. The underground workings are also to be separated from the pit by mine plug(s) as required. Subsequent to further risk reviews and assessments within BHOP the following in-rush risk assessment document was developed.

'***Inrush and Inundation Pathways from TSF3 - Rasp Mine_final_V2***'. This document presents the risks, paths and proposed locations of mine plug(s) if required (herein referred to as '*inrush report'* APPENDIX C). It identifies potential locations where mine plugs may be required if the tailings in TSF3 were to liquefy. From the review it was concluded that the available historical mine workings records may not include all the old workings.

In addition to the risk reduction measure of placement and compaction of dried tailings as engineered fill, the risk would be further reduced if the active workings are separated from the general area of historical mine workings around TSF3. Mine plugs are proposed to be installed selectively and progressively as required to separate the historical mine workings from the active mine workings, if in situ measurements of the placed tailings in TSF3 shows that it may be potentially liquefiable. The timing of plug construction is proposed to be linked to the periodic in situ assessment of the placed tailings with respect to the risk of liquefaction and progress of tailings filling in TSF3.

As outlined in Section 5.1.3 Golder conducted critical state testing on the BHOP tailings to assess the required critical void ratio (and hence density) the tailings needs to achieve to manage the risk of liquefaction of the tailings (Golder report reference 1896230-004-R-Rev0, presented in APPENDIX D). From the testing it was concluded that full stream tailings compacted to at least 95% Standard dry density is unlikely to be contractive and hence not liquefiable up to a confining pressure of approximately 1000 kPa. This confining pressure is equivalent to a compacted tailings thickness of approximately 53 m. This estimate is based on laboratory testing of tailings samples. During tailings deposition operations the risk of liquefaction of the as-constructed tailings in TSF3 relative to depth is to be assessed from on site specific measurements (such as the state parameter) using CPT probes. As such the risk of liquefaction will depend on the methods of deposition and compaction, as well as the efficacy of the drying cycles. Periodic CPT testing will be undertaken on placed materials to confirm the potential for the liquefaction as the pit is filled.

Depending on the characteristics of placed materials the confining pressure at which the tailings become potentially liquefiable may be higher or lower than 1000 kPa (approximately 53 m thickness). Once the assessed placed tailings approaches conditions that suggest it may be liquefiable, the contingency plugs (Section 5.3.2) designed are to be constructed to safeguard the integrity of underground workings.

To further reduce the possibility of water accumulation within the tailings in TSF3 it was decided that the pre-deposition works over the base of the pit would include a drainage layer in the form of seepage collection system and a waste rock layer. The mine plugs would be drained plugs, allowing water to pass through the plugs, with the intent of the plugs being to retain any potential rapid migration of tailings, if that were to liquefy.

5.3.1 Kintore Pit TSF3 Operational Testing for Liquefaction Risk

The risk of compacted tailings liquefaction in TSF3 is considered to be low, based on the information presented in Section 7.1.6.1. The tailings will be dried to approximately the Standard optimum moisture content (SOMC) prior to transport to TSF3 and then placed and compacted, overlying a base drainage layer.

To confirm that the designed engineered properties are achieved during placement, CPT testing will be conducted on the placed materials after at least every 15 metres thickness of engineered tailings is placed.

The frequency of testing may transition to approximately every 10 m thickness of filling based on the outcomes of a geotechnical assessment of the characteristics of the placed engineered tailings.

The assessment will be carried out with a program of CPT testing to the full depth of deposit to confirm that the tailings mass is unsaturated and collect data to assess the risk of liquefaction. The CPT testing program must extend to the full depth of placed tailings as the highest loads will be at the bottom of the tailings thickness and is the area where the most likely conditions for liquefaction may develop. Should the testing show conditions different to the design intent the risk will be re-assessed and suitable controls will be implemented. This may include but not limited to the installation of further underground mine plugs as outlined in the BHOP inrush assessment report and the Golder preliminary mine plug design report. The concept design of the various plugs is presented in Golder Report 'Kintore Pit: Preliminary Mine Plug Design' ref: 1896230-047-R-Rev1, dated 13 August 2020, presented in APPENDIX E. The concept designs of the plugs consider both liquefied tailings conditions and earthquake loading.

5.3.2 Underground Mine Plug

The inrush report details the potential pathways for ingress into Rasp Mine's underground workings if engineered fill placed in TSF3 were to liquefy and identifies the locations required to effectively isolate these pathways from current or currently proposed active mine workings through the installation of underground mine plug/engineered barriers and establishment of inrush control zones. The following six engineered barrier's locations were identified in the BHOP inrush report as shown in Figure 8.

1) Portal Plug
2) Western Min Decline near MLD Intersection (Decline Plug)
3) Dickenson's Shaft Western Min. Decline below SP3
4) 1000 ft Level East of Park bay
5) Block 11 Access Incline east of ladderway intersection
6) 1480 Sth (1480 Access Drive West of intersection with airway)

Figure 8 (copied from the inrush report) shows the minimum required mine plug(s) location(s) to isolate the inrush potential by separating the Main Lode (previously mined) from Western Mineralisation workings (current and proposed mine areas).

The inrush report also indicates that if access to specific Main Lode areas is critical for the future life of mine strategy, additional barriers might be required if there is a risk of liquefaction of the engineered tailings fill. In addition to these mine plugs, there are two internal shafts (rises) identified as an inrush risk if left open. These are the MLD-1270 rise and the BLK 11 exhaust rise. It is understood from the inrush report that these rises will be backfilled with cement stabilised fill as part of related mine plug construction if there was risk of the engineered tailings in TSF 3 liquefying, and any related mine ventilation changes that relate to the specific plugs will be installed at that time.

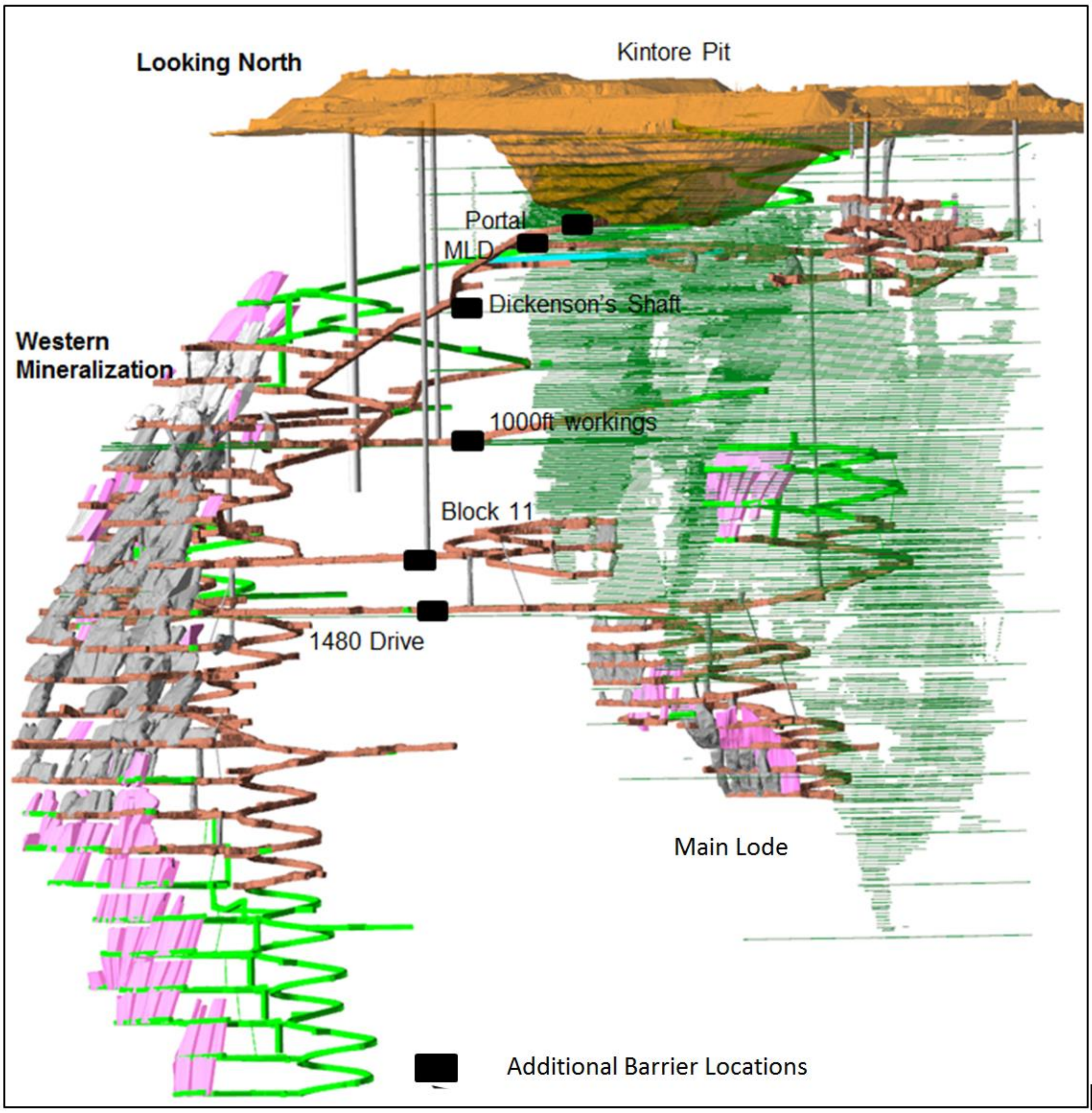


Figure 8: Location of underground mine plugs (extract of Figure 2 from inrush report)

The proposed locations and elevations of mine plugs in the inrush report are summarised in Table 4.

The timing of the potential installation of subsequent underground engineered barriers will be dependent on the in situ geotechnical properties of the engineered tailings fill placed during TSF3 operation. In addition to this control, the MLD will be filled with waste rock material prior to engineered tailings placement to provide passive support and restrict access to the immediate area underneath TSF3 footprint. The Portal Plug is therefore not required and will be replaced with a waste rock backfilled length of the adit to support the void and reduce the risk of stress relief effects potentially resulting in sudden movements once the tailings load is applied to the blast affected pit slope rock formation. The mine plug to be constructed as part of the TSF3 pre-deposition works is plug 2) the Western Min Decline near MLD Intersection and titled MLD in Figure 8, referred to in this report as the Decline Plug.

Table 4: Summary of the location of the mine plugs (from inrush report)

	Mine Plug	Easting (m)	Northing (m)	Reduced Level (m)
1	Western Min Decline near MLD Intersection (Decline Plug)	1148	9962	10212
2	Dickenson's Shaft Western Min Decline below SP3	1149	9903	10,145*
3	1000 ft Level East of Parkbay	2052	9612	10,046*
4	Block 11 Access Incline east of ladderway intersection	1698	9451	9944
5	1480 Sth (Access Drive West of intersection with airway)	1514	9600	9900

*Email from David Matthews on 2 July 2020

Easting, Northings and Reduced Level presented are relative to local Mine Grid.

5.3.2.1 Plug Design Basis and Assumptions

The plugs are designed for hydrostatic pressure of the full potential depth of tailings plus water hammer effects, resulting in a robust design. Note the intended co-placement of dried tailings as engineered fill with waste rock at the perimeter is expected to result in unsaturated conditions in the tailings, so the adoption of saturated conditions for the entire tailings mass is considered to be conservative (i.e., related to upset conditions contrary to design conditions). The design also assumes that the tailings liquefy and lose strength, resulting in heavy liquid/fluid tailings loading on the plugs. This conservative approach is considered appropriate given the potential consequence if the tailings placement does not achieve unsaturated conditions.

5.3.2.2 Decline Plug

Decommissioning of the decline comprises the construction of a plug, designed for the expected surcharge mass. The plug comprises a concrete bulkhead and rockfill, notched into the existing rock and located in the mine workings where the rock conditions have not been stress-relieved by the historical mining.

The Decline Plug location and photographs of the drive are presented in Figure 9 and Figure 10 respectively. The Decline Plug will be located at a depth of approximately 120 m (vertically from the pit crest) and will be 8.6 m in length. The locations and photographs for the other plugs listed in Table 4 have been provided in APPENDIX E.

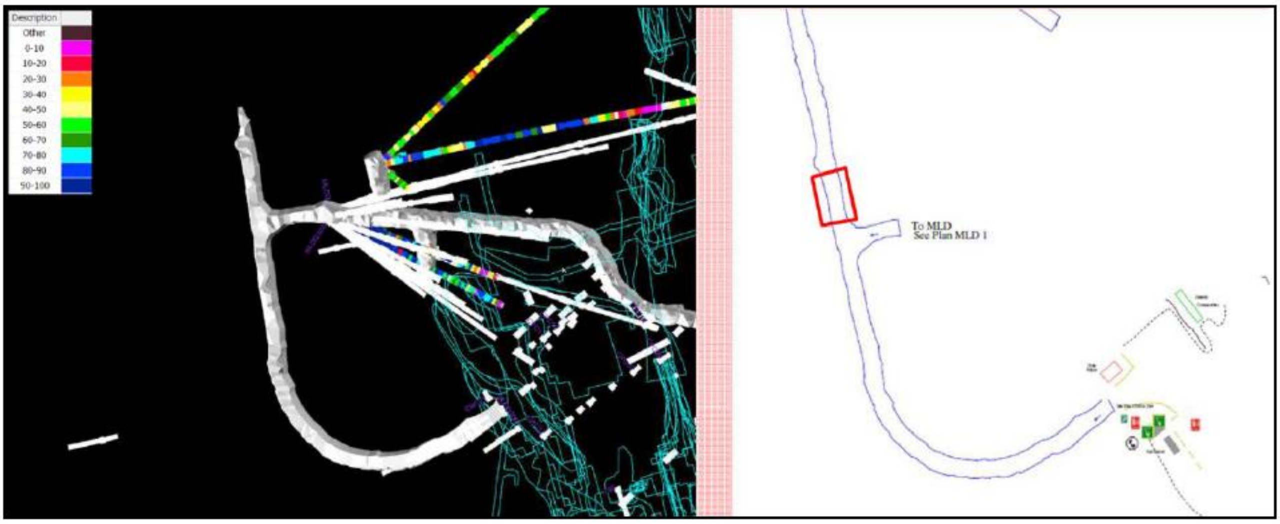


Figure 9: Location of the Decline Plug (extract from inrush report)

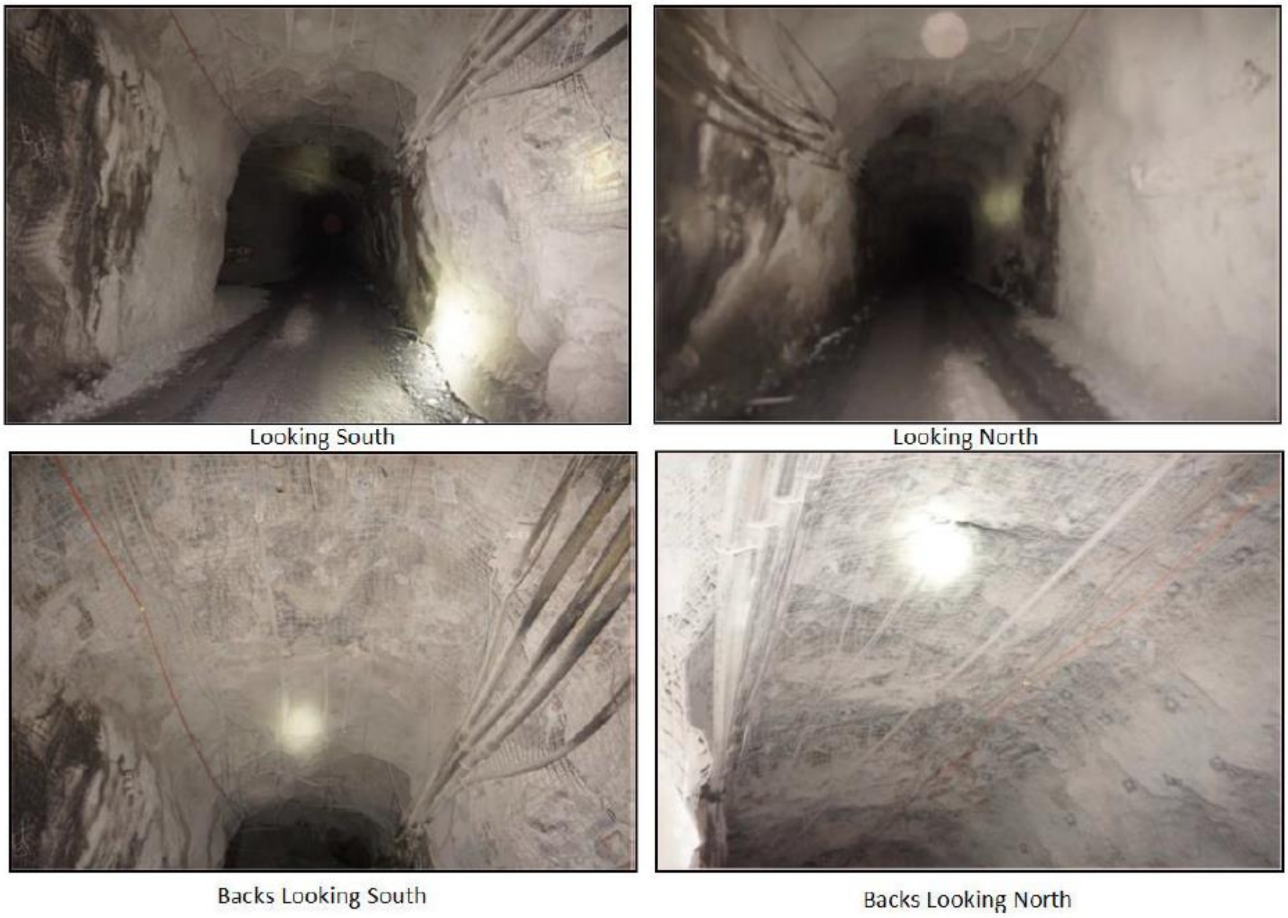


Figure 10: Photographs of the Decline Plug location (extract from inrush report)

5.3.2.3 Plug Construction

Plugs will be formed using upstream and downstream bulkheads to close off the tunnel section and facilitate placement of the plug concrete. The plugs will be constructed using concrete of at least 25 MPa compressive strength. Any existing ducts, pipes, cables etc in the area of the plug will be decommissioned and the service relocated away from the plug area. All the plugs will be pressure grouted.

Additives to improve concrete workability are recommended or alternatively additives to produce self-consolidating concrete may be considered.

Depending on the condition of any fibrecrete lining in the tunnels it may be necessary to remove some or all of the fibrecrete and to expose any existing rock bolt heads, install additional rockbolts as per plug design, before the mass concrete is placed. If the fibrecrete is removed any loose or spalled rock should also be removed to leave a competent rock surface.

All plugs would include a permanent drainage outlet through the plug with a high pressure valve on the downstream end that can be closed in an emergency. The valve should remain open under normal operating conditions.

The Decline Plug drain pipe would extend from the plug, through the filled adit and join to the drainage layer on the base of the pit. The outlet pipe would be covered with rockfill and aggregate to protect the pipe in the adit tunnel from the pit to the plug.

The drainage outlet through the Decline Plug would be high strength steel pipe suitably corrosion protected and designed for the maximum hydraulic pressure, so it remains operational during and after any liquefaction event. The drainage outlet and isolation valve will be situated at a location that is safely accessible downstream of the plug.

Construction materials and quantity estimates for the Decline Plug construction are outlined in Section 6.3.2 and Section 6.3.3.

6.0 TAILINGS PRE-DEPOSITION/HARVESTING WORKS

6.1 General

BHOP intends to slurry deposit thickened tailings in TSF2, allow the tailings to sun and air dry, harvest the dried tailings and place it in engineered conditions in TSF3. The development of TSF3 as a TSF and TSF2 as a drying area will require pre-deposition works to be constructed prior to placement of tailings. The pre-deposition works in TSF3 will commence once the new decline has become operational and access to the mine via the TSF3 is no longer required. The pre-harvesting works will also be undertaken at this time, together with works to complete the Tails Harvesting Haul Road.

6.2 Blackwood Pit TSF2

6.2.1 Pre-harvesting Works Elements

6.2.1.1 Blackwood Pit TSF2 General

Based on the information provided by BHOP, Golder has developed a conceptual layout plan for the proposed harvesting operations. This includes allowance for collection of supernatant liquid, stormwater management and internal access roads. This layout is based on:

- Providing capacity for stormwater storage to manage stormwater runoff.
- Tailings supernatant liquid being detained in each cell for progressive removal during filling operations.
- Providing a minimum 10 m width access road corridor for one way traffic (allowing for a trafficable width of approximately 5 m).
- Incorporating intermediate bunds (between cells) of up to approximately 15 m wide footprint to allow for tailings harvesting to be undertaken to a maximum thickness of approximately 1.5 m.

The layout presented in Figure 1 of APPENDIX B provides three approximately equal sized cells each with approximately 3 ha available drying area. It is noted that the TSF2 will be operated as an active TSF2 and will need to conform to the TSF requirements of Dams Safety NSW. Hence the freeboard, spillway, water management and monitoring requirements of TSF2 remain unchanged from current requirements.

Based on the proposed ‘8 days on 6 days off’ mill roster, BHOP would deposit thickened tailings into a single cell over an 8 day period in a 300 mm to 500 mm nominal initial thickness layer before allowing it to consolidate and dry for a period of up to 20 days. The dried tailings would be then harvested over a 14 day period. In this manner, at the commencement of each 8 day production period, tailings deposition would commence in a ‘new’ cell. Similarly, the harvesting fleet would move from one cell to another each 14 day period. An excerpt of the harvesting schedule nominated by BHOP is presented in Figure 11.

Harvested tailings will either be transported directly into TSF3, or may include some temporary stockpiling before transport into TSF3. This is dependent on logistics, harvesting contractor equipment schedule and weather conditions.

Week	Day	Cell A			Cell B			Cell C		
		Dep.	Dry	Harv.	Dep.	Dry	Harv.	Dep.	Dry	Harv.
Week 1	2	2								
	3	3								
	4	4								
	5	5								
	6	6								
	7	7								
Week 2	8	8								
	9		1							
	10		2							
	11		3							
	12		4							
	13		5							
	14		6							
Week 3	15		7					1		
	16		8					2		
	17		9					3		
	18		10					4		
	19		11					5		
	20		12					6		
	21		13					7		
Week 4	22		14					8		
	23		15						1	
	24		16						2	
	25		17						3	
	26		18						4	
	27		19						5	
	28		20						6	
Week 5	29			1	1				7	
	30			2	2				8	
	31			3	3				9	
	32			4	4				10	
	33			5	5				11	
	34			6	6				12	
	35			7	7				13	
Week 6	36			8	8				14	
	37			9		1			15	
	38			10		2			16	
	39			11		3			17	
	40			12		4			18	
	41			13		5			19	
	42			14		6			20	
Week 7	43	1				7				1
	44	2				8				2
	45	3				9				3
	46	4				10				4
	47	5				11				5
	48	6				12				6
	49	7				13				7
Week 8	50	8				14				8
	51		1			15				9
	52		2			16				10
	53		3			17				11
	54		4			18				12
	55		5			19				13
	56		6			20				14
Week 9	57		7				1	1		
	58		8				2	2		
	59		9				3	3		
	60		10				4	4		
	61		11				5	5		
	62		12				6	6		
	63		13				7	7		
Week 10	64		14				8	8		
	65		15				9		1	
	66		16				10		2	
	67		17				11		3	
	68		18				12		4	
	69		19				13		5	
	70		20				14		6	

Figure 11: BHOP proposed tailings harvesting schedule

6.2.1.2 Tails Harvesting Haul Road Extension

As presented on Figure 1 it is proposed to construct a sealed haul road from the concrete ramp exiting the southern side of TSF2 along the edge of the proposed box cut and join the existing haul road to the south of the new portal location to provide access route for the tailings harvesting fleet. This haul road would be an extension to the existing haul road network and operate as a dedicated road for haul trucks transporting harvested tailings between TSF2 and TSF3. The access within TSF2 would be constructed using compacted tailings excavated from TSF2 for the bulk formation and crushed waste rock used for surfacing of the road. The Tails Harvesting Haul Road would be sealed. The proposed location of the junction of the new Tails Harvesting Haul Road to the existing Mine Ore Haul Road to limit interaction between mine ore fleet vehicles and tailings haulage vehicles.

6.2.1.3 Blackwood Pit TSF2 Intermediate Bunds

The intermediate bunds between the three cells are proposed to be constructed with a crest elevation of a nominal 300 mm above the final tailings surface level for TSF2 and with an overall height of 1.8 m. The bunds are proposed to be formed with a nominal crest width of at least 5.5 m and with safety bunds on either side to enable them to be safely trafficked by light vehicles. Tailings delivery pipelines may be buried within the safety bunds. The bunds are intended to be formed using excavated tailings with nominal 3H:1V embankment batters with the external faces and crest covered with a layer of waste rock. The waste rock layer is intended to act as both an erosion protection layer and marker layer to help avoid inadvertent excavation of the bunds during tailings harvesting activities. The bunds will be engineered structures and the crest elevation will be lower than the adjacent perimeter embankment or pit rim of the TSF2 maintaining the required freeboard.

6.2.1.4 Blackwood Pit TSF2 Supernatant Management Network

Supernatant from the deposited tailings will be managed by incorporating a gated weir into the western end of each of the intermediate bunds. These weirs will be designed to enable them to be progressively raised and lowered on a nominal daily basis during tailings deposition to suit the deposited tailings surface level in the upstream bay and to enable supernatant to be decanted from the tailings surface to a sump formed adjacent to the bunds. Supernatant collected in the sumps will either be decanted or be extracted by pumping daily during deposition and returned to the mill. The sump may be lined to limit water infiltration into the adjacent tailings.

The western end of each cell will include a geotextile lined rockfill mound designed to be overtopped in the event of intense rainfall events. The mound will be incorporated with the gated weir to form intermediate overflow spillways for each cell.

The return water pipe from the sump to the mill will be incorporated within the crest safety bund of the intermediate bund.

6.2.1.5 Blackwood Pit TSF2 Stormwater Management System

The pre-deposition works will include the following to manage stormwater during operations::

- Construction of a stormwater pond on the tailings surface adjacent to the existing TSF2 spillway designed to store runoff from a 24 hour 10% annual exceedance probability (AEP) event. This pond will be formed by excavating tailings to form a depression and lining the depression to limit stormwater infiltration into the underlying tailings. Stormwater collected in this pond would be extracted by pumping with the water returned to the mill for use in operations. The stormwater pond would include access for pumping equipment.

- An open channel drain to convey runoff from each of the cells to the stormwater pond. This drain would be sized for the 10% AEP event and may be lined (where required) to limit infiltration to underlying tailings. This channel drain would run along the northern perimeter of the cells.
- Construction of intermediate overflow 'spillways' from the supernatant sumps in each cell that discharge to the open channel drain that in turn discharge to the stormwater pond. This is designed to enable stormwater runoff from each cell to be conveyed to the stormwater pond to limit disruption to operations. The intermediate overflow spillways would be formed at the west end of the intermediate bunds the overflow is to be formed with waste rock to limit risk of erosion. The intermediate overflow spillways would be designed to convey flows for a 1% AEP event.
- Maintaining the ability of the TSF2 to retain the 1 in 10,000 AEP storm event (approximately 48,000 m^3) without spillway discharge as required by Dams Safety NSW. The existing TSF2 spillway would remain as constructed and would discharge flows when the detention capacity of TSF2 is exceeded (as per its design intent and requirements of Dams Safety NSW).

6.2.2 Construction Materials

The pre-harvesting works is proposed to be constructed utilising the following materials:

- Tailings excavated from TSF2 used to form intermediate bunds and as fill for internal access road embankment construction.
- Rockfill sourced from mine waste rock stockpiles located within TSF3 or BHP Pit. Rockfill will comprise rock particles typically less than 500 mm in size and will be used as an erosion protection measure and as a marker layer to help prevent inadvertent over excavation of the bunds.
- Crushed and/or select mine waste rockfill with particles typically less than 70 mm for the wearing course and surfacing of internal access roads.
- Pipes to enable deposition of tailings within each of the three cells. It is expected pipes for this application may be available onsite. If this is not the case they will be required to be manufactured off-site and transported to site.
- Return water pipes. It is expected pipes for this application may be available onsite.

Quantity estimates for materials expected to be used in construction of pre-harvesting works for TSF2 are as follows:

Table 5: TSF 2 Pre-harvesting Works Quantity Estimates

Material Description	Unit	Estimated Quantity
Dried tailings excavated from TSF2 (for use in construction of intermediate bunds and internal access road)	Tonnes (dried)	25,000
Processed Rockfill (for use in construction of intermediate bund protection layer, internal access road wearing course and drain lining system)	Tonnes	5,000
Liner material (for drain and stormwater pond)	m^2	3,000
Tailings delivery pipeline (and spigots)	Linear m	1,000
Return water pipeline (to return collected supernatant water to the plant)	Linear m	1,000

Material Description	Unit	Estimated Quantity
Concrete (for construction of overflow weirs)	m^3	15
Platform (to enable pumped extraction of collected liquid from stormwater pond at TSF2 Spillway)	Item	1

6.3 Kintore Pit TSF3

6.3.1 Pre-deposition Works Elements

The pre-deposition works for TSF3 comprise:

- Decommissioning of the mine decline and portal within the TSF3 which will include the construction of the Decline Plug and installation of a transfer pipe to convey seepage collected from the base of the TSF3 to the mine's water management system.
- The current access (MLD) to the south of TSF3 will be closed and backfilled with rockfill. Decommissioning of the MLD would restrict access to the south west of TSF3. If future mining was considered to the south west of TSF3 area, access would be gained via further mine development undertaken at depth.
- Preparation of the TSF3 base including shaping of the base with mine waste rock to grade towards the portal. Construction of a seepage collection system across the base of the pit to collect and convey seepage from the tailings and stormwater infiltration. The seepage collection system includes a small diameter transfer pipe through the Decline Plug to extract collected seepage and manage as part of the mine water system. Seepage estimates are described in Section 7.2.4.
- Construction of a bridging layer nominally 10 m thick across the base of the pit comprising mine waste rock currently stockpiled within TSF3 to form a surface for deposition of the tailings. Waste rock is to be placed over the steeper sloping portion at the north and south ends of the shaped area of the pit to cover the seepage collection system by nominally 500 mm thick layer of waste rock.
- Construction of stormwater diversion measures around the pit rim to limit stormwater runoff into the pit.
- Placement of first lift of waste rock around the perimeter of the pit (excluding the southern side where waste rock is already present) in preparation for the tailings deposition. Subsequent lifts of waste rock are to be placed around the perimeter of the pit to the extent considered practical. If waste rock is proposed to be deposited with tailings (not at the perimeter) the location should be selected to avoid impacting the ability of future CPT investigations to be undertaken and recorded.

6.3.1.1 Kintore Pit TSF3 Seepage Collection Layer

A layer of waste rock will be placed at the base of the TSF3. This shaped layer will form a subgrade for the seepage collection system. The shaping works will comprise a layer of nominally compacted waste rock typically between negligible and 600 mm thickness, which is shaped to grade towards the existing portal. A network of drainage lines comprising perforated seepage collection pipes overlain with a mound of drainage aggregate will be constructed on top of the shaping layer. The seepage collection pipes grade towards the seepage outlet pipe starting at the existing portal and grading downwards in the existing adit to the proposed location of the Decline Plug. The seepage outlet pipe extends through the plug to convey seepage into the mine's water management system. The seepage outlet pipe will be placed on the floor of the existing adit towards the plug and be covered with a 700 mm high mound of fill over the pipe to help protect the pipe from potential damage.

The typical shape and details of the seepage collection layer and collection pipe network are presented in Figures 2 and 9 of APPENDIX A.

The system will be designed with a robust factor of safety based on the estimated seepage rates presented in Section 7.2.4.

6.3.1.2 Kintore Pit TSF3 Bridging Layer

A layer of waste rock will be spread across the pit floor and over the seepage collection layer to form a bridging layer across the base of the TSF3 (Figure 3 of APPENDIX A). The construction of the bridging layer will be carried out using a large dozer (i.e. a Caterpillar D8 or larger) to spread and nominally compact the waste rock. The waste rock will be sourced from the adjacent waste rock stockpile in the pit. Most of the waste rock will be excavated from the top of the existing waste rock dump in the pit. The bottom of the pit will be filled with waste rock to a variable elevation extending up to approximately RL 240 m, with the final shape to achieve a nominal thickness of 10 m over the floor of the pit and the adit entrance area. As part of filling the adit from the portal to the Decline Plug the void of the adit at the current portal entrance will also be filled with rockfill to limit the amount of collapse of the void that may occur with subsequent tailings and waste rock loading above the adit portal. The dozer may also be supported by an excavator and dumps trucks, as required.

The crest elevation of the existing waste rock dump will be lowered by this transfer of rock to the bottom of the pit. The elevation of the waste rock stockpile could be lowered by approximately 10 m to 20 m by the removal of the waste rock for the bridging layer.

It is proposed that a layer of non-woven separation geotextile would be placed over the base and extend nominally 2 m up the sides of the waste rock surround to control the risk of potential migration of fines from the tailings if the bottom of the pit was to become saturated. As an alternative (or in addition) to this, a riser pipe may be constructed from the start of the seepage outlet pipe at the current portal location to provide a backup to extract water from the waste rock layer (comprising the seepage collection layer and bridging layer) if the outlet pipe was to be non-functional. If there was a blockage in the seepage collection system or the outlet pipe through the plug, the riser pipe would be used with a submersible pump to remove collected seepage from the bottom of the pit. These specific components shall be defined at detailed design stage.

6.3.1.3 Old Tailings Slope

An old tailings slope exists in the north eastern wall of the TSF3 as shown on Figure 1 of APPENDIX A. The old tailings slope will be supported progressively by placing waste rock against the surface of the old tailings. The existing surface of the old tailings appears to have crusted over providing rainfall erosion resistance of the tailings slope. As filling progresses, depending on the outcome of a safety risk assessment, the surface of the old tailings may be selectively protected by either a layer of geotextile (or alternate product, for example a spray on protection layer) before continuing the placement of waste rock to control the risk of erosion.

Stormwater management and diversion measures already exist around the crest of the pit, to prevent rainfall runoff from outside the pit from entering the pit and from flowing over the exposed old tailings. These measures are proposed to be maintained.

6.3.1.4 Kintore Pit TSF3 Stormwater Management Works

The existing rim of TSF3 includes mounds to divert surface runoff away from the pit edge. The road at the top of the existing access ramp currently drains towards and into the pit. Its' catchment is relatively small and will be modified to divert any runoff from the road outside the pit to flow away from the pit. This will comprise the construction of a mound across the start of the access road formed with waste rock. This near crest modification is expected to take less than 2 days to complete and comprise grader, compactor and truck for the placement, shaping and compaction of the mound.

The runoff from the TSF3 catchment area resulting from a 24 hour duration 1:100 Annual Exceedance Probability (AEP) storm event is estimated to be approximately 9.8 ML. A significant proportion of this runoff is expected to flow through the waste rock layer around the perimeter of the pit and collect in the base layer of waste rock. The seepage rate expected into the base layer of waste rock is further discussed in Section 7.2.4. Stormwater ponding on the surface of the waste rock and tailings surface will be removed from the pit surface by pumping using mobile pumps and discharge pipe along the existing pit access ramp, as required.

The volume of stormwater in TSF3 is the same as the current stormwater volume in the Kintore Pit, so there is no change to the current volume of rainfall runoff being managed. The conditions once TSF3 pre-deposition works are completed is that the rate of stormwater reporting to the bottom of the pit will be substantially slowed due to the limited seepage rate through the perimeter waste rock layer, and negligible seepage rate through the compacted tailings.

6.3.2 Construction Materials

The pre-deposition works is proposed to be constructed utilising the following materials:

- Waste rock sourced from mine waste rock stockpile located within the TSF3. Waste rock will comprise rock particles typically less than 500 mm in size and will be prepared to form a stable platform for the subsequent tailings placement.
- Drainage aggregate for the drains will be sourced from the in-pit stockpile by processing the mine waste rock or may be imported from the adjacent hard rock quarry to the north east of the site. Drainage aggregate will be free draining and comprise particles nominal 20 mm in size with limited fines.
- Concrete for the Decline Plug prepared off-site and transported to site via concrete truck. The concrete is required to have a minimum compressive strength of 25 MPa and may contain additives to improve workability.
- Seepage outlet pipes and seepage collection pipes manufactured off-site and transported to site. The seepage outlet pipes and the seepage collection pipes will comprise 100 mm to 200 mm diameter pipes designed to manage the future load of the compacted tailings and waste rock. The seepage collection pipes will be perforated, and the outlet pipes will be solid wall. The outlet pipe will also include a gate valve located on the mine side of the plug.

6.3.3 Pre-Deposition Works Construction Quantities

Quantity estimates for materials expected to be used in construction of pre-deposition works for TSF3 are presented in Table 6.

Table 6: TSF3 Pre-deposition Works Quantity Estimates

Material Description	Unit	Estimated Quantity
Waste rock (moved from the in-pit stockpile to form the seepage collection system)[1]	Tonnes	4,000
Waste rock (moved from the in-pit stockpile to form the bridging layer)[1]	Tonnes	241,000
Drainage aggregate (from offsite source for seepage collection system)	m^3	1,550
Separation Geotextile	m^2	9,600
Perforated Pipe (for seepage collection system)	Linear m	650
Solid wall pipe (for plug construction)	Linear m	220
Mass concrete (for plug construction)	m^3	210
Waste rock sourced from underground for filling the MLD	m^3	34,900
Select Rockfill (for filling first 160 m of adit)	m^3	4,400
Waste rock for stormwater diversion bunds	m^3	100

1. Includes waste rock placed at the bottom of the pit as part of initial Pre-Deposition works only (i.e. not waste rock placed progressively against pit slopes)

7.0 CONSIDERATIONS RELATED TO THE DESIGN

7.1 Blackwood Pit TSF2

7.1.1 Tailings Drying Trials

BHOP undertook multiple tailings drying trials on tailings at TSF2 between June 2020 and January 2021. In July 2020 tailings sampling was conducted over a period of 21 days at 3 locations with the purpose of assessing tailings drying times. A further set of testing commenced in September 2020 as the July 2020 testing showed tailings had already reached a steady state moisture content from the commencement of measurement. The additional round of testing placed slurry in 200 mm deep buckets which were able to be moved as necessary to avoid effects from runoff and pooling water. In response to the results of these trails another round of drying trials was undertaken between 30 November 2020 and 6 January 2021. Monitoring of the 30 November 2020 to 6 January 2021 trials included measuring moisture content of placed tailings to depths of up to approximately 500 mm. A report prepared by BHOP summarising the results of this round of the trials is included in APPENDIX F.

In addition, BHOP provided Golder, via emails from Devon Roberts (BHOP) dated 8 and 13 October 2020 and Daniel Hitchcock dated 14 January 2021, weather monitoring records from the Rasp site for the period in which the drying trials was undertaken. These included records of rainfall, temperature and windspeed. Golder's assessment of the results of the drying trials is presented in the following subsections.

7.1.1.1 September 2020 - October 2020 trials

The results of the September/October trials and associated monitoring undertaken by BHOP indicate:

- All sample locations except the sample location on the tailings surface at the north east corner of TSF2 reached a gravimetric moisture content approximately equal to or below Standard Optimum Moisture Content (SOMC) of approximately 11%[3] within approximately 14 days. Tailings harvesting is proposed

[3] Moisture content = mass of water / mass of solids.

to be undertaken when the tailings is approaching the SOMC to enable effective compaction of the dried tailings. The 'millside' sampling locations near the deposition location reached a moisture content of less than 11% within 7 days. Based on the information provided it is understood samples were recovered from a depth of less than approximately 200 mm below tailings surface level.

- The sample location at the north east corner location of TSF2 was recorded to have '*pooled water approaching the sample point*' on days 10 to 12 and 'pooled water at (or over) the sampling point' on days 13 to 17 before the sampling location was moved to be away from the pooled water. The pooled water was supernatant water runoff from the upslope tailings beach. The presence of pooled water at the sample location is expected to have influenced the moisture content of the recovered samples.
- Rainfall events appear to influence the moisture content of the samples with increases in sample moisture contents recorded after rainfall events. For example, on 19 September 2020 a total of 29 mm of rainfall was recorded and moisture content measurements undertaken on 21 September 2020 (which was the first measurement undertaken after this rain event) indicated moisture content increases of up to approximately 10% compared with measurements undertaken on 18 September 2020. The moisture content at the sample locations returned to that approximately equal or below that recorded on 18 September 2020 by 28 September 2020, i.e.: 10 days later.
- During the 33 day trial period a total of 34 mm of rainfall was recorded onsite. The recorded average rainfall over the monitoring period of 1.03 mm/day is, based on Bureau of Meteorology (BoM) records for the Patton Street weather station, greater than mean rainfall for the same period for a typical year of approximately 0.7 mm/day. It is noted that evaporation is not recorded onsite or at the Patton Street weather station and daily records are not available for other BoM stations in Broken Hill for the trial period. The BoM records from the Stephen's Creek Reservoir weather station (approximately 15 km from the site) indicate:
  - Mean evaporation for September is approximately 5.8 mm/day
  - The lowest monthly period for evaporation is June when mean evaporation is approximately 2.4 mm/day
  - Mean daily evaporation over 12 month is approximately 7.2 mm/day.

7.1.1.2 November 2020 – January 2021 Trials

The results of the November-January monitoring period were designed to investigate the drying rate of a tailings layer of up to 500 mm thick. The results of the trial indicate:

- The majority of the trial period was conducted in December 2020. BHOP reported that December 2020 weather conditions at the site was wetter and cooler than typical conditions for that time of year. BHOP reported that the recorded December 2020 average maximum daily temperature was 30.3 ˚C compared to the mean 32.2 ˚C. BHOP also reported rainfall for December 2020 was 21.8 mm, higher than the average December rainfall of 18.3 mm and higher than the average for all months in the year of 18.9 mm. These trends are consistent with data reported by BoM for the Broken Hill Airport weather station. It is noted the BoM records from the Stephen's Creek Reservoir weather indicate mean daily evaporation for December is 11.6 mm which is:
  - approximately 5 times greater than that for June and
  - approximately 1.6 times greater than mean annual daily evaporation.
- The trial comprised depositing the full 500 mm thick layer of slurried tailings in one operation.

- The average moisture content of deposited tailings to a depth of approximately 400 mm below surface level in the trial area considered most representative by BHOP (In-Situ-4) reached approximately equal to SOMC within a period of approximately 1 week of deposition. The average moisture content of deposited tailings to a depth of 400 mm at an alternate trial location (Mill Pit) considered less representative by BHOP reached a moisture content approximately equal to SOMC within a period of approximately 19 days.
- The moisture content of the tailings at a depth of between approximately 400 mm and 500 mm:
  - reached a moisture content approximately equal to SOMC after approximately 30 days at the Mill Pit trial location.
  - Reached a moisture content of approximately 16% (i.e.: 5% wetter than SOMC) at the completion of the trial (after 24 days) at the In-Situ-4 trial location.

7.1.1.3 Summary

Based on the information provided it is expected that:

- A deposited thin layer (of nominal 200 mm to 300 mm thickness) of tailings will typically be able to dry to a moisture content approaching or below SOMC within a period of approximately 14 days. During summer periods this period may reduce to approximately 7 days.
- During summer months drying and harvesting may be able to be undertaken in increased layer thickness of up to approximately 500 mm based on the proposed production schedule and favourable weather conditions.
- The timeframe for tailings drying during winter period is expected to be slower than that indicated by the trials. It is expected that during cooler months operations will be restricted to suit deposition in thinner layers. Based on the available information and our experiences we expect drying in layer thicknesses of average 250 mm may be achievable during winter based on the proposed schedule.
- Significant rainfall events are expected to result in increased moisture content in the deposited tailings and are expected to increase the drying timeframe. The available information indicates this may be an additional approximately 7 to 10 days from that experienced without significant rainfall events.
- Drying to increased depths is expected to be able to be achievable if:
  - mechanical processes (such as ploughing or ripping during harvesting activities) are employed during the drying period, and/or
  - the tailings surface is ‘shaved’ multiple times during harvesting rather than waiting for the full depth to dry.

7.1.2 Proposed Approach for Drying and Harvesting

Laboratory testing of the tailings indicates that the maximum dry density of the tailings (with Standard compaction effort in accordance with ASTM D1556) is 1.98 t/m^3. The tailings slurry is deposited at a solids concentration of 65% by weight[4] which is equivalent to a dry density of 1.15 t/m^3 and a moisture content of approximately 53%. Experience and the field drying trials indicate that the tailings fairly quickly dries to a moisture content between 20% to 25% and then progressively desiccates to a moisture content approaching approximately 10% to 11%. The moisture content of the drying tailings over the initial 10 to 14 days after

[4] Solids concentration = mass of solids / total mass of slurry

deposition is expected to vary between approximately 5% to 10% over the layer thickness. The variation of moisture content with depth reduces significantly after this period when desiccation and unsaturated conditions develops over the depth of the tailings layer.

The approximate dry density of the tailings at 25% moisture content is 1.67 t/m^3. The tailings layer is proposed to be placed over 8 days when the mill is on the scheduled roster of operation. It is assumed that the tailings will consolidate and dry to an average density between the initial slurry density and the 25% moisture content density, with the average density being 1.41 t/m^3.

Adopting a target layer thickness after the initial drying of 300 mm or 500 mm, enables approximately 12,700 or 21,200 tonnes of tailings to be placed in a 3 hectare cell (respectively). The layer is expected to further reduce in thickness as the final desiccation drying occurs.

BHOP proposes an annual maximum tailings production rate of 480,000 tonnes. This is based on depositing in a layer thickness of up to approximately 500 mm during summer months and in thinner layers (to a minimum of approximately 250 mm) during periods of the year when weather conditions are less conductive to drying. Based on the proposed schedule for operations an annual production rate of approximately 480,000 tonnes is equivalent to an average layer thickness after initial drying of approximately 440 mm for each deposition cycle.

If tailings were able to be deposited to achieve 500 mm thickness after initial drying layers year round an upper limit production rate of up to approximately 550,000 tpa could theoretically be achieved, this however relies on favourable weather conditions throughout the entire year. The MOD6 maximum 480,000 tpa annual tailings production rate equates to an average layer thickness of approximately 440 mm based on the proposed tailings harvesting schedule. If the mill was operated such that tailings was deposited to achieve 500 mm thickness dried layers for 6 months per year and to achieve 250 mm thickness dried layers for the remaining 6 months, an annual production rate of approximately 412,000 tpa is expected to be able to be achieved.

Based on this it is expected that the entire available surface area of the TSF2 is expected to be required to be made available for tailings harvesting to enable the mine to achieve production rates equal to or approaching the 480,000 tonnes annual target. During periods where drying conditions are favourable (i.e. dry summer periods) it may be possible to use some of the available surface area on TSF2 for storage of stockpiled harvested tailings to provide operational flexibility in the event of operational unfavourable conditions. Similarly it is expected that during favourable conditions it may be possible to excavate tailings at a greater rate than deposition to help provide ‘backup’ storage capacity at TSF2 to help enable operations to continue in the event that tailings placement within TSF3 cannot be achieved for short periods.

However, it is considered likely that varying the tailings production rate throughout the year may be required in response to encountered weather conditions. This may in turn require flexibility in the mill operation cycle and the harvesting equipment compared with maintaining a consistent production rate. To help with planning around operations and to better understanding the tailings drying behaviour it is recommended that the deposited tailings be regularly assessed for moisture content over the deposited thickness at a number of locations within each drying bay.

7.1.3 Tailings Trafficability During Harvesting

In addition to the previously completed northern embankment completed in 2020 TSF2 has recently been upgraded to include a further two perimeter embankments constructed on the west and east sides of the pit. These embankments were partially constructed on compacted fill platforms constructed on the existing tailings beach, using compacted tailings sourced from the tailings beach. The tailings harvesting method adopted for the tailings sourced for the compacted fill platforms was similar to that proposed for the tailings harvesting process to be adopted for the harvesting of dried tailings for TSF3.

BHOP has advised that, based on experiences during recent construction activities associated with Embankments 1 and 3 at TSF2 the tailings surface becomes trafficable for tracked vehicles within approximately two to three days after tailings deposition has ceased, provided decant or rainfall runoff is promptly removed from the beach. Trafficability for wheeled light and wide wheel heavy equipment is reported to be typically possible within approximately one week after tailings deposition has ceased.

7.1.4 Tailings Deposition

Tailings will be deposited alternatively between the bays with tailings beaching generally towards the north and north west. Supernatant water pooling will be at/to the north end. Any excess water will be directed (via gravity flow) to the northeast end of TSF2. A stormwater pond will be formed in the tailings beach at the north east end of TSF2 adjacent to TSF spillway to detain runoff from the three bays (Figure 1 APPENDIX B). Water detained in the stormwater pond will be kept to a minimum by pumping the water for reuse, in accordance with the current TSF Maintenance and Operations Manual.

Fresh tailings would continue to be placed in TSF2 and allowed to dry naturally (solar and air). Once sufficiently dried the tailings would be harvested and then transferred to TSF3.

The tailings will be deposited in the bays in one thickness over the 8 days of mill roster, and left to dry for two subsequent mill roster cycles. This results in approximately 20 days of drying time after the completion of the deposition in a bay, before the proposed 14 days of harvesting. However, depending on weather conditions, it is expected harvesting of the surface layer could be performed earlier than the 20 day mark to increase the drying rate of tailings at greater depth. It is noted that drying will continue over the harvesting period. Drying over the harvesting period is considered an additional buffer for achieving tailings at the target moisture content for placement in TSF3.

The tailings slurry will be deposited from the eastern and southern sides of the bays to form a sloping tailings beach towards the supernatant water collection sumps in each bay. These sumps will be pumped out as needed to minimise the amount of water ponding on the tailings, and maximise the drying opportunity for the tailings. Experience has shown that a tailings sump storing water will wet-up adjacent tailings, so it is proposed that the sumps include a tarpaulin to reduce wetting effects of adjacent tailings. These tarpaulins may be removed during tailings harvesting and reinstalled in the formed sump prior to fresh tailings deposition, or permanent sumps formed with waste rock protection around the perimeter. This will be determined during detailed design.

BHOP has reported that survey of beach slopes undertaking during construction of TSF2 embankments, typically indicates a beach angle of approximately two percent over 300 metres from the tailings discharge point.

The current perimeter embankments crests and existing tailings surface grade downwards from south west to north east. It is intended that the drying cells are operated generally in a similar way to the current tailings deposition orientation with deposited tailings grading downwards to the north, and deposition occurring generally from the southern end of each cell. This approach enables the currently constructed perimeter embankments to be utilised as part of the tailings drying system.

7.1.5 Stormwater Management on Tailings Surface

To store the required stormwater runoff it is proposed to excavate a stormwater pond into the tailings beach within the Cell 3 footprint adjacent to the spillway (Figure 1 of APPENDIX B). It is proposed to retain a volume of 10,000 m^3 which is approximately the runoff from a 10% AEP event (approximately 1 in 10 year). Based on an average storage depth of 3 m this equates to a surface area of approximately 3,300 m^2.

It is noted that stormwater runoff from a 24 hour 1% AEP (approximately 1 in 100 year) event is estimated to generate approximately 18,000 m^3 of runoff. A 24 hour 1% AEP event would result in some inundation of the Cell 3 drying and harvesting area. This is expected to temporarily disrupt operations in this cell. Depending on the beach angle of deposited tailings it is expected that approximately 15% to 30% of the Cell 3 harvesting area may be impacted by inundation resulting from stored runoff from a 1% AEP storm event.

As noted in Section 6.2.1.5 the TSF2 is designed to retain the 1 in 10,000 AEP storm event (approximately 48,000 m^3) without spillway discharge as required by Dams Safety NSW. In the event of a storm event of this magnitude the majority of the Cell 3 harvesting area would be inundated and accordingly disruption to drying and harvesting operations is expected.

The storm water pond excavated next to the emergency spillway to retain runoff would include a pump platform to enable extraction of water from the area to be reused in the plant.

7.1.6 Stability of Blackwood Pit TSF2

The stability of TSF2 was considered for the proposed harvesting process of the tailings and for the future closure shape of the TSF2. The closure considers a waste rock layer to be placed over the final tailings surface. The loading of the future waste rock layer for closure is higher than the loading for the proposed harvesting process of tailings, so the loading conditions assessed in the following sections are for a more onerous waste rock layer loading. The detailed assessment and testing results are presented in the Golder report ref 1896230-044-R-Rev0, attached in APPENDIX G.

7.1.6.1 Static Liquefaction

Golder assessed the risk of liquefaction of tailings in the TSF2 storage facility. Data collected from a cone penetration test (CPTu) programme completed on the existing tailings in TSF2 on 7 and 8 February 2020 was used to assess this risk. The investigation was carried out in three locations on the tailings surface. Two of the locations are near where Embankments 1 and 3 of the TSF2 are constructed. The location of the third CPTu test was selected to be near the “low” spot of the tailings beach (north east end) where the tailings drying and desiccation conditions are expected to have been least favourable in the past. The locations of the CPTu tests are presented in Figure 1 of APPENDIX G attached, which shows the tailings beach contours near the time of the investigation.

The report presents the results of the CPTu analyses and the associated slope stability assessment relative to the embankments along the sides of the pit and the final waste rock rehabilitation profile over the top of the tailings storage facility.

The state parameter (Ψ) of the tailings has been estimated using methods proposed by Been & Jefferies. The state parameter provides a framework for identification of soil/tailings that may be prone to rapid strength loss i.e. static liquefaction. Generally, soil/tailings with $\Psi < -0.05$ is dilative (dense) and are immune to brittle strength loss during rapid or cyclic shearing. When $\Psi > -0.05$, there is a risk of strength loss resulting from changes in stress, with the likelihood of occurrence and the severity of strength loss increasing with increasing Ψ.

The following can be inferred from the state parameter analysis:

- The top layer (~ 5 m) of tailings is dilative and over consolidated. This is likely due to lower rate of rise, and relatively dry site conditions over the previous 2 years before the investigation;
- CPTu 01 has numerous bands of contractive material below 5 m depth;

- CPTu 03 has a layer of strongly contractive tailings from about 24 m to 30 m below the tailings surface elevation at beginning of 2020, as indicated in last row in Table 9.

A summary of the 85th percentile state parameter for each CPTu is provided Table 7.

Table 7: Characteristic State Parameter

CPT ID	Depth Interval (m)	Characteristic State Parameter (85th percentile)
BW CPTu 01	0 – 5	-0.055
	5 - 12	-0.029
BW CPTu 02	0 – 5	-0.077
	5 – 24	-0.046
	24 – 26.5	-0.031
BW CPTu 03	0 – 5	-0.085
	5 – 24	-0.050
	24 – 30	0.009

Based on the above results the tailings in TSF2 at the time of CPTu testing are not likely to result in static liquefaction for the shallower depth over tailings. The results suggest that the tailings would have a stable surface under mobile vehicle loads. The lower portion of tailings at the three locations are likely to be marginally at risk for static liquefaction.

7.1.6.2 Cyclic Liquefaction

TSF2 has been assessed against a maximum credible earthquake (MCE) with a return period of 10,000 years to meet the consequence category and closure requirements outlined in ANCOLD (2019). Geoscience Australia (Allen et al 2018) publishes seismic hazard maps and peak ground accelerations (PGA) for Australia for various return periods up to 5,000 years. In the absence of site specific hazard information we have extrapolated from this data to estimate the PGA for a return period of 10,000 years. The PGA for a 10,000 year return period is estimated at 0.147 m/s^2.

7.1.6.3 Cyclic Resistance

Cyclic liquefaction occurs where seismic loading results in increased pore pressures resulting from cyclically induced strain. The increase in pore pressures results in a decrease in vertical effective stress and corresponding reduction in strength. The cyclic resistance ratio (CRR) is based on the method proposed by Robertson (2009) with the undrained shear strength capped to the critical state friction ratio of 1.2 (i.e. 30°) based on database of critical state properties for various soils presented by Been and Jefferies (1992).

The factor of safety (FoS) against liquefaction is defined as CRR/CSR for a magnitude 7.5 earthquake. Data for all the CPTu's results in FoS close to unity for the majority of the tailings for a PGA resulting from a return period of 10,000 years. This indicates that the tailings may liquefy under this event.

The factor of safety against liquefaction is close to or just below unity for a significant portion of the tailings in the Maximum credible earthquake event with a PGA of 0.147 m/s^2.

7.1.7 Slope Stability

7.1.7.1 Perimeter Embankments

TSF2 includes three embankments over parts of the pit perimeter. Embankment 2 has been constructed on weathered rock or engineered rockfill foundations. Embankments 1 and 3 are constructed partly over the tailings beach.

The upper 5 m thick layer of tailings is dilative and over-consolidated. The foundation pressure under the proposed embankments and proposed harvesting cell bunds is estimated to be less than the over-consolidation pressure of the upper layer of the tailings, so it is assessed that the tailings will remain dilative when loaded by the proposed embankment. Hence the 5 m layer of tailings below embankments and bunds are assessed to retain a peak strength ratio of 0.21 under static loading conditions.

The minimum target factors of safety values as per the ANCOLD guidelines for the consequence category of the TSF2 are:

- Static conditions (drained and undrained conditions) = 1.5
- Post liquefied conditions = 1.1

For all of the above slope stability analyses, the post liquefied strength analysis is the critical case and the reported factors of safety relate to the post liquefied condition. The results of the slope stability analyses indicate the target factors of safety are met and are presented in Table 8 and APPENDIX G.

Table 8: Slope Stability Results

Location	Factor of Safety
Embankment 1	1.9
	3.4 extending into liquefied tailings
Embankment 2	2.1
	1.8 with phreatic surface
Embankment 3	< 1.5 without modification
	2.1 with buttress
Waste Rock Slope	2.0

The assessment shows that the tailings storage facility is expected to meet contemporary slope stability targets, both for static and post-liquefied conditions of the tailings, on the basis that the tailings beach is operated to continue promoting desiccated tailings, supernatant water and stormwater is removed in a timely manner.

7.1.7.2 Intermediate Bunds

Two intermediate bunds will separate the three containment cells at the TSF2. Analysis of intermediate bund stability was undertaken for the case where saturated tailings are filled to maximum capacity of 1.5 m height to one side of the bund, and dry tailings fully excavated to base level at the opposite side of the bund. This simulates a critical scenario where maximum lateral force is experienced at one side of the bund (full-height saturated tailings) with no resisting lateral force at the opposite side of the bund (fully excavated case). A surcharge load of 10 kPa was applied to simulate the design traffic loading along the crest of the bund.

A phreatic surface is included through the bund to simulate conservative slope stability conditions. An undrained strength was applied to the existing tailings below the intermediate embankments. The undrained strength was identified through testing of tailings samples as summarised in Table 3. Saturated tailings against the bund were modelled with a maximum shear strength of 2 kPa to reflect the relatively low strength of these tailings. A horizontal seismic loading factor of 0.0150 g is applied to the bund stability analysis to conservatively reflect the peak ground acceleration (PGA) for the Broken Hill region in accordance with the 2018 Interactive Australian Earthquake Hazards Map and corresponding to the 1 in 500 year ARI event. Analysis of the bund under the described geometry and material parameters yields a minimum factor of safety (FoS) of approximately 1.5, with potential failure being a shallow slip through the downstream slope extending into the existing tailings layer. Results of this analysis are provided in APPENDIX H and suggest that the proposed bunding design meets conventional targets for engineered earthworks structures with the saturated tailings, vehicle and seismic loads.

7.1.8 Dust Suppression

7.1.8.1 Pre-harvesting Works

BHOP has advised it proposes to employ a combination of an automated sprinkler system and water cart application along with the addition of dust suppression substances, where required, to suppress dust during pre-harvesting works for TSF2.

7.1.8.2 Operational Dust

BHOP has advised it proposes to employ a combination of an automated sprinkler system and water cart application along with the addition of dust suppression substances during harvesting operations at TSF2. The proposed design arrangement for the sprinkler system is presented in Figure 12.

Any sprinkler system installed on TSF2 will include measures to manage risks associated with pipe damage due to tailings settlement and excavation during operations. These measures are expected to include:

- Installation of pipes at an elevation below the maximum expected excavation depth.
- Use of flexible pipe materials such as HDPE that are resistant to damage, corrosion and suitable for large deformation applications.
- The use of pipe ‘sleeves’ or similar measures to reduce the risk of pipe damage due to tailings settlement, if detailed analysis suggests that conventional HDPE may be overstressed.
- Vertical pipe sleeves installed in the tailings mass from the buried pipe to the sprinkler head locations and surrounded with waste rock to provide protection and support to the sleeve during deposition and excavation of the tailings. A number of sprinklers will be located on the bund crests, as per Figure 12.
- Pressure sensor linked to automated alarm and automatic cutoff valve system that shuts off the system in the event of pressure loss or other event that may indicate pipe leakage. This is intended to reduce the risk of undetected pipe leakage into the underlying tailings mass.

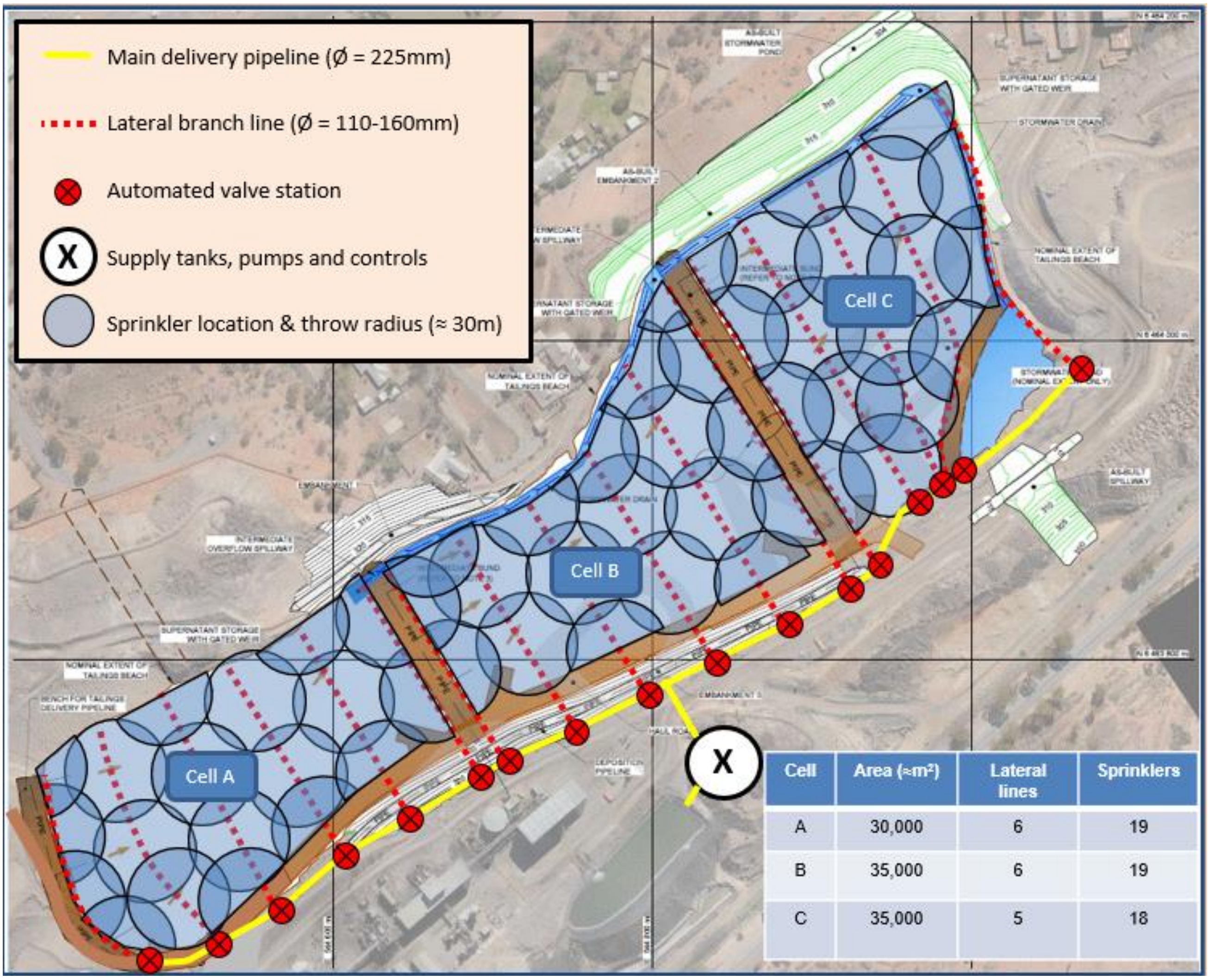


Figure 12: Nominal Sprinkler System Arrangement of TSF2 (developed by BHOP)

7.2 Kintore Pit TSF3

7.2.1 Tailings Deposition

The dried full stream tailings will be sourced from harvesting in the TSF2 and deposited as engineered tailings fill in the central part of TSF3. This fill will be transported and co-disposed along with waste rock. Waste rock will be placed progressively around the perimeter of the pit.

The harvesting fleet will be scheduled to load, haul and place the dried tailings into the bottom of the pit over a period of a maximum 10 hours per day, during day shift only. It is expected that spreading and compaction of a days' delivery of harvested tailings will take a few hours per day. BHOP may progressively spread and compact the dried tailings, or the work may be carried out in campaigns spaced a few days apart depending on equipment selected.

It is expected that the average transfer rate between TSF2 and TSF3 may be approximately 170 tonnes per hour, which is approximately 3.1 trucks per hour, based on 55 tonne load per truck. Higher transfer rates may occur during peak periods.

Waste rock will be progressively placed around the perimeter of the pit, as compacted tailings is placed within the central part of the pit. The waste rock will be placed in near horizonal layers, and the top shaped to a design shape to suit progressive stormwater management. The waste rock filling plan will be updated at least yearly to suit the progress of the tailings filling plan and the stormwater management infrastructure. The waste rock will be placed to an elevation nominally 0.5 m above the tailings level. Remote operated equipment may be used to help enable this material to be placed safely.

The dried tailings will be placed in near horizontal layers of a nominal 250 mm thickness across the entire area and be compacted with a roller. The layer thickness and roller mass will be determined as part of the commissioning stage of tailings placement process based on a trial pad, to develop the most effective placement method to achieve a dry density ratio of at least 95% Standard compaction effort in accordance with ASTM D1556. Density requirements are related to stability of the tailings mass which its important during operation and closure.

7.2.2 Filling Rate of Kintore Pit TSF3

The surface area of the bridging layer at the base of the TSF3 (top of bridging layer and shaping layer at approximately RL 240 m AHD) presented in the concept design is approximately 14,600 m^2. The volume of compacted tailings at the full tailings production rate of 480,000 tpa is equal to approximately 21,277 m^3/month. This volume is related to the compaction target dry density of 1.88 t/m^3. BHOP has advised it expects to deposit 130,000 tpa of waste rock into TSF3 which equates to approximately 59,000 m^3 per annum.

The rate of rise based on a tailings production rate of 480,000 tpa and 130,000 tpa of waste rock, and a total capacity of 4,305,000 m^3, is summarised in Table 9 and presented in Figures 4, 5, 6 & 7 of APPENDIX A. The rate of rise accounts for material from the surface of the bridging layer upwards as the drainage and bridging layers are proposed to be constructed using waste rock from the Tipple stockpile.

Table 9: TSF 3 preliminary filling schedule (all elevations and volumes are approximate)

Year	Approximate filling elevation (AHD)	Estimated Cumulative Volume of Tailings Produced	Estimated Cumulative Volume of Waste Rock Produced	Estimated Combined Total of Tailings and Waste Rock Produced
1	255 m	255,319 m^3	59,091 m^3	314,410 m^3
2	265 m	510,638 m^3	118,182 m^3	628,820 m^3
3	275 m	765,957 m^3	177,273 m^3	943,230 m^3
4	280 m	1,021,277 m^3	236,364 m^3	1,257,640 m^3
5	285 m	1,276,596 m^3	295,455 m^3	1,572,050 m^3
6	290 m	1,531,915 m^3	354,545 m^3	1,886,460 m^3
7	295 m	1,787,234 m^3	413,636 m^3	2,200,870 m^3
8	300 m	2,042,553 m^3	472,727 m^3	2,515,280 m^3
9	304 m	2,297,872 m^3	531,818 m^3	2,829,691 m^3
10	308 m	2,553,191 m^3	590,909 m^3	3,144,101 m^3
11	312 m	2,808,511 m^3	650,000 m^3	3,458,511 m^3
12	316 m	3,063,830 m^3	709,091 m^3	3,772,921 m^3
13	~ 320 m	3,319,149 m^3	768,182 m^3	4,087,331 m^3

The full capacity of the pit to the crest level RL 320 m is approximately **4,305,000 m^3** and therefore after 13 years of filling, the pit is at approximately 98% capacity expended and 2% remaining. This leaves around 217,669 m^3 of capacity remaining. At the production rates with a material split of approximately 81% tailings and 19% waste rock, in the final year (Year 14) the pit can receive a further approximately 176,760 m^3 of tailings and approximately 40,909 m^3 of waste rock.

A further 1 to 2 years of capacity is expected to be achieved in the pit if the proposed mound shape was formed above the pit rim (approximately 450,000 m^3) and depending on the achieved tailings density in the pit and the extent of completed consolidation. This storage volume is based on the final tailings filled surface presented in Figure 8 of APPENDIX A.

7.2.3 Stormwater Management on Tailings Surface

During filling the surface of the tailings will be shaped to form a depression or low areas to collect rainfall runoff on the tailings surface. The low area is designed to aid day to day operational stormwater management. From the testing conducted on the compacted tailings and due to the tailings being partially saturated when transported into the pit, it is known from the findings of tailings laboratory testing presented in APPENDIX D that the tailings have a low permeability and so infiltration into the tailings from stormwater runoff will be minimal and very slow.

The design intent is that collected rainfall on the tailings surface is removed from the low area within 7 days of rainfall events. The low area and dish shape of the tailings surface will be maintained during the ongoing tailings deposition works. The discharge pipe from the low area will be located on the existing access ramp into the pit, as shown in Figures 4, 5, 6 & 7 of APPENDIX A, to enable pump access to the low area. Removal will be by pumping or water truck. It is estimated that a 24 hour 1% AEP event will result in up to approximately 9.8 ML of rainfall runoff accumulated on the tailings surface, assuming 80% total runoff coefficient.

Minor volumes of collected runoff will be either evaporated on the compacted tailings surface or pumped out of the pit to maximise the drying area of the tailings surface for trafficability and compaction purposes. During the initial stages of the tailings placement, it is expected it will be necessary to pump most of the runoff out of the pit after a large rainfall event, due to the relatively small surface area available near the bottom of the pit.

Some runoff is also expected to infiltrate via the waste rock layer at the perimeter of the pit.

7.2.4 Seepage

Seepage from the tailings mass placed in TSF3 is expected to be minimal, as the tailings will be compacted in a partially saturated state, and there is expected to be no free water in the tailings during normal operating conditions. Seepage may however occur related to rainfall infiltration into the waste rock perimeter fill around the circumference of the pit. Rainfall will run off from the pit slope above the level of the waste rock fill and report to the top of the waste rock surface. The top of the waste rock surface will be shaped to direct the runoff to low spots on the tailings surface from where the majority of the water will be removed by mobile pump, as required when significant rainfall occurs. Low intensity rainfall runoff is likely to infiltrate the waste rock and seep to the bottom of the pit, where the seepage will be collected in the base drainage system and be managed as part of the mine dewatering operations. The volume of rainfall reporting to the bottom of the pit will be similar or less compared to what has and is currently the case with the active mine entrance adit at the bottom of the pit.

To provide additional robustness to the design a sloping riser pipe may be included in the waste rock surround to provide a backup to the outlet pipe through the adit plug at the base of the pit. The large diameter riser pipe would be intended to enable a submersible pump and discharge pipe to be lowered down the riser pipe to remove collected seepage water from the base of the pit.

Potential seepage through the waste rock perimeter has been estimated based on an assumed coefficient of permeability 3 x 10^{-6} m/s for the waste rock. A thickness of 10 m of waste rock was allocated in the assessment as an upper bound. It is assumed that the waste rock thickness will not exceed 10 m and therefore this provides a conservative approach to estimating the seepage which will report to the base of the pit. This permeability is equivalent to approximately 260 mm/24 hours, which is far higher than the general rainfall intensity at the site. Based on an area of infiltration equal to the surface of the rock layer around the perimeter of the TSF3 the maximum seepage is estimated to be up to a maximum of approximately 3.5 ML/day. This seepage estimate is based on the available surface area of the waste rock surface at approximately RL 320 m AHD which represents the maximum available area during the operating life of the TSF. Accordingly, the amount of seepage during earlier stages of filling is expected to be less due to a smaller surface area of waste rock around the perimeter, and the volume temporarily retained on the surface (which can be removed by pumping) is greater. Similarly the estimated 1% ARI rainfall for the site is estimated at approximately 139 mm over 24 hours. Assuming approximately 90 mm of this rainfall infiltrates the waste rock surround, the volume of infiltration is estimated at 0.97 ML/day.

The waste rock layer in the base of the pit (at assumed 25% porosity) will provide a storage volume of approximately 27.5 ML which provides storage for approximately 9 days of seepage based on the maximum potential daily seepage rate and can detain numerous 1% ARI rainfall infiltration events.

For purposes of comparison, the maximum runoff from a 24 hour duration 1 in 100 ARI event for the pit slopes catchment area (at RL 240 i.e. at the beginning of tailings deposition where the tailings surface area would be at its smallest and the pit slopes would be largely exposed) is estimated to be approximately 9.8 ML. Therefore, theoretically, the waste rock layer at the base of the pit (the seepage collection layer and bridging layer) could hold up to approximately three times this amount. If 100% of the runoff was to infiltrate though the waste rock layer, it would result in a water level approximately 2.7 m above the base of the waste rock layer. Due to the permeability and thickness of the waste rock, it would take multiple days for the full volume of runoff to flow to the base. Whereas after 5 years of deposition in TSF3, the tailings surface would retain the majority of the rainfall on the tailings surface. The runoff from a 24 hour duration 1 in 100 ARI event for the tailings surface at RL 290 m AHD (after approximately 5 years of deposition) is approximately 9.3 ML, this volume is expected to be retaining on the low permeable tailings surface (as discussed in Section 7.2.3) and so in this case the difference would be expected to be seepage collected at the bottom of the pit, approximately 0.5 ML.

Considering a condition outside the intended operation of TSF3 with the compacted tailings being saturated, the infiltration rate into the top of the tailings from rainfall or ponding water is less than 10 mm per day, based on the saturated permeability of the tailings. So after a week of stormwater storage only the top approximately 70 mm thickness of the tailings is expected to be wet, which will dry back within a couple of weeks after the free or ponded water is removed by pumping as intended, and subject to air and sun drying.

Under design conditions where the tailings are placed partially saturated, the thickness of wet tailings after a week of stormwater storage is likely to be less than 5 mm. This will similarly readily dry back within a short period.

It is noted that under design conditions the placed engineered tailings fill is unsaturated and hence no active seepage is expected to occur within the tailings or from the ongoing compression of the tailings due to self weight consolidation of the tailings.

7.2.5 Water Quality

The mine has in the past and is currently continuing to manage groundwater in the mine via pumping extraction from Shaft 7 at the south west end of the lease and a dedicated mine dewatering system. The groundwater management system is also required for the operation of the adjacent mines.

The concentration of analytes in the existing mine water is generally higher than the concentration of analytes in the tailings filtrate, with the exception of calcium and alkalinity. In general, the pH of the tailings filtrate is close to neutral (pH 7) and slightly higher than the mine water. This is expected given the measured higher alkalinity of the tailings filtrate relative to the mine water.

The water quality of the collected groundwater at Shaft 7 has been measured from 2018 to 2019 over a period of more than 10 months. Similarly the water quality of the tailings filtrate from the current tailings stream into TSF2 has been measured over a similar period. The results of the water quality measurements are presented in Table 10, which compares the average, maximum and minimum ranges of the test results for a range of analytes.

Table 10: Groundwater Quality vs Tailings Filtrate

	Units	Average		Maximum		Minimum	
		Underground water	Tailings filtrate	Underground water	Tailings filtrate	Underground water	Tailings filtrate
pH		6.3	7.1	6.6	9.8	6.1	5.6
Electrical Conductivity	µS/cm	12800	9064	14100	10500	11700	7990
Total Dissolved Solids @ 180 °C	mg/L	11606	7183	15200	12300	5000	5480
Total Alkalinity	mg/L	9.8	38	24	82	5	12
Sulphate as SO_4	mg/L	5466	3574	5860	4540	4900	2900
Chloride	mg/L	1620	1408	1910	2040	1290	1130
Calcium	mg/L	517	789	590	958	470	647
Magnesium	mg/L	294	49	354	149	247	3
Sodium	mg/L	1719	1251	1920	1470	1520	992
Potassium	mg/L	114	149	130	178	98	119
Cadmium	mg/L	2.4	0.05	2.71	0.411	2.02	0.0012
Lead	mg/L	1.6	0.40	4.66	2.13	0.438	0.001
Manganese	mg/L	333	18	492	165	245	0.097
Zinc	mg/L	956	3.4	1060	48.4	829	0.005
Iron	mg/L	1.9	0.39	3.22	1.71	0.38	0.05

The proposed placement of dried compacted tailings in TSF3 is expected to result in no or negligible seepage from the tailings, as the material is partially saturated during placement and to be compacted to a high density. Hence any seepage from TSF3 is likely to be related to infiltration into and through the waste rock surround around the perimeter of the pit. Currently a large waste rock mound already exists in the pit and is subject to the same infiltration as is anticipated once the pit is converted to a TSF.

Under design conditions no seepage is expected to occur from the compacted tailings mass, so there is no medium for any impact on groundwater quality from the compacted tailings.

Runoff and seepage from the floor of the pit currently is managed as part of the mine water management system, with runoff flows entering the mine via the adit. The proposed conversion of the pit to a TSF is expected to reduce the quantity of water reporting to the bottom of the pit due to the majority of the pit footprint being covered by compacted tailings, and the proposed rainfall water management on the surface of the low permeability compacted tailings. Sections 7.2.3 and 7.2.4 show that the seepage rate reporting to be bottom of the pit is likely to be approximately 4% of the volume of water that reported to be bottom of the pit in the past during a 1 in 100 year rainfall event. This water volume will seep through the waste rock surround against the pit wall. The report titled ‘Long Term Geochemical Degradation Assessment for Waste Rock MOD6 Waste Rock Management, Rasp Mine’ by Environmental Resources Management Australia Pty Ltd, dated 16 March 2021, indicates the acid rock generation risk is low, so runoff contacting the rock is expected to result in minimal change in water quality. Where water may contact tailings at the interface between tailings and waste rock, it is expected that the water quality of this small volume of water may be similar to the water quality of the existing tailings, which is better than the water quality that is being pumped out of the mine at Shaft 7 at the south west end of the lease. Therefore, the small quantity of water reporting to the bottom of the pit is expected to have negligible impact on the mine groundwater quality.

The potential impact on groundwater quality of the smaller volume of water reporting to the bottom of the pit, if the water was not collected in the seepage collection system included in the bottom of TSF3, is expected to result in at least equal or better quality that the current water quality. Due to the small volume of water the water quality impact may not be materially significant.

7.2.6 Old Tailings Slope

An old tailings slope exists within the northern batter of the TSF3 slope (Figure 1, APPENDIX A). Kintore Pit was commenced in 1984 and the tailings slope was exposed during pit development. The tailings slope has been assessed by Ground Control Engineering (report ref. G0201 Rev 05 *Stability Assessment of Pit Slope Comprising Historic Tailings*, dated 20 August 2019, APPENDIX I). The report indicates the tailings slope appears to be cemented, with factors of safety above 1.0 when the tailings is dry.

The stability of the slope appears to be sensitive to changes on phreatic surface conditions that have been assumed in the slope. As groundwater at the site is deep, a phreatic surface may develop in the slope if surface water permeates the ground behind or above the slope. The slope is located in a relative elevated area of the site and the site has implemented a stormwater management plan, and there are currently no known buried water or liquid service pipes in this area, so the conditions are favourable for a low risk of surface water infiltration. These conditions must however continue to be monitored, and any proposed changes to surface water management should consider the implications to the old tailings slope.

The extent and reliability of the cemented condition of the old tailings has not yet been verified. The surface condition of the existing old tailings slope will be maintained with a layer of non-woven geotextile or a sprayed surface protection system to reduce the risk of erosion of this layer. The surface protection would be placed against the slope before progressively placing waste rock against the old tailings, considering access constraints this may require the use of long reach and/or remote controlled equipment and/or other safety measures. The geotextile or alternative method is to control potential erosion of the surface of the tailings slope from stormwater infiltration that may flow within the waste rock.

The extent of the area to be managed in this way is subject to progressive assessment of the old tailings slope by an appropriately experienced geotechnical engineer as the filled level of waste rock and compacted tailings rises in the pit.

7.2.7 Old Workings

The TSF3 contains a number of locations where old workings extend through the pit slope. The critical state testing and analyses of the tailings has indicated that the compacted full stream tailings is potentially susceptible to liquefaction at high stress (at a thickness greater than 53 m).

As the TSF3 is filled with tailings, the tailings in the bottom portion of the pit may become liquefiable, so any existing voids or known flow pathways out of the pit are to be designed with additional measures to reduce the size and/or porosity of the opening, and to provide additional restraint to potential tailings flow into the void or pathway.

The eastern side of the pit includes several small drives (generally less than 2 m high and 1 m wide) that are located some way above the base of the pit. These drives are proposed to be covered with a buttress of waste rock. The waste rock buttress will be formed once the waste rock level in the pit approached 1 m below the invert of the opening. The buttress will be formed within the waste rock surround of the pit, at these locations.

Where an opening is encountered the area will be filled with large boulders and covered with compacted waste rock buttress that extends 10 m beyond the top and sides of the hole through area. The width of the waste rock buttress will be at least 10 m from the pit slope. A layer of non woven separation geotextile shall be placed on the outside face of the waste rock buttress and be covered with another layer of waste rock to hold it in place. The geotextile is to be placed on the bottom, front, sides and top of the buttress to fully envelope the buttress and intercept potential liquefied tailings flow paths into the buttress. Based on engineering advice and considering the actual size of the opening, a biaxial geogrid (or other reinforcing material) may be placed across the opening and extending nominal 5 m either side of the opening edge and be covered with the waste rock buttress if considered necessary.

On the north side of the pit slope the residual crushed timber supports of an old stope are visible. The area of the old stope will similarly be buttressed with a geotextile enveloped waste rock buttress, to control the risk of potential tailings migration into the old workings. The extents of the buttress will be similar to the buttress on the east slopes.

Access for construction equipment to form the buttress will be via the existing access ramp into the pit and onto the waste rock surround or the compacted tailings surface.

7.2.8 Waste Rock Slope

The existing waste rock stockpile slope has been formed by end tipping and dozing over the edge. Hence the stability of the slope is expected to be marginal and likely to have a factor of safety close to 1.0. The slope is coarse waste rock and has properties of granular material. Ground Control Engineering Pty Ltd prepared a slope stability assessment of the waste rock slope during placement of the tailings in the pit. The assessment is presented in their report *G0197_RE01_VE01 Kintore Pit Waste Rock Slope Stability Assessment*, dated 20 August 2019, APPENDIX J.

The assessment indicates that the waste rock slope may experience shallow sloughing of the near surface materials, and that the placement of engineered fill against the toe improves the stability of the slope. If a substantial phreatic surface was to develop in the waste rock slope the stability is reduced, with factors of safety for deep seated slips that are considered to be similar to those conventionally adopted values for temporary slopes, and lower factor of safety for shallow slips.

For the area near the waste rock slope it is proposed that no excavations occur near the toe, only rock fill and tailings placement. When construction and filling activity is to occur in this area the slope should be monitored for cracks and early signs of movement. If ravelling of the slope was to occur the displaced rock can be left in place and fill continued to be placed around it.

The seepage collection system includes drainage lines near the slope so the risk of a significant phreatic surface developing in the slope is expected to be low.

7.2.9 Dust Suppression

7.2.9.1 Pre-deposition Works

During the placement of the waste rock in the bottom of the pit the potential exists for minor dust to be generated. We note the risk of dust generation is expected to be low as the material comprises waste rock which will be watered during placement and compaction. We note the works are proposed at the bottom of an approximate 100 m deep pit, so wind and dust risks are inherently low.

To further reduce the potential for generation of dust during construction, the following measures are proposed.

- Routine water spraying along proposed haulage routes using a water cart.
- Application of water during placement of waste rock via water cart after spreading and during compaction.

A construction dust management plan will be developed with the construction contractor to implement the above measures. The construction schedule will also include limitations on works permitted during windy days.

7.2.9.2 Operational Dust

During active fill deposition, the silty sand material excavated from TSF2 will be tipped onto the compacted surface in a moist state. The moist engineered fill will be periodically spread and compacted in layers. The risk of significant dust generation from a moist engineered fill surface is considered to be negligible.

The risk of dust generation from compacted tailings once above the pit rim has not yet been assessed but is expected to be relatively low. A backup dust suppression strategy is proposed, should the risk of dust generation be higher than expected.

The dust control plan will comprise dust suppression using a water cart with sprayers. As a backup option, a water cart could apply dust suppressant if considered necessary.

a. Blasting from Ongoing Mining

Golder undertook an assessment related to the risk of tailings liquefaction at the Rasp Mine posed by blasting at the site. The outcomes of this assessment are presented in Golder Technical Memorandum titled 'Rasp Mine – Potential Impact of Blasting on Tailings Storage Facility' ref: 1896230-024-M-Rev0, dated 4 October 2019 provided in APPENDIX K.

Based on our assessment of information provided by BHOP and summary of the work carried out by numerous researchers on the potential liquefaction of tailings, the following provides our summary of findings and recommendations:

- TSF1 is an old tailings dam with the upper portion of the deposit in a relatively dry state, and moderate density based on piezocone testing conducted on the TSF. The lower portion of the tailings of the TSF was saturated and at a lower density at the time of CPT investigation conducted on the tailings. Based on these conditions a preliminary PPV of less than 25 mm/sec is suggested, and should be reviewed based on the results of the proposed piezometers to be installed (see below).

- In TSF2 two of the raise embankments are partially constructed on desiccated and compacted tailings, underlain by hydraulically placed tailings. CPT investigations prior to embankment construction confirmed the tailings were partially saturated and at a moderate density, with a low risk of liquefaction. Hence a PPV limit of 50 mm/s is considered to present a reasonable limit to avoid potential liquefaction.
- The containment of the proposed dewatered tailings in TSF3 is the pit wall rock, and the tailings is proposed to be compacted in layers in the pit and operated to result in an un-saturated tailings mass. Hence blasting related liquefaction is not an issue under design conditions so no PPV limit is assigned to this TSF.
- Limiting excess pore pressure limits the risk of liquefaction. Vibration and pore pressure monitoring of the blasts should be carried at the existing TSF's to verify the pore pressure response to the modelled vibration values. This would allow for the refinement of the vibration and pore pressure attenuation model based on site-specific data at distances where tailings liquefaction is a consideration.
- Monitoring of induced vibrations and pore pressure in the closest tailings from the blasting as it approaches the tailings. This will provide a record of the PPV at the specific locations in question and enable refinements of the developed models.
- Review and assessment of the vibration and pore pressure responses should be carried out by the dam engineer for the TSF's, to review the results and potentially conduct inspections of the facilities to review the integrity.
- Instrumentation of tailings should be undertaken. This would include both ground vibration and porewater sensors. This would allow for the site-specific assessment of:
  - The PPV induced in the tailings (rather than in the rock only) and refinement of the vibration attenuation model within the tailings; and
  - Potential rises in pore water pressure for given recorded PPVs.
- Should vibration monitoring exceed a warning level of 70% of the preliminary PPV limits described, a redesign of the blasts should be undertaken. This condition will be reflected in the technical blasting management plan.
- Vibrating wire piezometers should be installed within TSF 1.
- The blasting magnitude and correlating results recorded in TSF1 piezometers could then be used to form an assessment on the likelihood of liquefaction of the TSF. This data would provide a basis to assess the stability of the TSF including in relation to blasting at the site.
- Golder understands Dams Safety NSW has also imposed a condition of a maximum PPV limit of 30 mm/s at any point on the TSF2 embankments as a result of mining.

8.0 MONITORING REQUIREMENTS

8.1 TSF2

Monitoring of TSF2 should continue to be undertaken in accordance with the *Operation, Maintenance and Surveillance Manual* (Golder Report ref: 1896230-038-R-Rev0, dated 22 April 2020) which outlines inspections and monitoring requirements for TSF2 as a declared dam by Dams Safety, NSW. These monitoring requirements include daily, weekly and monthly routine inspections. Monitoring requirements are provided during special events such as large floods and earthquakes, as well as a requirements for monitoring during blasting or high vibration mining.

This manual should be updated as considered appropriate to suit the proposed harvesting operations on TSF2.

8.2 Dust Monitoring

Dust monitoring is intended to continue to be undertaken in accordance with current site operational requirements during pre-deposition and operations proposed to be undertaken under MOD6 and could be updated to include additional monitoring requirements made by regulators.

8.3 Moisture Content

The moisture content of deposited tailings at TSF2 will be monitored within each drying bay.

This monitoring will be undertaken to the proposed harvesting depth to confirm whether deposited tailings have reached the target moisture content for harvesting and to what depth harvesting can be undertaken.

8.4 Compaction and Density Monitoring

The density and associated compaction program for tailings placed in TSF3 will be monitored and controlled by:

- Developing and implementing a method specification for placement and compaction of tailings. This method specification would be developed based on the outcomes of a trial pad process to confirm compaction techniques (e.g. equipment, number of passes and layer thickness) required to achieve the target dry density for placement.
- Periodic (minimum twice per month) field monitoring of dry density of placed silty sand fill (using nuclear densometer or other agreed methodology) to confirm placed tailings density.

Furthermore compacted tailings in TSF3 would be assessed with regard to strength and liquefication risk every 10 m to 15 m thickness of filling. The assessment would be carried out with a program of Cone Penetration Testing to full depth of deposit to confirm that the tailings mass is unsaturated and not subject to liquefaction.

8.5 Vibration Monitoring

Vibration monitoring should be undertaken in response to the recommendations included in Section a. This should include the installation of piezometers into the tailings mass of TSF1 as a comparative tool to record and predict the effects of blasting on the TSF. The location of piezometers and monitoring program should be agreed with an appropriately experienced geotechnical engineer.

TSF 2 should continue to be vibration monitored with the PPV limit as imposed by Dams Safety NSW.

Vibration monitoring is considered to not be required at TSF 3.

8.6 Seepage Monitoring

8.6.1 TSF3

The rate of seepage collected from the drainage outlet pipe through the Decline Plug at TSF3 (as shown on Figure 2 of APPENDIX A) will be monitored. The monitoring will include either a record of pumping rate, time and frequency, or a gauged weir plate into a sump before being pumped. The monitoring will enable assessment of the change in flow rate over time, and also provide the opportunity to periodically measure the quality of the seepage water. Actual seepage from the pit is expected to be minimal, and so an accurate monitoring device such as a V notch weir monitor is expected to be appropriate. The final detail of the monitoring device should be decided once the actual flow rate is observed. Very low flow rates may require tip-bucket type measurement devices that are capable of measuring very small flow rates. Any seepage should be recorded and assessed.

8.6.2 TSF2

A stormwater detention pond is proposed to be located at the existing spillway. The outside slope of the pit area in this area is relatively steep. To inform slope stability assessment and seepage review in this area it is proposed that two piezometers should be installed in this area and be monitored as part of the TSF2 tailings harvesting program. The proposed location is shown on Figure 1 of APPENDIX B and should be located either side of the spillway close to the crest. Ideally, these piezometers shall be drilled to the depth of the ground level outside of the pit. The pond presented in Figure 1 of APPENDIX B shows the nominal extent only. The capacity and dimensions of this stormwater detention pond will be assessed at a detailed design stage.

9.0 CONCEPT TSF CLOSURE PLANS

9.1 TSF2 Closure Concept

The following provides an updated closure concept for TSF2 (from MOD4). The primary objective of closing TSF2 is to ensure a safe and stable structure that prevents or minimises the potential for lead borne dust to be entrained by wind and transferred to areas within the City of Broken Hill, as well as stormwater management.

During the final stages of mining, production tailings will cease to be harvested and will be used to fill the cells within TSF2. Water collection and water spray infrastructure will be buried within the facility or removed and placed in underground voids. The surface is expected to be relatively stable with minimal settlement or deformation occurring during and after placement of the capping layer.

Once all the cells have been filled, it is proposed to cover the tailings with a layer of waste rock to provide a permanent cover to the surface and protect the tailings from erosion by wind or rainfall runoff. The waste rock will be tested and material with an average of <0.5% Pb will be utilised as capping material. Similarly to the capping of Mt Hebbard and other Free Areas the waste rock is proposed to be paddock dumped or similar over the existing surface.

A paddock dumping approach would comprise 40 tonne haul trucks dumping loads adjacent to one another to cover the surface of the tailings. If paddock dumping is implemented, no spreading or compaction of the dumped loads is proposed to be undertaken. This approach helps in manage dust generation and may encourage vegetation growth in depressions. Water trucks will be used to control dust generation during the placement of waste rock.

The paddock dumping placement approach will result in a surface with numerous tightly spaced mounds and depressions between the mounds. During rainfall events rain will collect in the depressions between the mounds which will be designed to hold rainfall to retain a 1 in 100 ARI event. The standing water contained within these depressions is expected to infiltrate the placement area or evaporate. It is estimated based on 1 in 100 ARI rainfall and assuming initial infiltration losses of 15 mm and a continuing loss of 2 mm/hr that standing water contained in the depressions resulting from a 1 in 100 ARI rainfall event will be less than 400 mm depth. Accordingly, runoff from a 1 in 100 year 24 hour rainfall event would be wholly contained within the depressions formed by the paddock dumping mounds. A general tailings surface and hence the paddock dumped surface slope will be maintained directing stormwater towards the spillway, with runoff in excess of 1 in 100 year events discharging through the spillway which will be left in situ for this purpose.

The cover layer will be constructed over the entire tailings surface and be integrated into the in situ rock on the pit rim and the surface of the embankments. Wind and rain erosion of the embankments is expected to be minimal. No further rehabilitation of the downstream embankment slopes is envisaged.

The stormwater pond in the south eastern corner of Cell C will be filled. The existing stormwater pond as shown on Figure 13 is proposed to be removed and water from the slope of Embankment 2 allowed to flow offsite. The majority of the surface stormwater runoff in this area will be from the embankment slope which has been capped with waste rock that has a low waste rock content (average <0.5% Pb).

Seepage flow rate from the collection system within the embankments will be monitored periodically. Where the seepage rate is negligible the sumps may be decommissioned and removed. Removed sumps and any other removed materials would be disposed as part of the mine rehabilitation procedure to underground voids or other tailings storage facility.

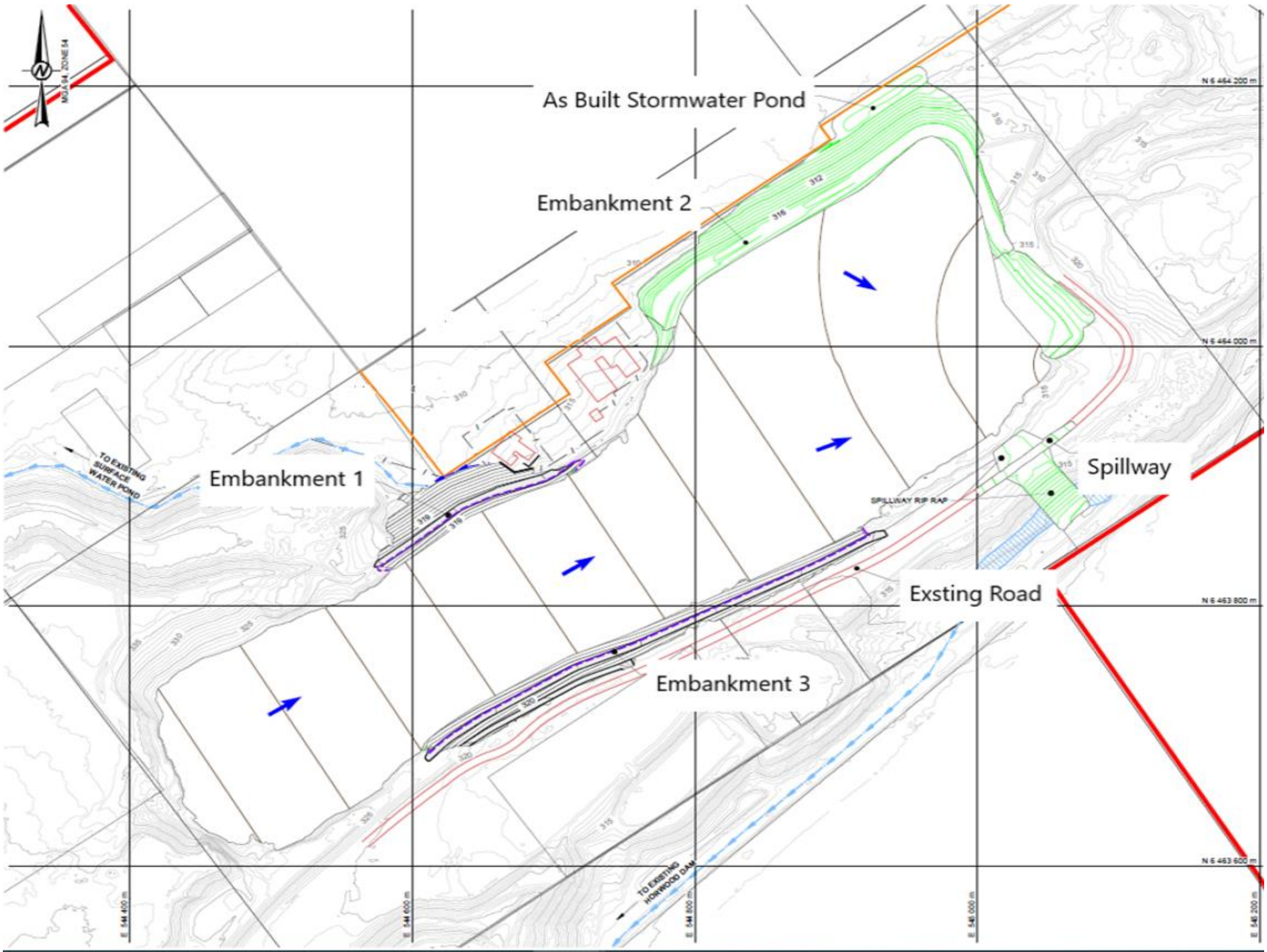


Figure 13: TSF2 at Closure

If the tailings surface (approximately 10 hectares) is capped with a layer ranging nominally from 500 mm to 700 mm, an approximate waste rock tonnage of 110 kt to 154 kt will be required.

9.2 TSF3 Closure Concept

As outlined in Section 4.2 it is estimated that as part of MOD6 operations TSF3 will be filled to an elevation of between approximately RL 280 and 290 m AHD. This results in a void as the final tailings surface will be approximately 20 m to 30 m below the surrounding pit rim.

If closure was to occur at this time it is proposed the void would remain with the top of the tailings to be covered. The final surface of the filled pit is proposed to be covered with a layer of waste rock to protect underlying tailings or soils from erosion by wind or rainfall runoff. The tailings will be compacted during placement so is expected to be trafficable for construction equipment when filling ceases. If the proposed method of placement is achieved with compaction efforts carried out by earthworks methods at the target moisture content and density, settlement is anticipated to be minor. Waste rock will be placed by paddock dumping or alternative with the aim to minimise dust.

However, if additional and or future approvals are granted to fill the pit to the natural surface level, as the tailings surface reaches the crest of the pit the depression formed by the southern branch of the access ramp will be filled in to promote surface runoff from the tailings mound towards the stormwater pond to be located near Little Kintore Pit. The waste rock perimeter layers around the circumference of the pit may be stopped at approximately 10 m below the pit rim, or lower if operational considerations and geotechnical assessments of the as placed compacted tailings confirm it is not needed for tailings liquefaction risk management. Tailings would be filled and compacted against the pit edge and would result in the perimeter waste rock layer being capped to surface water infiltration once the TSF is filled and closed.

The final surface of the tailings is proposed to be covered with a layer of waste rock to protect the tailings from erosion by wind or rainfall runoff. The tailings will be compacted during placement so is expected to be trafficable for construction equipment when filling ceases.

The surface is expected to be relatively stable with minimal settlement or deformation occurring during and after placement of the cover layer. It is expected that the final thickness of cover over the tailings may be between approximately 500 mm and 700 mm.

The edge of the final surface will be shaped to direct excess rainfall runoff towards the south. A stormwater detention pond will be located to the west side and within the infilled Little Kintore Pit and may extend partially onto the edge of the pit mound. Little Kintore Pit is intended to be filled with waste material excavated from the Boxcut excavation and then capped with selected waste rock which will be shaped to develop the required stormwater detention pond with a capacity to retain the stormwater runoff from both TSF3 and the Little Kintore Pit catchments.

Progressive rehabilitation of the final filled mass surface would be undertaken (where appropriate) in line with the site's final landform requirements and closure strategy.

10.0 WASTE ROCK STORAGE

The proposed MOD6 development is expected to manage a significant volume of waste rock generated from underground mining operations. In addition, waste material would be excavated from the proposed Boxcut to the south west of the existing TSF2

The location and geometry of proposed waste rock placement areas are described in the following subsections. A summary of the estimated capacities of each of the placement areas is presented in Table 11.

BHOP has advised it expects to deposit 130,000 tpa of waste rock into TSF3 which equates to approximately 59,000 m^3 per annum.

Table 11: Estimated capacity of Waste Rock Placement Areas

Placement Area ID	Description	Approximate Capacity (m^3)	Approximate Capacity (kt)[1]
A	Placement within TSF3[3]	295,000	649
B	Infill of north end of BHP Pit	30,000	66
C	Infill of Little Kintore Pit[4]	166,000	365

Placement Area ID	Description	Approximate Capacity (m^3)	Approximate Capacity (kt)[1]
D	Atop Mount Hebbard[2] or Free Area	40,000	76
E	Kintore Pit Tipple (temporary storage of Boxcut material)	18,200	40
Total		634,200	1,383

Note 1 Waste Rock assumed placed density 2.2 t/m3.

2 Waste Rock Atop Mount Hebbard assumed 1.9 t/m3 paddock dumping density.

3 The capacity of Placement Area A in TSF3 is to an elevation equal to the estimated top of tailings surface at Year 5 (approximately RL 290 m AHD). Additional capacity for waste rock storage is available within the pit above this elevation.

4 Capacity reported by BHOP

10.1 Placement Area A – with Tailings in TSF3

As described in Section 3.0 it is proposed to co-dispose waste rock in TSF3 with engineered tailings. Waste rock will be placed across the base and sides of TSF3. The waste rock proposed to be placed across the base is assumed to be sourced from the in-pit stockpile and therefore has not been included in the totals in Table 9.

As the compacted tailings is deposited into TSF3, waste rock will be progressively placed against the pit walls. If waste rock is proposed to be deposited with tailings (not at the perimeter) the location should be selected to avoid impacting the ability of future CPT investigations to be undertaken and recorded by survey. Waste rock is intended to be placed in near horizontal layers of a nominal 1 m thickness progressively with tailings placement. Based on this it is expected that all waste rock from mining operations could be placed within TSF3. It is expected that the material will be placed, spread and track rolled using a dozer. It is expected that haul trucks will be able to access the proposed Placement Area A via the existing ramp into the TSF3 which will also be used by the tailings harvesting fleet.

The volume estimate presented in Table 11 is based on the proposed 130,000 tpa waste rock production rate to an elevation of approximately 290 m AHD. Additional waste rock storage capacity is available within TSF3 with a total of 768,000 m^3 to be placed during the life of the facility at the proposed production rate.

10.2 Placement Area B – Infill of north end of BHP Pit

Placement Area B is proposed to be constructed within the north end of the existing BHP Pit in the central portion of the Rasp Mine (Figure 1).

It is understood that waste rock will be truck tipped from the edge of the BHP Pit. Alternatively, if an access ramp is built, waste rock could be placed in near horizontal layers of a nominal 1 m thickness starting from the base of the pit. The material would be placed, spread and track rolled using a dozer. It is expected that haul trucks could access the proposed Placement Area B via ramp into the BHP Pit. The details of placement are considered to be an operational decision and will be made prior to placement.

The surface of the placement area is designed to be shaped to grade in a south western direction. It is expected that stormwater from the relatively small pit catchment will collect at this location. This is considered to be consistent with the approach presented in the existing stormwater management plan for the site.

At closure the final surface of the waste rock is proposed to be covered with a layer of selected waste rock to help provide protection from wind entrainment of dust and to provide a ‘final’ seal.

10.3 Placement Area C – Little Kintore Pit Infill

Placement Area C is proposed to be constructed to infill the existing Little Kintore Pit. The maximum thickness of waste rock proposed to be placed to infill Little Kintore Pit is approximately 17 m.

Waste rock for this placement area is proposed to be placed in the same manner as proposed for Placement Area B and as described in Section 10.2. It is expected haul trucks will access the pit using the eastern side of the pit. The existing abandoned shaft exposed in the floor of the pit will be filled.

The final surface of the waste rock is proposed to be covered with a layer of selected waste rock to help provide protection from wind entrainment of dust and to provide a 'final' seal.

The final surface will be shaped to develop the required stormwater detention pond to accommodate stormwater runoff for both Little Kintore Pit and Kintore Pit (TSF3) post closure.

10.4 Placement Area D – Atop Mt Hebbard or Other Free Areas

BHOP propose to place waste rock as rehabilitation capping to minimise wind entrainment of dust with elevated lead concentrations on top of the existing Mt Hebbard or at any of the other 'free areas'. 'Free areas' is a term used by BHOP and refers to areas of the site which are non-active mining areas. The waste rock is proposed to be 'paddock dumped' over the existing surface to provide an undulating surface that would help resist wind effects and provide small depressions for water collection. The proposed paddock dumping approach is to comprise the 40 tonne haul trucks dumping loads adjacent to one another to cover the surface of the stockpile. No spreading or compaction of the dumped loads is proposed to be undertaken in order to manage dust and encourage vegetation growth in depressions. It is expected that haul trucks will be able to access this placement area location via the existing access road which enters the proposed placement area location from the current mine haul road. The existing access road may be upgraded to enable this to be safely undertaken.

Based on the assumptions presented in Table 12 and a proposed offset dumping arrangement similar to that presented in Figure 14 a minimum fill depth of 700 mm is achieved if the truck loads are dumped within 4 m of one another (centre to centre spacing, in a triangular grid) and dumped loads overlap by approximately 1 m.

Table 12: Paddock Dumping Assumptions

Parameter	Value	Unit
Waste rock density (including voids)	1.9	t/m^3
Effective truck payload	40	Tonnes
Effective volume per truck	21	m^3
Waste rock angle of repose	37	Degrees
Mound height	2	metres

Figure 14: Indicative Paddock Dumping Layout

A paddock dump placement area of this nature will result in a surface with numerous tightly spaced mounds and depressions between the mounds. During rainfall events any rainfall will gravitate towards the depressions between the mounds. It is estimated based on 1 in 100 ARI rainfall and assuming initial infiltration losses of 15 mm and a continuing loss of 2 mm/hr that standing water contained in the depressions resulting from a 1 in 100 ARI rainfall event will be less than 400 mm depth. Accordingly, runoff from a 1 in 100 ARI rainfall event would be wholly contained within the depressions formed by the paddock dumping mounds. The standing water contained within these depressions will infiltrate the placement area or evaporate.

Accordingly, runoff from rain events will be contained on the surface of the placement area. This is consistent with the approach presented in the BHOP report titled 'Rasp Mine – Site Water Management Plan' dated January 2019 (ref BHO-PLN-ENV-004,APPENDIX L) (the SWMP) for this portion of the site (Catchment Area 19).

10.5 Placement Area E – Kintore Pit Tipple

Placement Area E is a proposed to be used for temporary storage of waste rock material generated from the Boxcut excavation prior to the construction of the TSF 3 pre-deposition works. It is intended that material temporarily stored at this location will be used as part of the pre-deposition works for TSF3.

BHOP have advised the waste rock at this location will be placed in accordance with current practices on the operating Kintore Pit Tipple. Access will be from the existing ramp.

11.0 OTHER STORMWATER MANAGEMENT CHANGES RELATED TO MOD6

It is understood BHOP are operating the Rasp Mine in accordance with the stormwater management plan presented in the BHOP report titled 'RASP Mine – Site Water Management Plan' dated January 2019 (ref

BHO-PLN-ENV-004) (the SWMP). The SWMP includes measures which are intended to retain runoff from a 1 in 100 ARI 24 hour rainfall event from the active mine areas. Measures included in the SWMP to help achieve this include a network of drains and a number of relatively small stormwater storage areas / ponds.

The proposed MOD6 development (including the proposed waste rock placement areas) results in some changes to existing site topography which impacts aspects of the stormwater management measures currently in place at the site and accordingly requires some changes to the SWMP.

11.1 Proposed Boxcut

The proposed Boxcut is to be excavated to the south west of TSF2 primarily within Catchment Area 37 (as described in the SWMP). A small portion of the western extent of the proposed Boxcut extends into Catchment Area 39. It appears, based on the SWMP, the existing stormwater storage area within Catchment Area 37 (S37) is outside the proposed extents of the Boxcut and will be retained.

The Boxcut is related to a new mine portal and decline, and it is preferred to limit the volume of rainfall runoff entering the mine. To limit the volume of stormwater that enters the Boxcut it is proposed diversion drains be constructed around its perimeter. The perimeter diversion drains are to be designed to report to S37 or S41 based on existing topography as indicatively shown in Figure 15. The access road should also be designed with a mound at the entry point to the Boxcut to help prevent stormwater entering the excavation at this location.

Managing stormwater in this manner will result in a net reduction in stormwater reporting to S37 and S41 (compared with that allowed for in the SWMP). The small portion of the Boxcut extending into Catchment Area 39 will result in a small reduction in the volume of stormwater reporting to the Plant Water Pond.

Figure 16 presents proposed design geometry for the Boxcut as presented in Ground Control Report G0202 dated 17 December 2020, APPENDIX N. Stormwater that falls within the proposed Boxcut (i.e. inside the diversion drains) will be required to be managed using a network of drains within the proposed excavation. It is proposed that drains be installed on the upper bench to help collect stormwater that falls upstream of this bench and divert it out of the Boxcut towards S37 or S41. Depending on detailed design geometry for the proposed Boxcut a similar drainage system may be able to be developed for the lower bench to further limit the volume of stormwater collected in the Boxcut. Remnant stormwater that is not able to be collected and removed from the excavation by drains of this nature will be required to be collected in a sump (or storage basin) located on the lower bench. This collected stormwater could be removed by pumped extraction to either S37 or S41, or be managed as part of the underground mine water system. The Tails Harvesting Haul Road is proposed to be formed on the upper bench of the Boxcut (shown in pink on Figure 15) and will be used to transfer tailings from TSF2 to TSF3. A drainage channel will be installed along the road that will direct stormwater to S37.

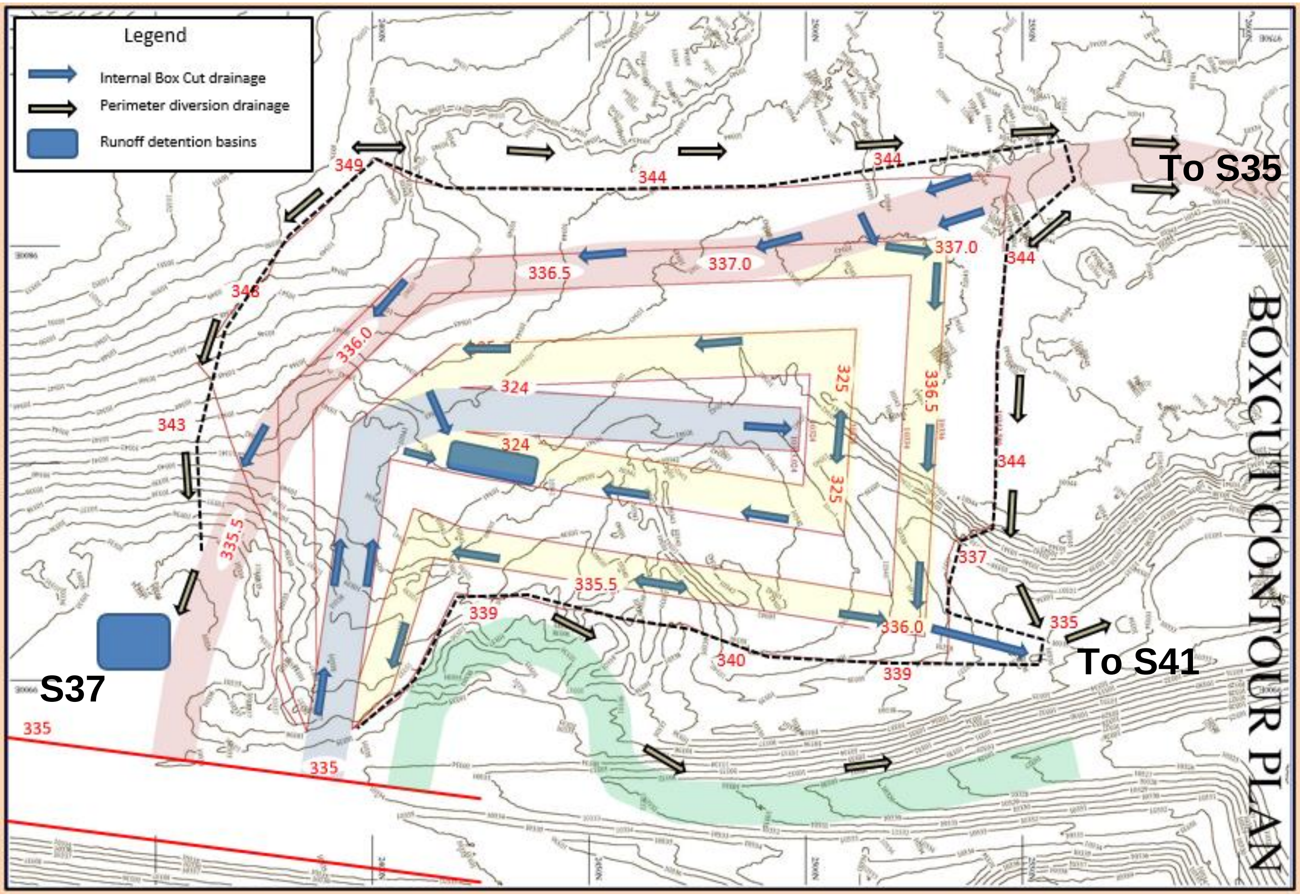


Figure 15: Boxcut diversion drains schematic arrangement (edit of image provided by BHOP)

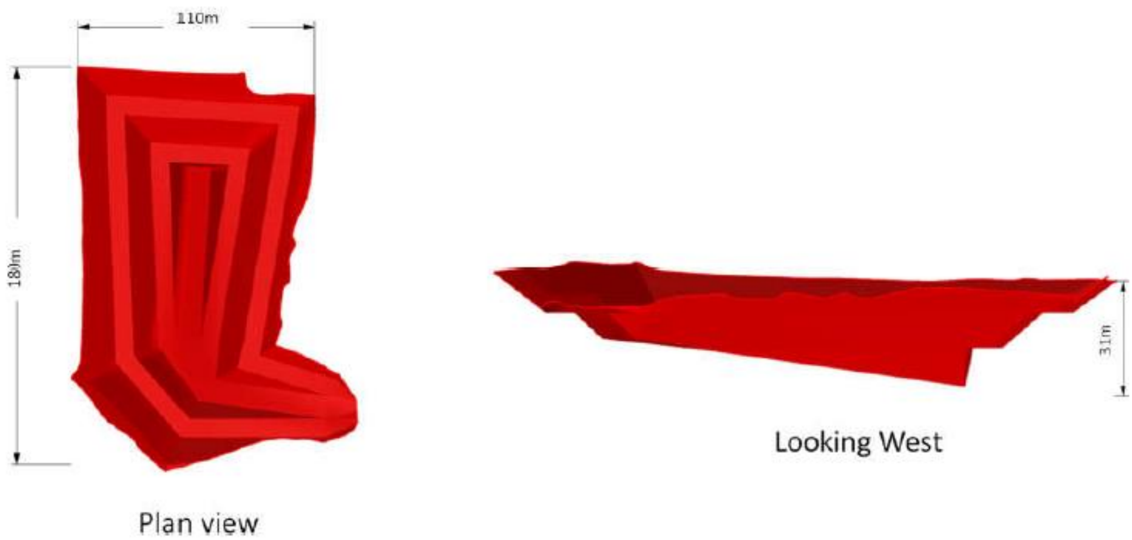


Figure 16: Proposed Boxcut design dimension (Excerpt of Ground Control Report G0202 dated 17 December 2020)

The estimated stormwater volume generated by the 1:100 ARI design storm event falling on the Boxcut catchment area is estimated to be 1200 m^3, of which a significant portion is expected to be able to be diverted from the catchment by gravity drains as described above.

11.2 Little Kintore Pit

Stormwater management of Little Kintore Pit is described in Section 10.3, and is proposed to be consistent with the approach outlined in the SWMP only with a larger capacity to store runoff from a greater catchment. The waste rock stored in Little Kintore Pit at closure will be shaped to accommodate the stormwater runoff from the TSF3 surface and the Little Kintore Pit catchment.

11.3 Kintore Pit TSF3

Stormwater management of TSF3 is discussed in Sections 6.3.1.4, 7.2.3, 8.6.1 during operation and 9.2 for closure.

11.4 BHP Pit

There are no proposed changes to stormwater management from that presented in the SWMP for BHP Pit.

11.5 Blackwood Pit TSF2

Stormwater management of TSF2 is discussed in Sections 6.2.1.5, 7.1.5, 8.6.2 during operation and 9.1 for closure.

11.6 Mt Hebbard / Capped Free Areas

As outlined in Section 10.4 stormwater is proposed to be managed by the paddock dumping approach and in accordance with the SWMP for Mt Hebbard and capped free areas receiving waste rock.

12.0 DEFINITIONS AND ACRONYMS

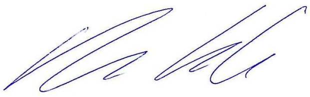
Table 13: Definitions and Acronyms

Term or Acronym	Definition
AHD	Australian Height Datum
ARI	Average Recurrence Interval
AEP	Annual Exceedance Probability
BHOP	Broken Hill Operations Pty Ltd
BoM	Bureau of Meteorology
CPT/CPTu	Cone Penetration Test
CRR	Cyclic Resistance Ratio
CSL	Critical State Line
CSR	Cyclic Stress Ratio
DOL	Dolerite
FoS	Factor of Safety
HDPE	High Density Polyethylene
ktpa	Kilo Tonnes Per Annum
LL	Liquid Limit
ML	Mega Litres

Term or Acronym	Definition
MLD	Main Lode Drive
MCE	Maximum Credible Earthquake
PEL	Pacific Environment Ltd
PGA	Peak Ground Accelerations
PI	Plasticity Index
PPV	Peak Particle Velocity
RL	Reduced Level
SWMP	Stormwater Management Plan
SOMC	Standard Optimum Moisture Content
SMDD	Standard Maximum Dry Density
tpa	Tonnes Per Annum
TSF	Tailings Storage Facility
UCS	Uniaxial Compressive Strength
USCS	Universal Soil Classification System

Signature Page

Golder Associates Pty Ltd



Darren Webb
Principal Civil Engineer

Fred Gassner
Senior Principal Engineer

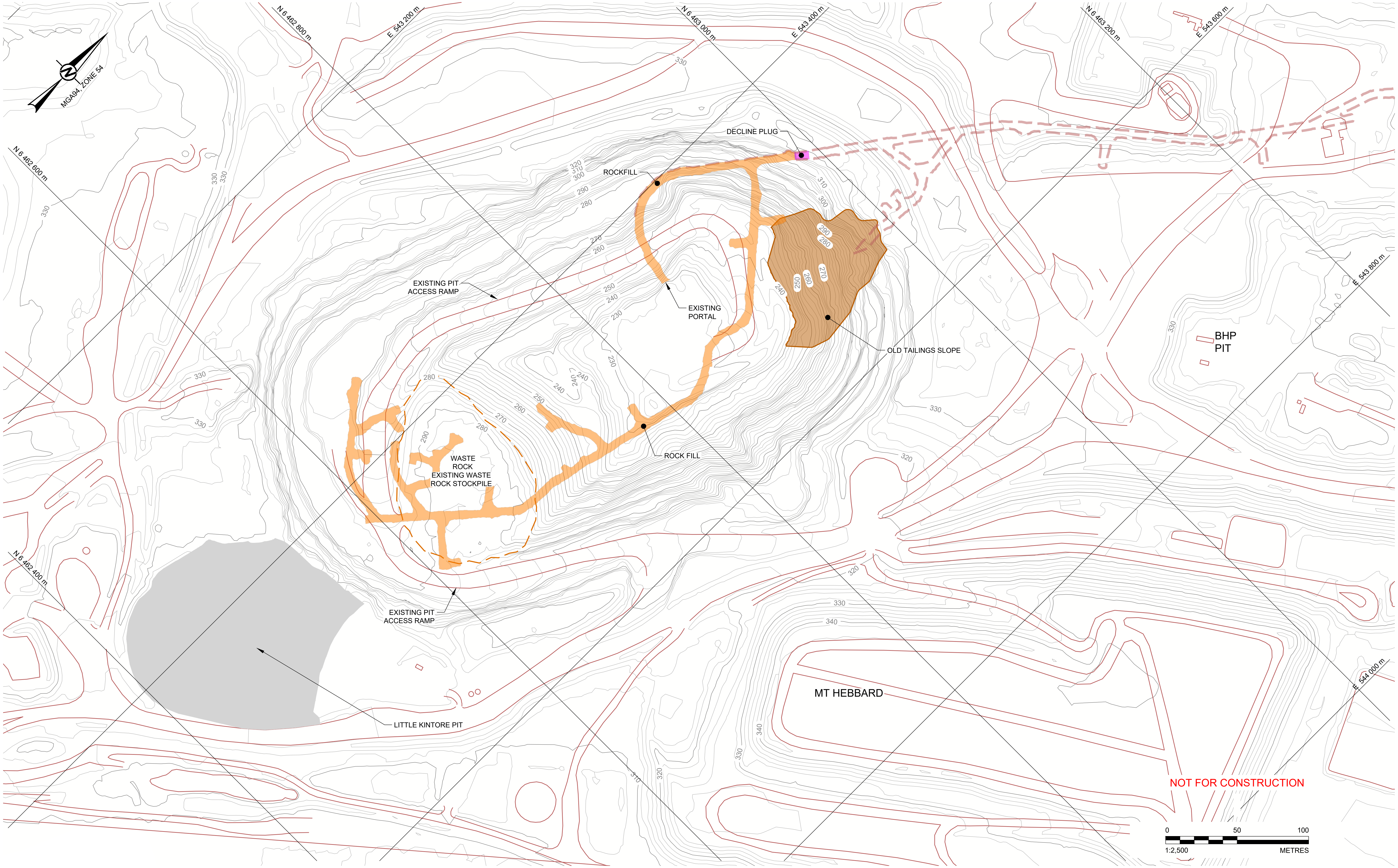
DRW/FWG/agm

A.B.N. 64 006 107 857

https://golderassociates.sharepoint.com/sites/25201g/deliverables/054 r rasp mine mod6/1896230-r-054-rev1 rasp mine mod6.docx

APPENDIX A

Kintore Pit TSF3 Figures



LEGEND

EXISTING CONTOURS AT 2 m INTERVALS

EXTENT OF TIPPLE AREA SURVEY (MARCH 2021)

REFERENCE(S)

FILES SUPPLIED BY CBH:

BASE SURVEY, DATED 25 APRIL 2016, FILE: 500mm Contours of RASP Final Surface 200mm filter.dxf
TIPPLE AREA SURVEY, RECEIVED 30 MARCH 2021, FILE: tipple_local.dxf
OLD WORKINGS TUNNEL, RECEIVED 31 AUGUST 2017, FILE: old_workings_b10b7_mga.DXF
WORKING TUNNELS, RECEIVED 31 AUGUST 2017, FILE: RASP_WORKINGS_KINTORE_MGA.DXF
BOUNDARIES, RECEIVED 11 MAY 2016, FILES: SURF_LEASES_MGA.DXF AND MGA_CML7_LEASE_BDY.DWG

FILE FROM GROUND CONTROL ENGINEERING:

BYPASS FOR SHAFT 6, REPORT REF.: G0186.AA RE01 V04

CLIENT
BROKEN HILL OPERATIONS PTY LTD

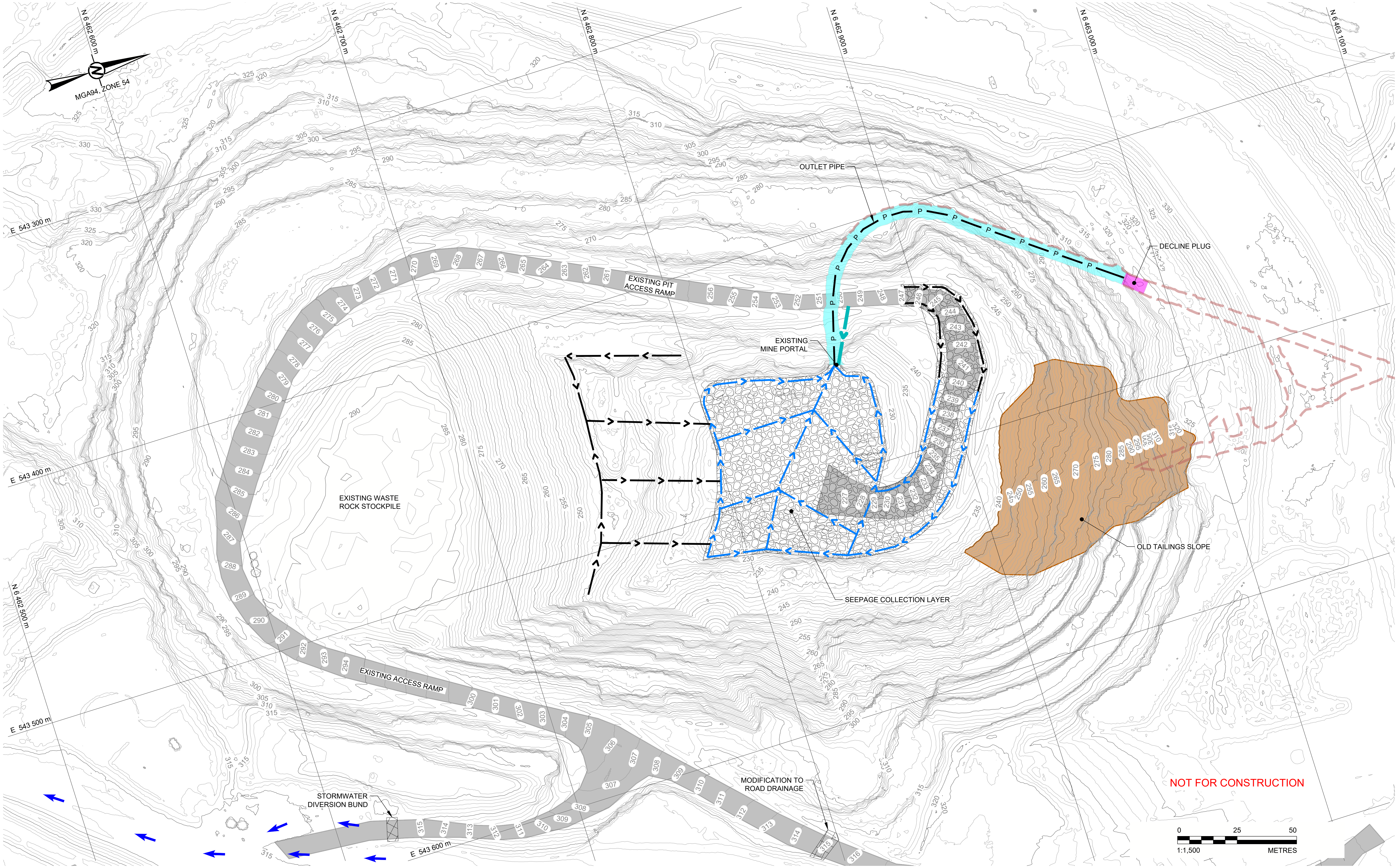
PROJECT
KINTORE PIT TAILINGS STORAGE FACILITY

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2021-06-09
DESIGNED	AGM
PREPARED	TM
REVIEWED	DRW
APPROVED	DRW

TITLE
RASP MINE - KINTORE PIT DECLINE PLUG

PROJECT NO.	CONTROL	REV.	FIGURE
1896230	018-R	3	1



LEGEND

- EXISTING CONTOURS AT 1 m INTERVALS
- ROCKFILL IN EXISTING PORTAL AREA
- MLD PLUG
- PERFORATED SEEPAGE COLLECTION PIPE ABOVE RL. 240 m
- PERFORATED SEEPAGE COLLECTION PIPE AT BASE OF PIT
- SELECT ROCKFILL LAYER
- OUTLET PIPE
- RISER PIPE (BACKUP MEASURE FOR SEEPAGE EXTRACTION)
- STORMWATER RUNOFF DIRECTION FOLLOWING BACKFILL OF RAMP

NOTE(S)

1. REFER TO FIGURE 1 FOR REFERENCES.
2. REFER TO FIGURE 9 FOR TYPICAL SEEPAGE COLLECTION PIPE DETAILS.

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BROKEN HILL OPERATIONS PTY LTD

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GOLDER MEMBER OF WSP

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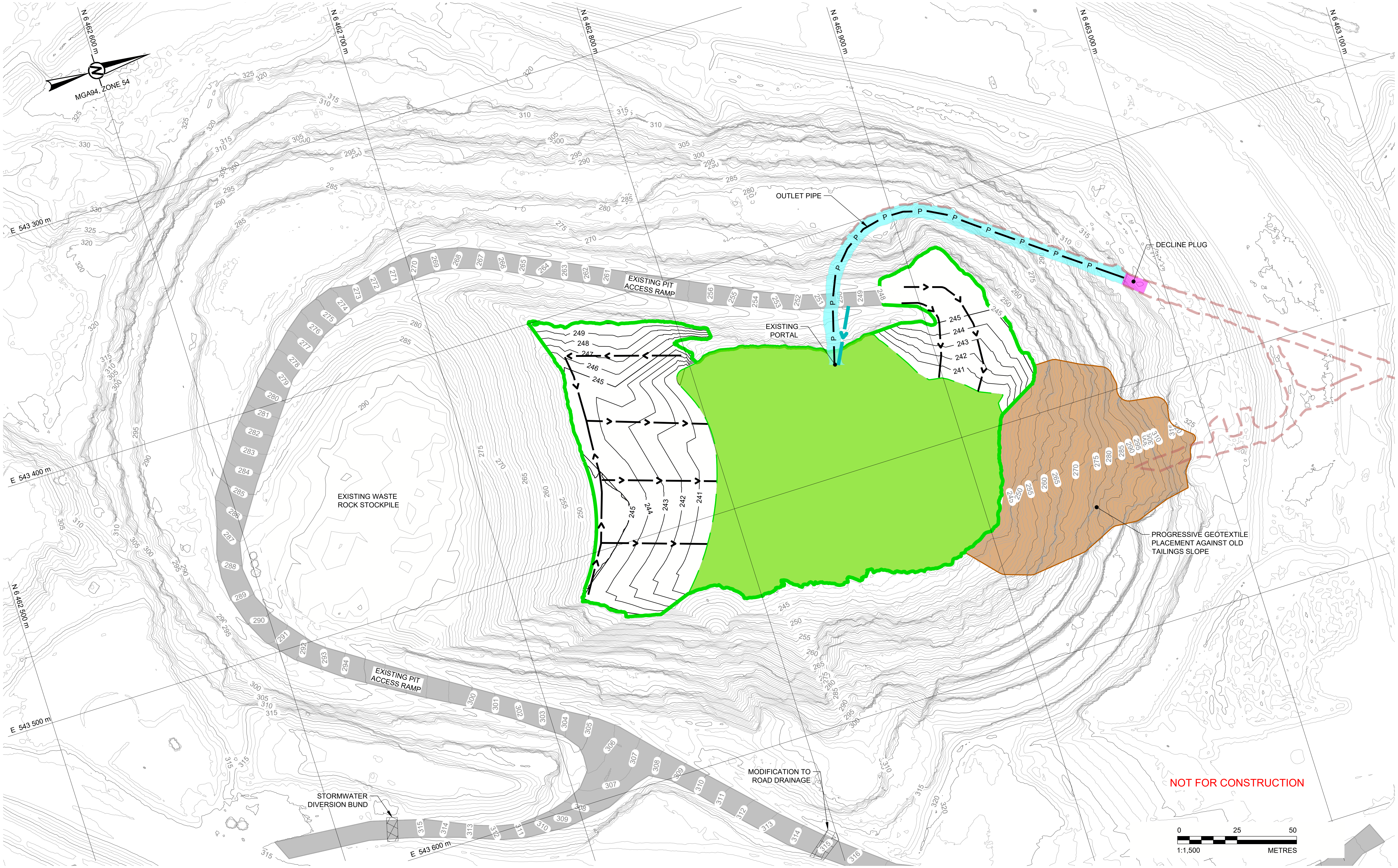
DESIGNED	AGM
PREPARED	TM
REVIEWED	DRW
APPROVED	DRW

PROJECT
KINTORE PIT TAILINGS STORAGE FACILITY

TITLE
SEEPAGE COLLECTION LAYOUT

PROJECT NO.	CONTROL	REV.	FIGURE
1896230	018-R	3	2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3
25 mm



LEGEND

- EXISTING CONTOURS AT 1 m INTERVALS
- INDICATIVE SHAPING AND BRIDGING LAYER CONTOURS AT 1 m INTERVALS
- ROCKFILL FROM PORTAL TO PLUG
- MLD PLUG
- EXTENT OF BRIDGING LAYER TO RL. 240 m
- PERFORATED SEEPAGE COLLECTION PIPE ABOVE RL. 240 m
- P — OUTLET PIPE
- RISER PIPE (BACKUP MEASURE FOR SEEPAGE EXTRACTION)

NOTE(S)

1. REFER TO FIGURE 1 FOR REFERENCES.
2. REFER TO FIGURE 9 FOR TYPICAL SEEPAGE COLLECTION PIPE DETAILS.

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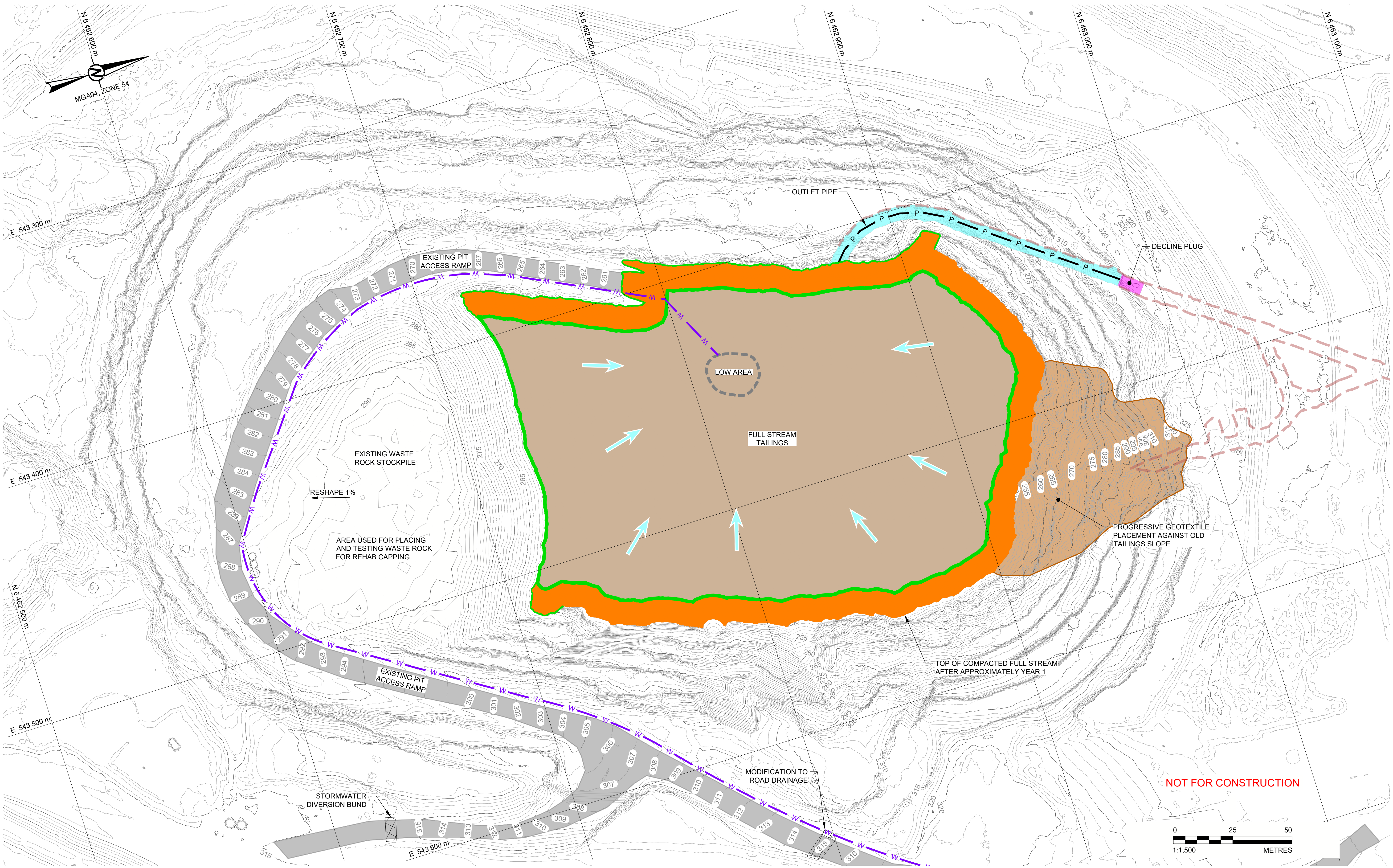
PREPARED	TM
REVIEWED	DRW
APPROVED	DRW

PROJECT
KINTORE PIT TAILINGS STORAGE FACILITY

TITLE
BRIDGING LAYER

PROJECT NO.	CONTROL	REV.	FIGURE
1896230	018-R	3	3



LEGEND

- EXISTING CONTOURS AT 1 m INTERVALS
- MLD PLUG
- ROCK FILL
- EXTENT OF TAILINGS
- P — OUTLET PIPE
- TAILINGS GRADE (STORMWATER MANAGEMENT)
- W — RETURN WATER PIPELINE

NOTE(S)

1. REFER TO FIGURE 1 FOR REFERENCES.

CLIENT
BROKEN HILL OPERATIONS PTY LTD

PROJECT
KINTORE PIT TAILINGS STORAGE FACILITY

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2021-06-09
DESIGNED	AGM
PREPARED	TM
REVIEWED	DRW
APPROVED	DRW

TITLE
PROGRESSIVE FILLING (END OF YEAR 1)

PROJECT NO.	CONTROL	REV.	FIGURE
1896230	018-R	3	4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3

25 mm

LEGEND

- EXISTING CONTOURS AT 1 m INTERVALS
- MLD PLUG
- ROCK FILL
- EXTENT OF TAILINGS
- TAILINGS GRADE (STORMWATER MANAGEMENT)
- W RETURN WATER PIPELINE
- P OUTLET PIPE

NOTE(S)

1. REFER TO FIGURE 1 FOR REFERENCES.

CLIENT
BROKEN HILL OPERATIONS PTY LTD

PROJECT
KINTORE PIT TAILINGS STORAGE FACILITY

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-06-22
DESIGNED	AGM
PREPARED	TM
REVIEWED	DRW
APPROVED	DRW

TITLE
PROGRESSIVE FILLING - YEAR 2

PROJECT NO.	CONTROL	REV.	FIGURE
1896230	018-R	4	5

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3
25 mm

Path: \\golder.gds\gap\AU_VDV\Melbourne\Geomatics\CBH\Rasp Mine\99_PROJECTS\1896230_Rasp Mine TSF Design Broken Hill\018-R002_PRODUCTION\DWG\ | File Name: 1896230-018-R-005.dwg | Last Edited By: tmansour Date: 2021-06-22 Time:1:48:47 PM | Printed By: TMansour Date: 2021-06-22 Time:1:59:16 PM

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25 mm | IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3

LEGEND

- EXISTING CONTOURS AT 1 m INTERVALS
- ROCK FILL
- EXTENT OF TAILINGS
- TAILINGS GRADE (STORMWATER MANAGEMENT)
- W — RETURN WATER PIPELINE
- P — OUTLET PIPE

NOTE(S)

1. REFER TO FIGURE 1 FOR REFERENCES.

CLIENT
BROKEN HILL OPERATIONS PTY LTD

CONSULTANT

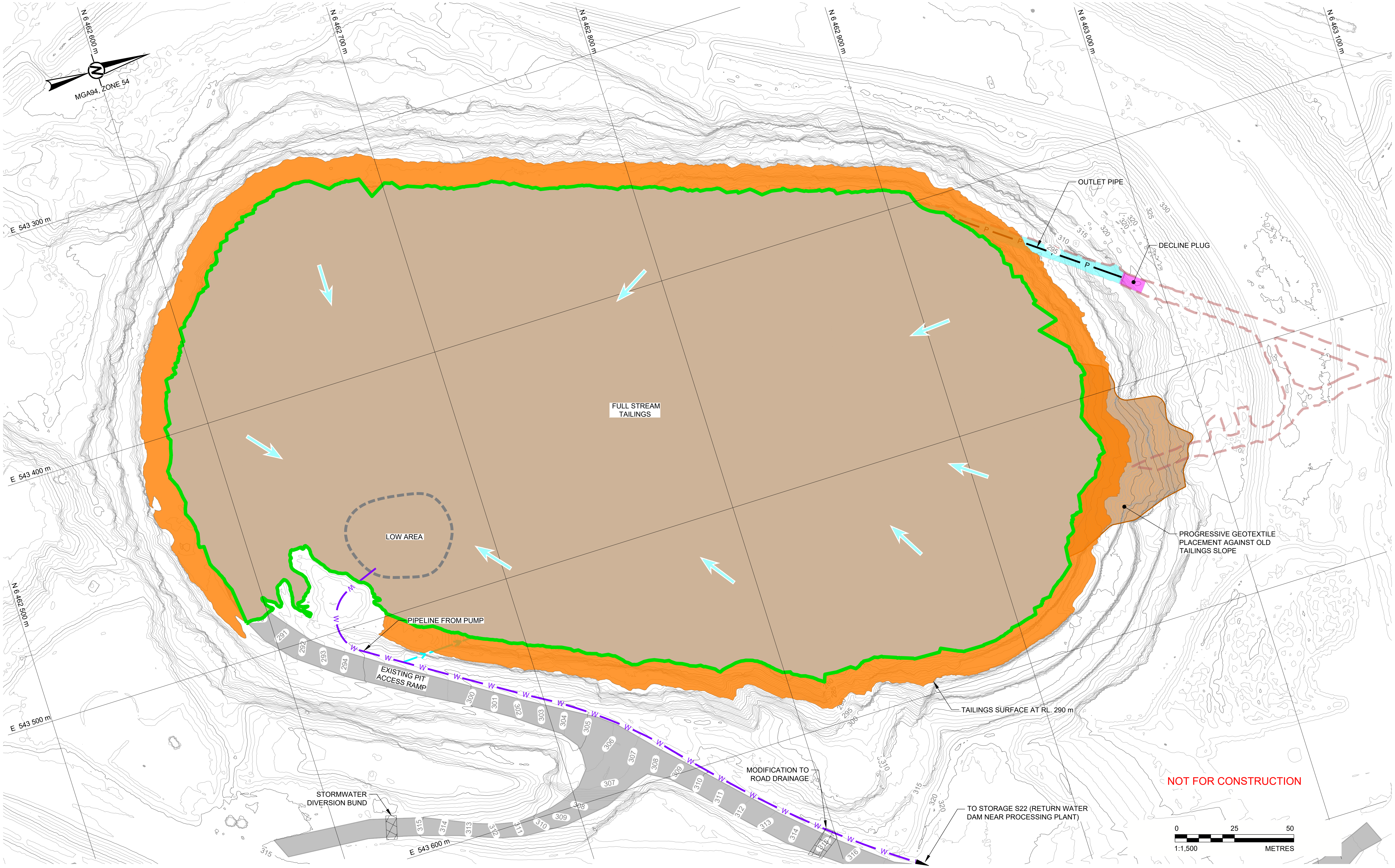
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-06-22
DESIGNED	AGM
PREPARED	TM
REVIEWED	DRW
APPROVED	DRW

PROJECT
KINTORE PIT TAILINGS STORAGE FACILITY

TITLE
PROGRESSIVE FILLING - YEAR 4

PROJECT NO.	CONTROL	REV.	FIGURE
1896230	018-R	4	6



LEGEND

EXISTING CONTOURS AT 1 m INTERVALS	
ROCK FILL	
EXTENT OF TAILINGS	
RETURN WATER PIPELINE (W)	
OUTLET PIPE (P)	

NOTE(S)

1. REFER TO FIGURE 1 FOR REFERENCES.

CLIENT
BROKEN HILL OPERATIONS PTY LTD

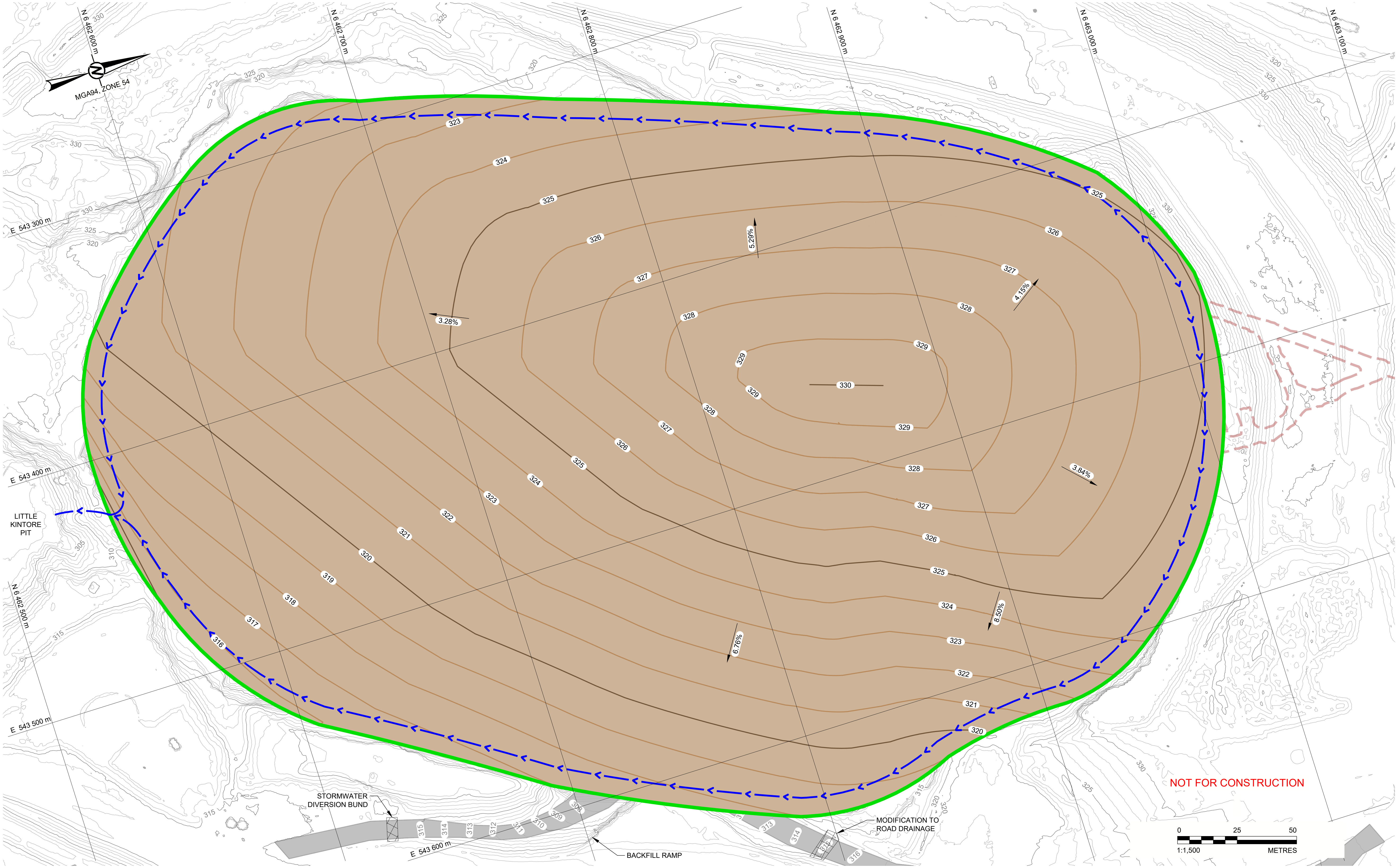
PROJECT
KINTORE PIT TAILINGS STORAGE FACILITY

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-06-22
DESIGNED	AGM
PREPARED	TM
REVIEWED	DRW
APPROVED	DRW

TITLE
PROGRESSIVE FILLING - YEAR 6

PROJECT NO.	CONTROL	REV.	FIGURE
1896230	018-R	4	7



LEGEND

EXISTING CONTOURS AT 1 m INTERVALS

EXTENT OF TAILINGS BEACH

TAILINGS BEACH CONTOURS AT 1 m INTERVALS

STORMWATER RUNOFF

WORKINGS TUNNEL

NOTE(S)

1. REFER TO FIGURE 1 FOR REFERENCES.

CLIENT

BROKEN HILL OPERATIONS PTY LTD

PROJECT

KINTORE PIT TAILINGS STORAGE FACILITY
RASP MINE, BROKEN HILL

CONSULTANT

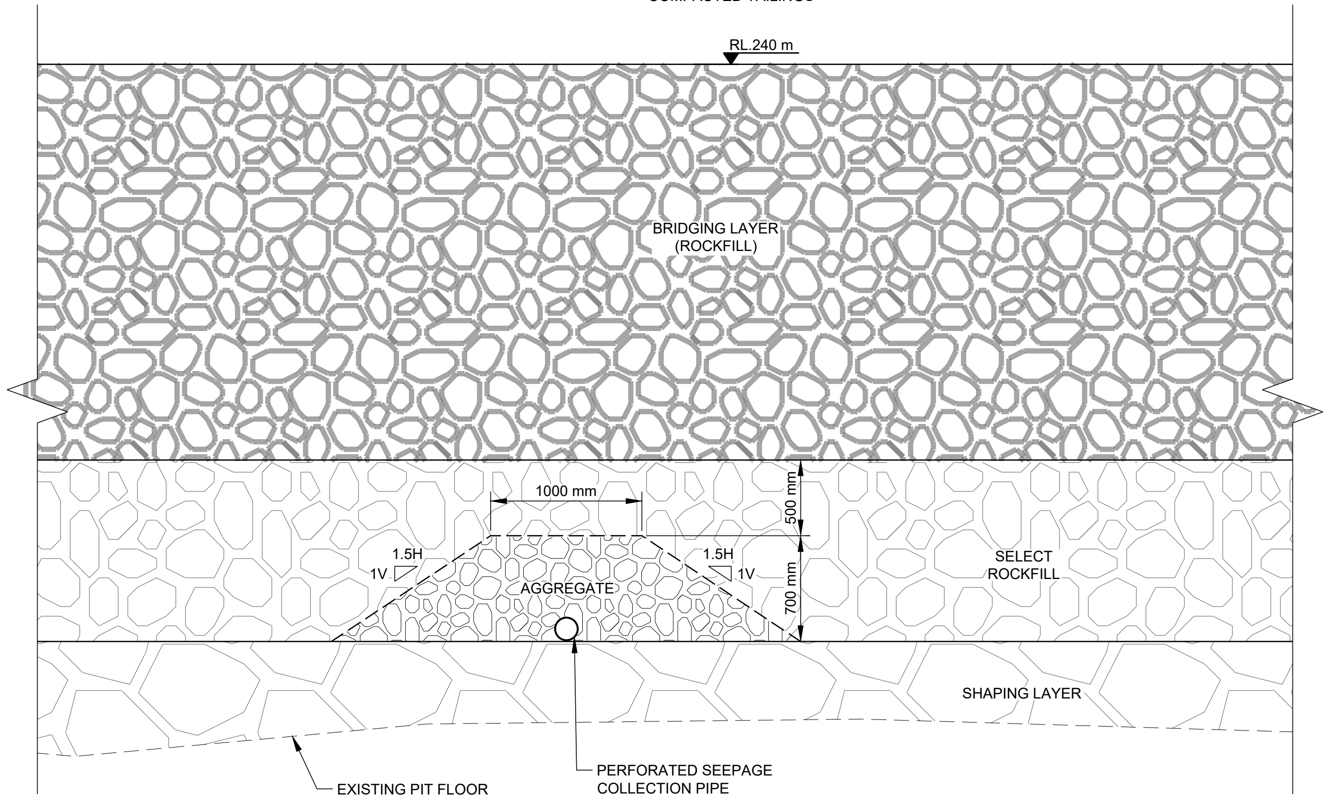
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-06-09
DESIGNED	AGM
PREPARED	TM
REVIEWED	DRW
APPROVED	DRW

TITLE

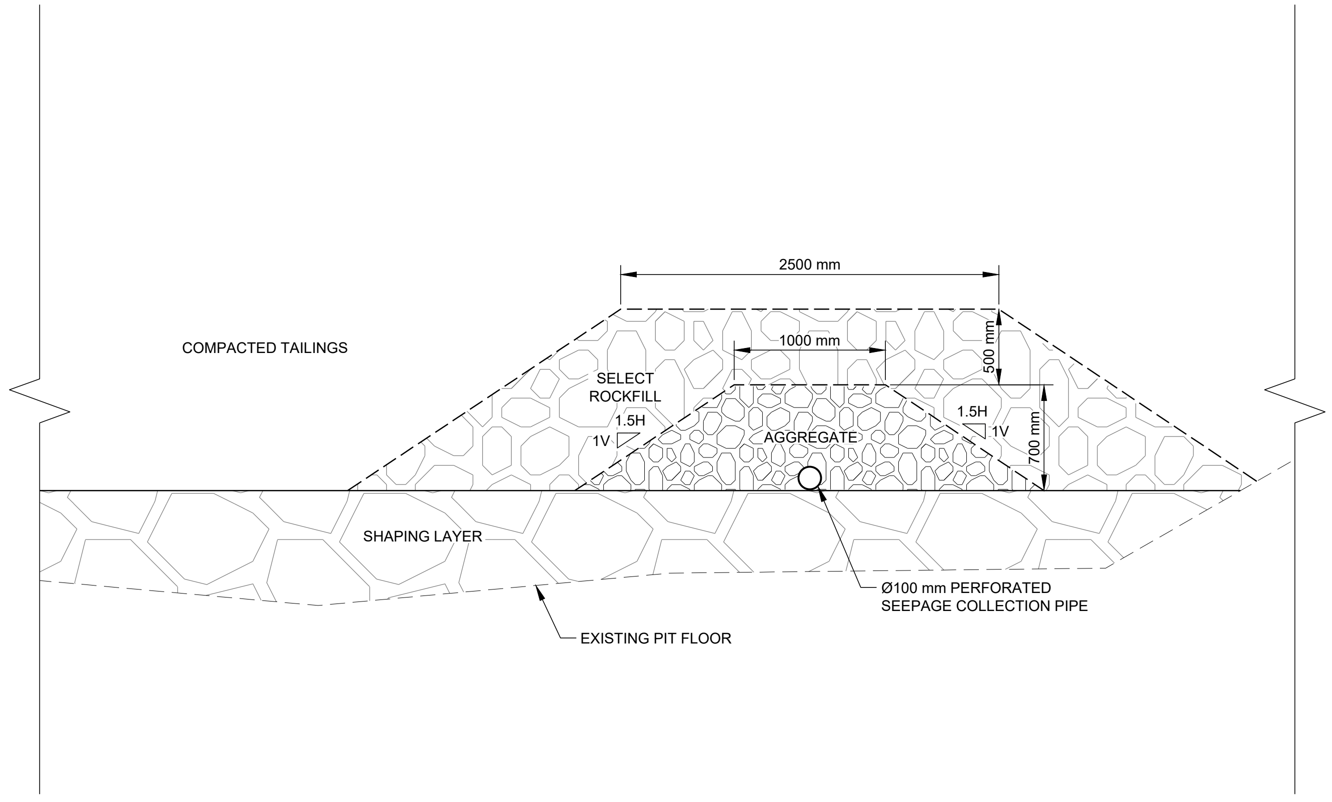
TOP OF FINAL FILLED TAILINGS

PROJECT NO.	CONTROL	REV.	FIGURE
1896230	018-R	1	8



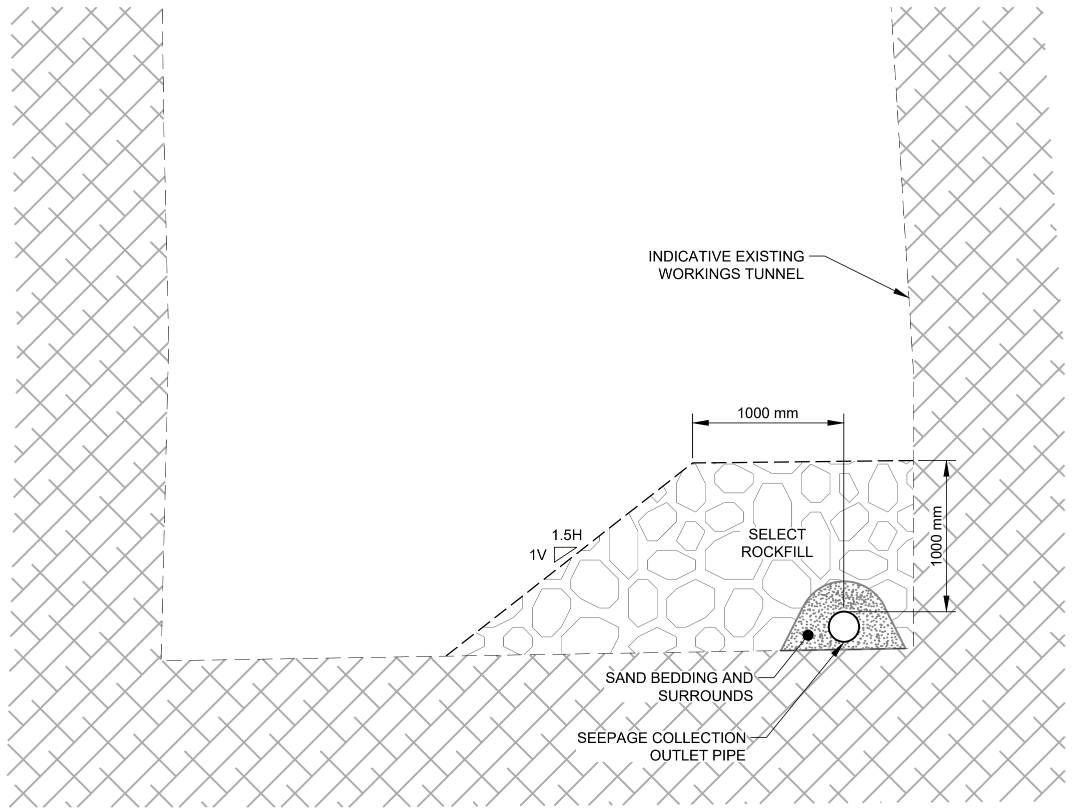
TYPICAL SEEPAGE COLLECTION PIPE ON BASE OF PIT

SCALE 1:50



TYPICAL SEEPAGE COLLECTION PIPE ABOVE RL. 240 m

SCALE 1:50



TYPICAL SEEPAGE OUTLET PIPE IN TUNNEL

SCALE 1:50

NOT FOR CONSTRUCTION

0 1 2
1:50 METRES

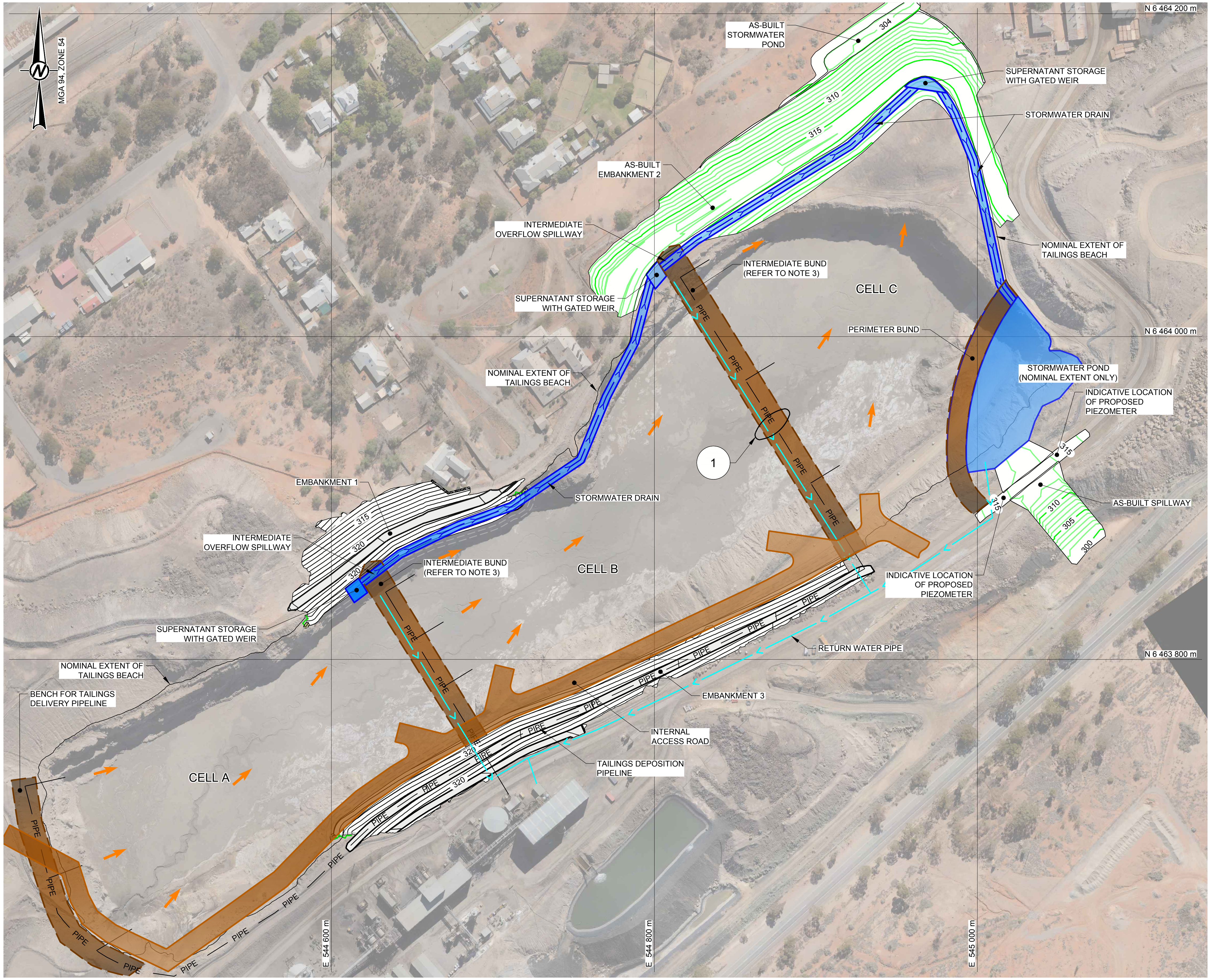
NOTE(S)

1. REFER TO FIGURE 1 FOR REFERENCES.
2. REFER TO FIGURES 2 AND 3 FOR SEEPAGE COLLECTION LAYOUT.

CLIENT	BROKEN HILL OPERATIONS PTY LTD
PROJECT	KINTORE PIT TAILINGS STORAGE FACILITY
CONSULTANT	GOLDER MEMBER OF WSP
YYYY-MM-DD	2021-06-09
DESIGNED	AGM
PREPARED	TM
REVIEWED	DRW
APPROVED	DRW
TITLE	TYPICAL SEEPAGE COLLECTION DETAILS
PROJECT NO.	1896230
CONTROL	018-R
REV.	3
FIGURE	9

APPENDIX B

Blackwood Pit TSF2 Figures



LEGEND

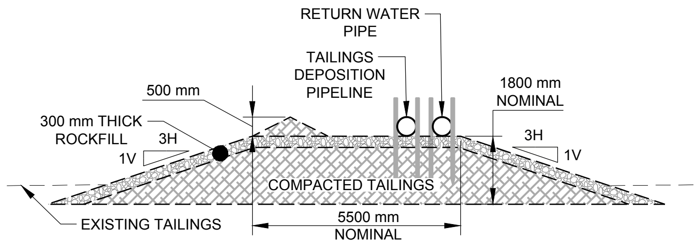
(black double line)	2018 DESIGN EMBANKMENTCONTOURS AT 1 m INTERVALS
(green line)	AS-BUILT EMBANKMENT AND SPILLWAY CONTOURS AT 1m INTERVALS
(orange arrow)	NOMINAL DIRECTION OF FALL OF TAILINGS BEACH
(blue line)	TAILINGS DEPOSITION PIPELINE
(cyan line)	RETURN WATER PIPELINE

NOTE(S)

1. ALL LEVELS ARE REFERENCED IN METRES TO AUSTRALIAN HEIGHT DATUM (m AHD).
2. AERIAL IMAGERY IS APPROXIMATE AND UTILISED FOR INDICATIVE PURPOSES ONLY.
3. LOCATION OF BUNDS TO BE SELECTED TO PROVIDE APPROXIMATELY EQUAL SIZED CELLS (AFTER ALLOWANCE FOR HAUL ROAD, DRAINS AND PONDS).

REFERENCE(S)

1. AS CONSTRUCTED INFORMATION GENERATED FROM INFORMATION PROVIDED BY CBH ON 15 JANUARY 2020 IN DIXON SURVEY FILE(S):
   - WAE Spillway Final Rip Rap Area 191203.dwg
   - WAE Spillway Select Fill Underside and Top 190930.dwg
   - WAE Spillway Rip Rap Area and Seepage Pipes 191002.dwg
2. AS CONSTRUCTED INFORMATION GENERATED FROM INFORMATION PROVIDED BY CBH ON 17 FEBRUARY 2020 IN DIXON SURVEY FILE(S):
   - WAE Embankment 2 Final Contours 200216.dwg
   - WAE Embankment 2 Final Surface 200216.dwg
3. AERIAL IMAGE SOURCED FROM CBH RECOURCED LIMITED FILE: Rasp Mine MGA54 10cm.ecw, RECEIVED 11 MAY 2016.



SCALE 1:200 (1) TYPICAL DETAIL OF INTERMEDIATE BUND

NOT FOR CONSTRUCTION

0 5 10
1:200 METRES

0 50 100
1:2,000 METRES

CLIENT
BROKEN HILL OPERATIONS PTY LTD

PROJECT
BLACKWOOD PIT TAILING STORAGE FACILITY
RASP MINE, BROKEN HILL

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2021-06-09
DESIGNED	AGM
PREPARED	TM
REVIEWED	DRW
APPROVED	DRW

TITLE
TAILINGS HARVESTING CONCEPT SCHEMATIC LAYOUT

PROJECT NO.	CONTROL	REV.	FIGURE
1896230	054-R	0	1

APPENDIX C

Inrush Report 'Inrush and Inundation Pathways from TSF3 - Rasp Mine_final_V2'

TECHNICAL REPORT

Inrush and Inundation Pathways from TSF3

Contributors to original report:

Eamonn Dare	Technical Services Superintendent
Matt Stone	Senior Mine Engineer
Richard Fitzpatrick	Geological Engineer
David Matthews	Geotechnical Engineer
Kane Kreeck	Civil Engineer
Ben Taylor	Mining Engineering Manager
Joel Sulicich	HSE Manager

Version 3 updated by:

Eamonn Dare	Technical Services Superintendent
Date:	25/03/21

Version 3 reviewed by:

David Matthews	Geotechnical Engineer
Carlos Vanegas	Metallurgical Manager
Andrew McCallum	Group Manager Metallurgy
Gwen Wilson	Group Manager Safety Health Environment Community

TABLE OF FIGURES

GLOSSARY

Barricades- A barricade is used to restrict access and not used as an inundation or inrush risk control device.

Barrier – A structure between the inundation and inrush hazard (an area where people may be) designed to prevent the release of the hazard into the working area.

Dip- The angle at which a bed, stratum, or vein is inclined from the horizontal, measured perpendicular to the strike and in the vertical plane.

Impoundment Areas / Impoundments – Areas containing or confining water or materials that may flow when wet.

Inrush – A sudden and often overwhelming flow of water or waste rock including historical sand fill into mine workings

Inrush Control Zone – (ICZ) This zone is the zone required around an inrush hazard that is a principal mining hazard under cl 46 of the WHS Regulations, in which additional controls are required to be implemented.

Pentice – A barrier constructed / installed at the base of a vertical opening (e.g. raise) to prevent falling material making contact with persons or machinery.

Plugs – An engineered bulkhead that is specifically designed to protect workers from an inrush / inundation event.

Risk- the chance of something happening that will have an impact on objectives

Risk assessment – the overall process of risk identification, risk analysis and risk evaluation.

Workings – The entire systems of openings in a mine. Typical usage restricts the term to the area where the ore or waste is being mined.

Naming Convention - All historical Main Lode (ML) workings are referred to in feet. Shafts levels were named from the top of the collar. All modern workings in the Western Mine are named by Relative Level (RL). 1000 ft level is equivalent to 7sub level in the mine.

1. CONTEXT

1.1. GENERAL

Rasp Mine is proposing to utilise the Kintore Pit as a Tailings Storage Facility (TSF3) once the capacity of the current facility (TSF2) is reached. The Kintore Pit is currently used as the main access portal into the Rasp underground mine. A new mine access portal and decline will be established via a proposed boxcut to the North of the current portal location.

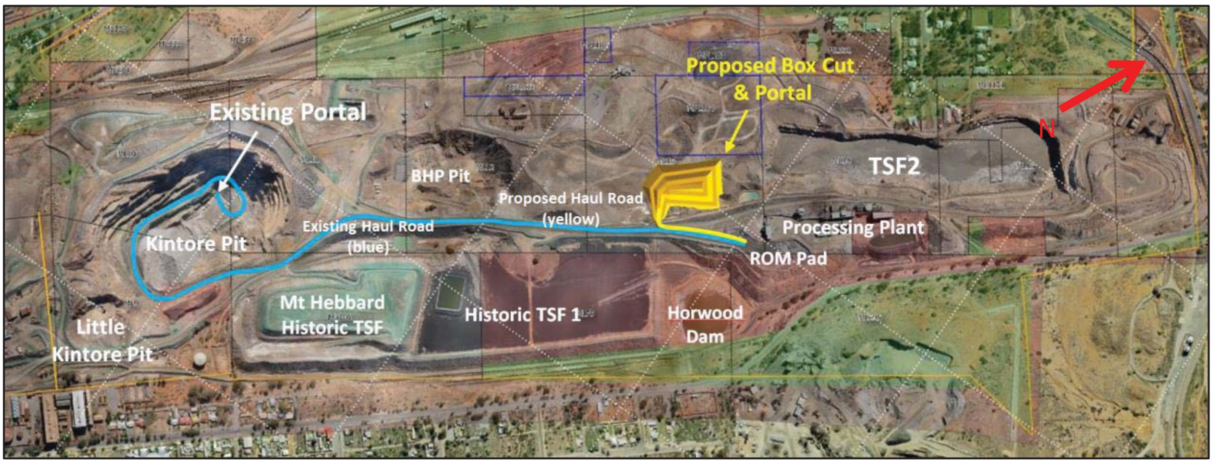


Figure 1 – Site Plan showing proposed box cut location

The Kintore Pit has previously intersected historical mine workings within the Main Lode and as such is potentially connected to current and future active mine workings via a series of historical rises, stopes and level development. Historical survey records and mine plans have been used to determine the properties of many of these openings, however the properties and exact nature of some areas are unknown.

The critical controls proposed to manage the risk of tailings or water entering historic and active workings within the proposed TSF3 include:

1. Filling of the MLD drive with waste to remove access beneath the Kintore Pit.
2. Dewatered tailings co-disposed with waste rock, compacted and placed in the Pit as engineered fill.
3. Installation of a drainage layer in the Pit with a seepage collection system managed as part of current mine dewatering system.
4. Rockfill (waste rock) layer placed over and against historical workings in the bottom and walls of the Pit.
5. Installation of an engineered plug at the underground portal entrance.
6. Filling voids in Pit walls as they become known and accessible.
7. Monitoring of placed tailings to monitor liquefaction potential of tailings; And as required additional barriers will be installed at specified locations if liquefaction potential is identified from monitoring.

These additional barriers at specified locations to isolate active areas from the risk of inrush are only required if the tailings have the potential to liquefy, for this to occur three conditions must be satisfied:

1. Tailings at near saturation
2. Tailings void above the critical void ratio
3. Change in stress condition, such as a breach of the rock surrounds into historic mine workings or a rise in the water levels within the tailings.

It is proposed to periodically assess the potential liquefaction risk of the placed tailings in the Pit by conducting in situ testing of the entire depth of tailings. According to Golder, this will enable an assessment to be made whether the tailings are dry or wet and approaching conditions, (identified above) , conducive to liquefaction. Only then will the additional barriers be installed, (Golder, 2020 (1896230-047-Rev1)).

This report details the potential pathways between Rasp Mine's underground workings and Kintore Pit. Also detailed are the locations of the additional barriers required to effectively isolate these pathways from current or future active mine working, if required (Figure 2).

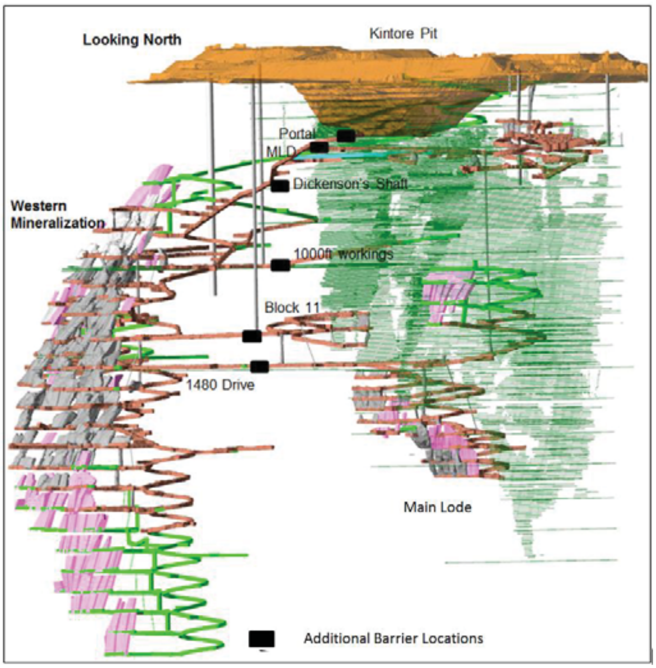


Figure 2- Additional Barrier Locations

This report will be distributed to Golder Associates Pty Ltd and Ground Control Engineering Pty Ltd for their information and recommendations on barrier design and specifications for each of the identified locations. Also to provide any additional recommendations identified to manage the risks associated with inrush or inundation due to placing dewatered and compacted tailings into Kintore Pit.

This report additionally details the potential pathways for ingress into historic workings below the current tailings storage facility in Blackwoods Pit (TSF2) and surrounding shafts which could be impacted by an inrush or inundation event. The secondary aim of this report is to provide key information that will be incorporated into the Principle Hazard Management Plan (PHMP) - Inrush and Inundation and also contribute to the PHMP Subsidence.

The following table provides a summary of the pathways and recommended controls to be implemented to minimise the risk associated with inrush and inundation.

APPENDIX D

‘Kintore Pit Tailings Storage Facility - Critical State Testing’ ref: 1896230-004-R-Rev0, dated August 2018.

REPORT

Kintore Pit Tailings Storage Facility

Critical State Testing

Submitted to:

Broken Hill Operations Pty Ltd
130 Eyre Street
BROKEN HILL NSW 2880

Submitted by:

Golder Associates Pty Ltd
Level 3, 1 Havelock Street, West Perth, Western Australia 6005, Australia

+61 8 9213 7600

1896230-004-R-Rev0

August 2018

Distribution List

1 electronic copy – Broken Hill Operations Pty Ltd

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FIGURES

APPENDICES

1.0 INTRODUCTION

This report presents the results of laboratory testing carried out by Golder Associates Pty Ltd (Golder) to assess the liquefaction potential of Rasp Mine tailings for Broken Hill Operations Pty Ltd (BHOP). Golder carried out the testing as part of its scope for preliminary design of the Kintore Pit Tailings Storage Facility (TSF), detailed in our proposal P1896230-002-L-Rev2, dated 3 April 2018.

2.0 OBJECTIVE

BHOP is proposing to backfill its Kintore Pit with tailings. The tailings will be dewatered using vacuum filters, spread in layers and compacted with a roller.

Two types of tailings will be placed in the pit, a full-stream tailings ("Tails Cyclone Feed") and a fine tailings ("Tails Thickener U/F"). The occurrence of the two types of tailings are driven by underground operational needs and will vary over time. The layers of tailings in the pit may therefore vary between full stream and fine tailings layers.

The pit itself is over 100 m deep with an adit near the base of the pit that leads to active underground workings. It is important that the in-pit tailings storage facility (TSF) be designed to mitigate the risk of sudden inflow of tailings and water to the underground workings. The purpose of the current laboratory testing is assess the potential for liquefaction of the tailings in the pit based on critical state soil mechanics. For the purpose of this assessment, it is assumed that some portion of the tailings will become saturated following placement.

3.0 SAMPLE RECEIPT AND PREPARATION

Samples were delivered in nine 20-L buckets to the Golder Laboratory in Osborne Park, WA in mid-May 2018. Five buckets contained "Tails Cyclone Feed" and the remaining four contained "Tails Thickener U/F". Figure 1 provides an example of the buckets received.

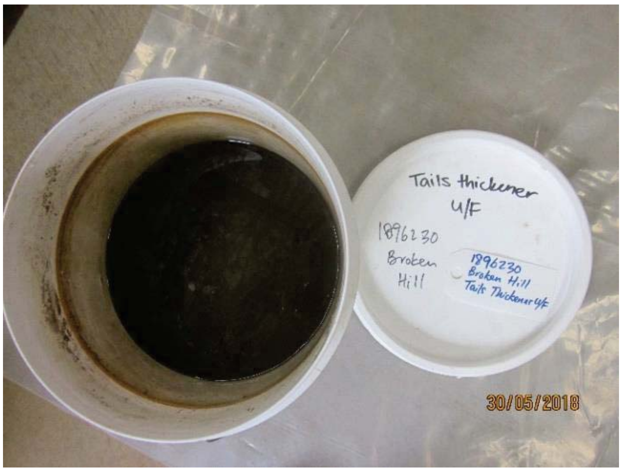

Figure 1: Tail thickener U/F

Golder syphoned and collected the water in separate buckets for later use in the critical state line (CSL) triaxial testing (refer to Section 4.2). The material was transferred to a plastic container (see Figure 2) and dried in a 50°C oven.

Figure 2: Material transferred to plastic container for drying at 50°C

4.0 METHOD

4.1 Overview

Index, compaction and element testing was carried out on both of the tailings samples. Index testing comprised percent fines (percentage passing 75 µm), Atterberg Limits and specific gravity (SG). Table 1 summarises the testing programme.

Table 1: Laboratory testing programme

Test Purpose	Test Type	Method	Quantity
Index testing (Classification)	Percent fines	AS 1289	2*
	Atterberg Limits		2*
	Shrinkage Limit (SL)		2*
	Specific gravity (SG)	ASTM D5550	2*
	Standard Maximum Dry Density (SMDD)	AS 1289	2*
Element testing (Critical state)	Triaxial – Consolidated Isotropically Undrained (CIU)	Refer to Section 4.2	4**
	Triaxial – Consolidated Isotropically Drained (CID)		4**
Consolidation testing	Consolidometer	Refer to Section 4.3	2*

Notes: *One test per source; **Two tests per source.

4.2 Triaxial tests

The triaxial tests were carried out using the following steps:

- Tails Cyclone Feed and Tails Thickener U/F samples were dried to a gravimetric water content (GWC) of approximately 7% and 11% by mass, respectively. These moistures were visually observed to be suitable for loose moist tamping of the materials.
- A vacuum mould was prepared, with a triaxial membrane inside the mould.
- The material was placed and gently compacted within the mould in eight layers.
- A suction of 10 kPa was applied to the sample with a vacuum pump, to assist in maintaining the sample shape during test setup.
- The triaxial device was assembled, the cell filled with water and cell pressure increased to 20 kPa.

- The specimens were flushed from bottom to top with demineralised water, to remove the majority of the entrapped air within the specimen and re-establish the initial pore-fluid chemistry (i.e. prior to sample preparation).
- Additional back pressure saturation, beyond the initial demineralised flushing, was provided from the decanted site process liquor.
- The cell and back pressures were then increased to promote saturation of the material. During this process, a maximum difference between cell and back pressure of 20 kPa was maintained, to prevent the specimen being exposed to significant effective stresses.
- Quality of saturation was assessed using a B-check, wherein the specimen is sealed and pressure applied to the sample, while the pore pressure response within the sample is monitored. All undrained and drained tests undertaken in this study obtained a B value of 0.99, which indicated that the pore pressure response of the sample was 99% or greater than of the applied load, indicating a material of sufficient saturation for testing.
- Once consolidation was complete, samples were sheared, either drained or an undrained depending on the desired test conditions. The samples were sheared to a maximum axial strain of approximately 30%, to enable critical state conditions to be inferred, where possible.
- Each specimen was frozen prior to removal from the triaxial membrane and platens, to improve the accuracy of the GWC measurement. GWC measurement was then carried out in an oven at 110˚C.

Figure 3: Example of specimen before and after triaxial test

4.3 Consolidometer tests

Consolidation testing was undertaken in a slurry consolidometer apparatus. A slurry consolidometer is generally used to measure the compressibility and hydraulic conductivity of slurries. In this case, the consolidometer was adapted to measure these properties of a compacted tailings sample. The consolidometer allows testing of larger samples than tested by a conventional oedometer and also allows hydraulic conductivity testing of the sample, similar to a Rowe cell. The test is undertaken consolidating a specimen in stages. Once primary consolidation is completed for each stage, a constant head hydraulic conductivity test is carried out.

The test is carried out in a 71 mm diameter stainless steel chamber fitted with an acrylic loading ram and low-friction sealing rings. The loading ram separates the cell pressure from the chamber housing the sample. The cell and sample chambers are connected to three separate pressure pumps to enable measurement of vertical load and top (back) and bottom (base) sample pressures. During the consolidation stages, the water pressure in the cell is increased in stages transferring the load to the acrylic plunger. The plunger slides downwards consolidating the sample. Vertical displacement, pressures (cell and top/bottom sample pressures) and inflow/outflow volumes are monitored during the test.

The testing procedure comprised:

1) The material was tamped in three layers to a height of approximately 60 mm to a target average dry density of approximately 95% Standard Maximum Dry Density (SMDD)
2) The sample was flushed with process water from the bottom to the top of the sample with the aim of achieving saturation
3) The apparatus was closed and a cell pressure of 5 kPa applied to the sample
4) The cell and sample pressure were increased progressively to 105 kPa and 100 kPa, respectively; hence maintaining a vertical effective stress of 5 kPa
5) Following application of back pressures under 5 kPa effective stress, the applied stress was increased in stages to a maximum vertical effective stress of 1600 kPa
6) Constant head hydraulic conductivity testing was undertaken at the end of each consolidation stage to establish a relationship between void ratio and hydraulic conductivity
7) Once the loading stages were completed, the sample was unloaded to 0 kPa
8) The sample was then extruded from the consolidometer mould for final sample height and dry solids measurement.

5.0 RESULTS

5.1 Classification testing

The index test results are summarised in Table 2. Based on the results, the Tails Cyclone Feed is classified as a non-plastic Silt[1] and the Tails Thickener U/F is classified as a low plasticity Silt (ML) in accordance with Australian soil classification system (AS 1726:2017).

Table 2: Index test summary

Sample ID	GWC (%)	SG	Liquid Limit (LL) (%)	Plasticity Index (PI) (%)	SL (%)	Fines Content (%)
Tails Cyclone Feed	5.2	3.04	22	0	0	45
Tails Thickener U/F	12.1	3.01	29	5	1	91

[1] Applying the universal soil classification system (USCS), the Tails Cyclone Feed would be classified as a Silty Sand.

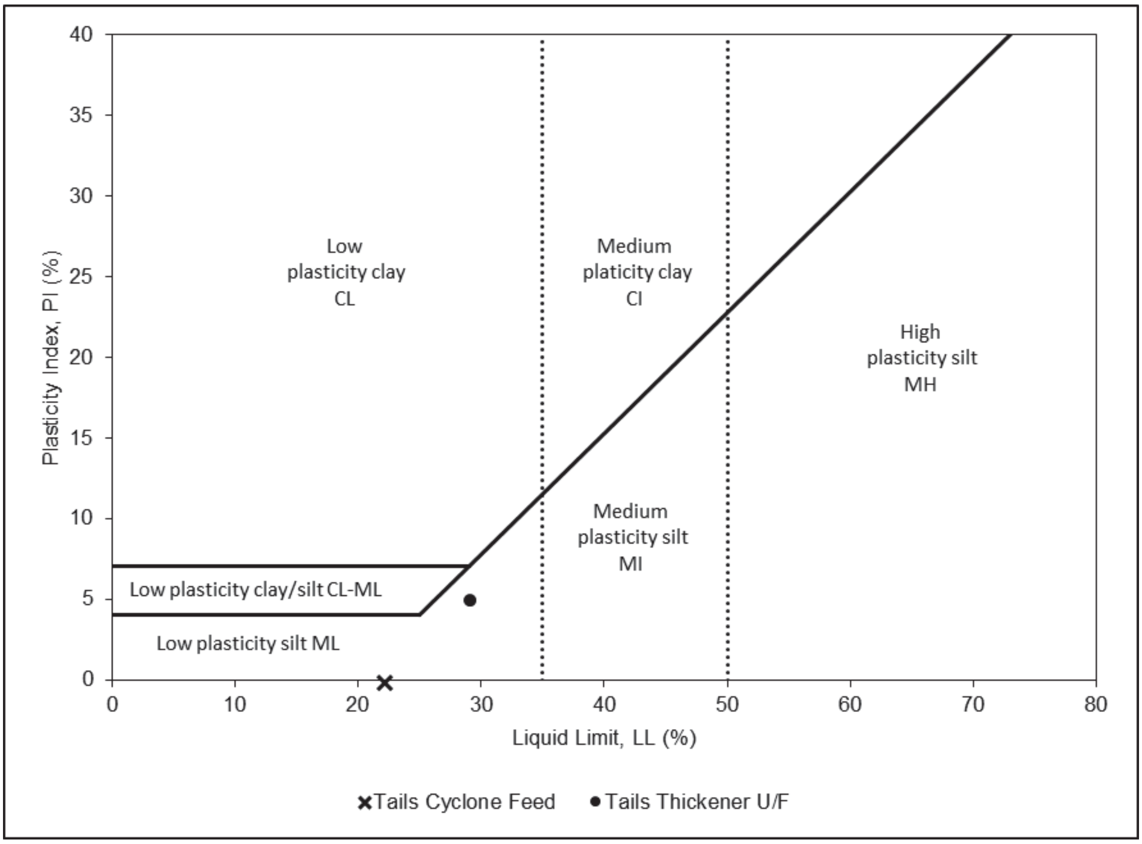

Figure 4: Soil classification based on Atterberg limits

5.2 Compaction testing

The results of the compaction testing are summarised in Table 3.

Table 3: Compaction testing summary

Sample ID	Optimum Water Content (%)	Standard Maximum Dry Density (SMDD) (t/m^3)
Tails Cyclone Feed	10.0	1.98
Tails Thickener U/F	15.0	1.76

5.3 Critical state testing

The critical state line (CSL) is a useful concept to understand geomechanical behaviour of materials. Generally, materials that are looser than the CSL exhibit contractive behaviour during shearing, while those denser than the CSL exhibit dilation. Further, significantly dilative materials are unlikely to exhibit static liquefaction, which occurs when contractive materials are loaded (often under drained conditions) to a shear stress ratio that allows contractive undrained shearing to be triggered. Once the CSL is established, material behaviour can be investigated based on the concept of a state parameter (ψ) (Jefferies and Been, 2015). The state parameter is the void ratio difference between the current state of the soil (i.e. prior to shearing) and the critical void ratio at the same mean effective stress. Typically, a material is regarded at risk of contractive behaviour when the state parameter is greater than -0.05. To reduce the potential for liquefaction or shear-related strength loss, it is desirable for a material to maintain a ψ<-0.05 over the operational life of a facility.

The results of the triaxial testing are presented as follows:

- Laboratory certificates for the tests are presented in Appendix A.
- The results are summarised in Table 4.
- The state diagrams for Tails Cyclone Feed and Tails Thickener U/F materials are presented in Figure 5 and Figure 6, respectively.
- The stress paths and critical frictional angle are presented in Figure 7 and Figure 8.
- A comparison of the CSL for both tailings types is shown in Figure 9.

Table 4: Summary of triaxial testing results

Triaxial ID	Test Type	CSL Parameters		K	Undrained Strength		Critical Friction Angle Φ_c (°)
		Γ	Λ		Peak Su/σ'v	Residual Su/σ'v	
Cyclone Tails Feed							
TX1-1000 kPa	CID	0.9474 (1.214)*	0.044 (0.086)*	1.00	-	-	33.8
TX2-100 kPa	CID			0.96	-	-	38.9
TX3-300 kPa	CID			0.99	-	-	36.4
TX4-300 kPa	CIU			0.99	0.21 (ψ=0.066)	0.12	34.6
Thickener U/F Tails							
TX1-100 kPa	CID	1.077	0.049	0.96	-	-	37.3
TX2-300 kPa	CID			0.99	-	-	34.2
TX3-1000 kPa	CID			1.00	-	-	32.1
TX4-100 kPa	CIU			0.96	0.21 (ψ=0.068)	0.12	38.7

Note: * Values in parentheses indicate CSL parameters for vertical effective stress (σ'_v) > 590 kPa.

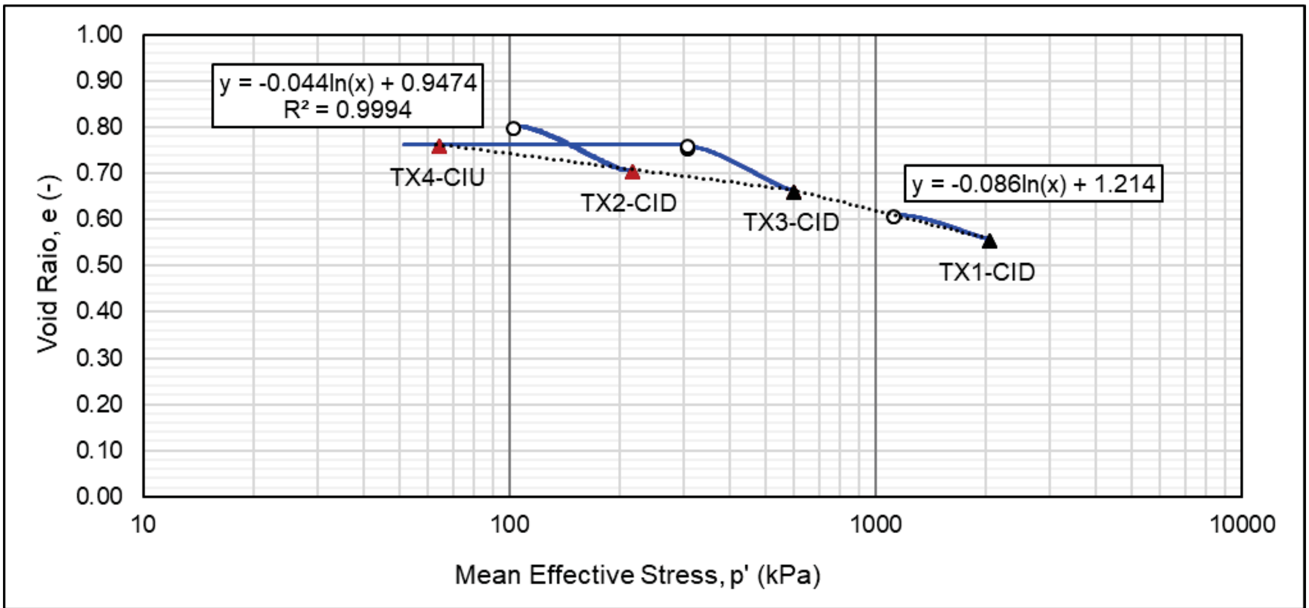

Figure 5: Critical state line for Tails Cyclone Feed

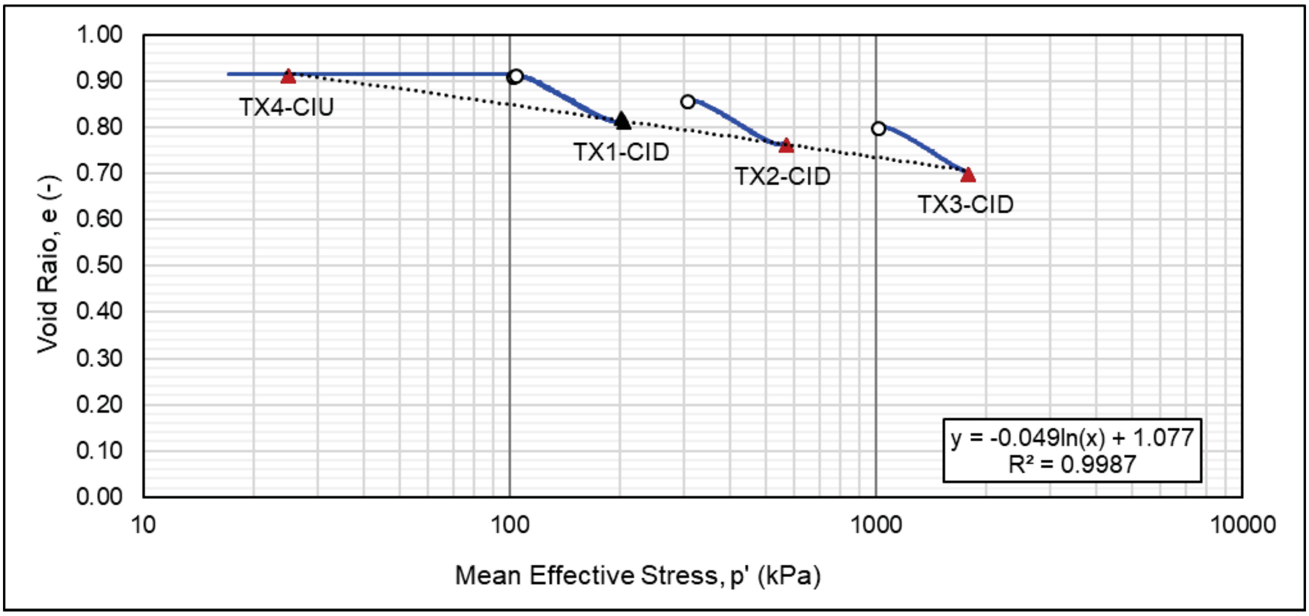

Figure 6: Critical state line for Tails Thickener U/F

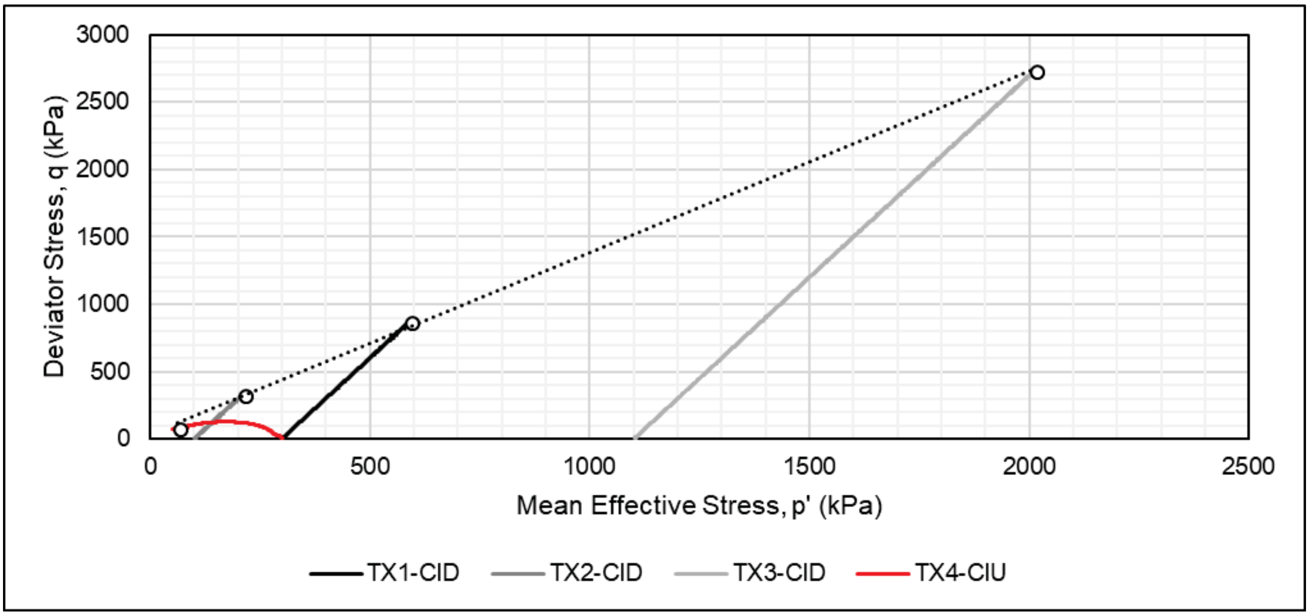

Figure 7: Cambridge plot and critical friction angle for Tails Cyclone Feed

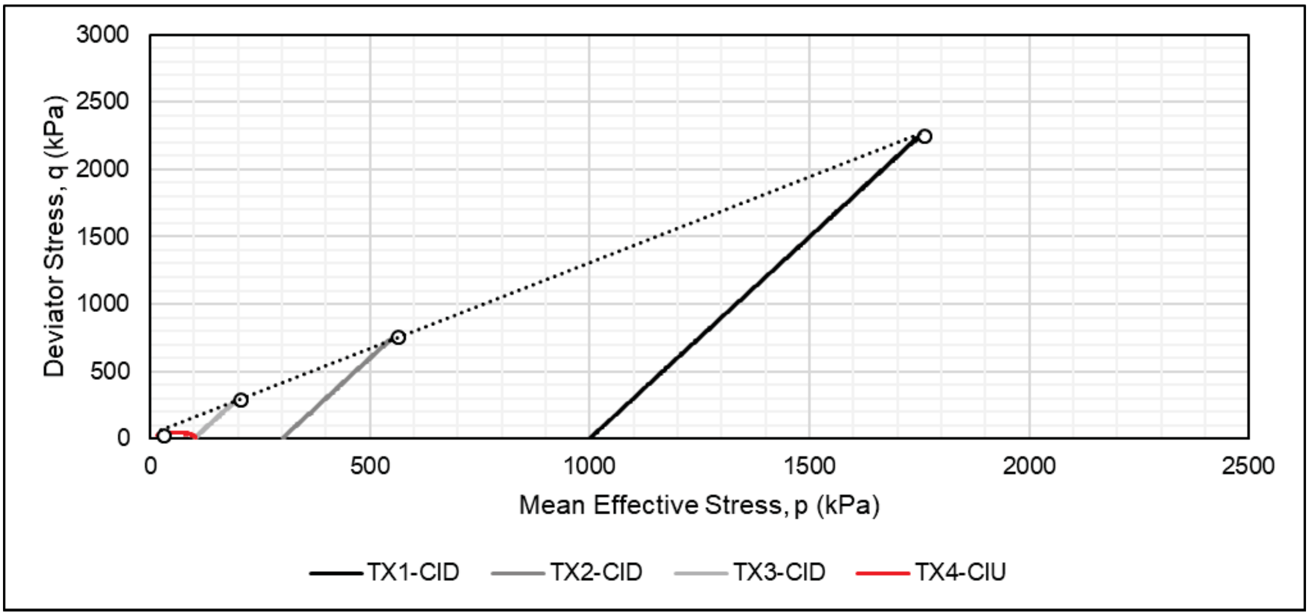

Figure 8: Cambridge plot and critical friction angle for Tails Thickener U/F

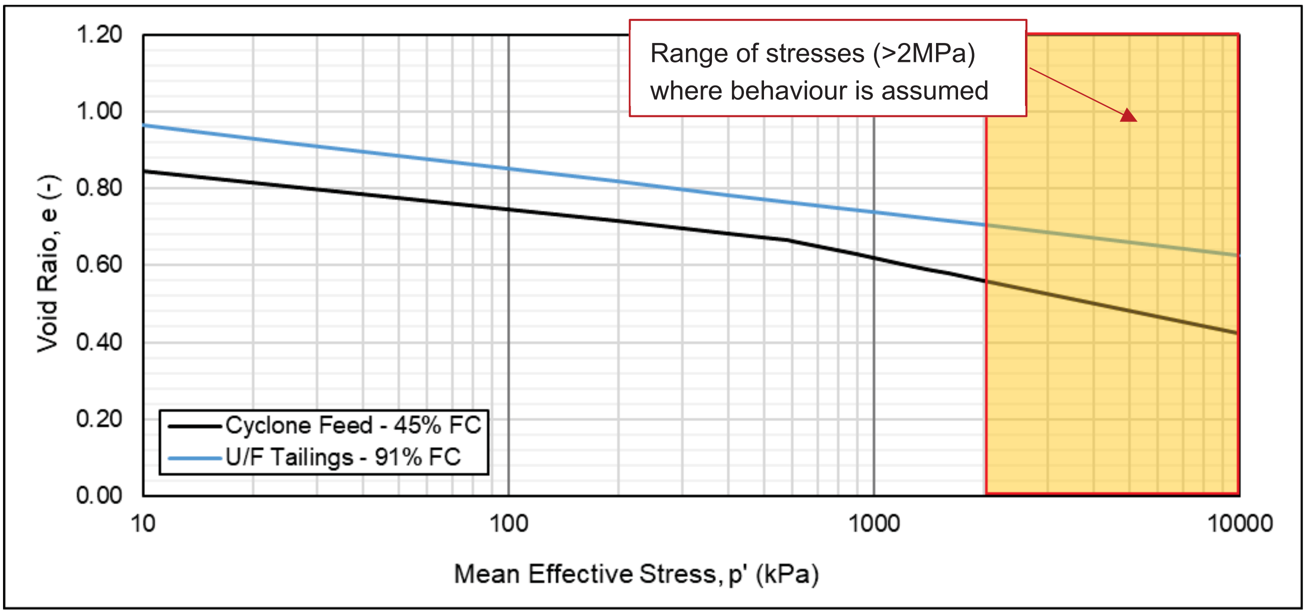

Figure 9: Comparison of CSL from Tails Cyclone Feed and Tails Thickener U/F

The results of the critical state testing indicate:

- The slope of the critical state line for Tails Cyclone Feed and Tails Thickener U/F samples are similar up to a stress of approximately 600 kPa. From this stress, the CSL of the Tails Cyclone Feed seems to curve from the conventional semi-logarithmic representation. It is noted that several materials present curvature of the CSL (e.g. Jefferies and Been 2015, Verdugo 1992) and the natural logarithmic trend representation is more a convenient engineering approximation rather than an intrinsic material property.
- The CSL of the Tails Cyclone Feed is lower than the CSL of the Tails Thickener U/F, which is evidenced by the lower CSL intercept Γ at a mean effective stress of 1 kPa.

- The slope of the CSL and its location in the e-p' space is the result of a combination of factors, such as the particle size uniformity, fine content, plasticity and particle shape. For example, a material with a uniform gradation has been observed to produce steeper and higher CSLs than materials that are well-graded, despite having similar fines content (e.g. Jefferies and Been, 2015). The different CSLs observed for the two tailings samples is likely a function of their intrinsic geotechnical characteristics.
- The critical friction angle inferred from the CID and CIU triaxial testing varies between 32° and 39°, which is typical of silt tailings.
- The peak and residual consolidated undrained shear strength ratios from CIU triaxial compression was 0.21 and 0.12, respectively for both tailings samples, at ψ of approximately +0.07. A material with higher state parameter could exhibit lower peak and residual strengths than inferred from this study. Generally, a minimum residual strength for loose contractive soils of 0.05 or less has been reported by several study of liquefaction case related failures (e.g. Olson and Stark, 2002, Robertson, 2010, Jefferies and Been, 2015).

5.4 Consolidation testing

Consolidation testing was carried out on Tails Cyclone Feed and Tails Thickener U/F compacted to approximately 95% SMDD to assess the potential for the tailings to become contractive under load following compaction in the pit. The Tails Cyclone Feed was prepared to a dry density of 1.85 t/m^3 (93% of SMDD) and the Tails Thickener U/F was prepared to 1.74 t/m^3 (99% of SMDD).

Laboratory test certificates for the consolidation testing are provided in Appendix A. Key results from the testing are presented in Figure 10 to Figure 13.

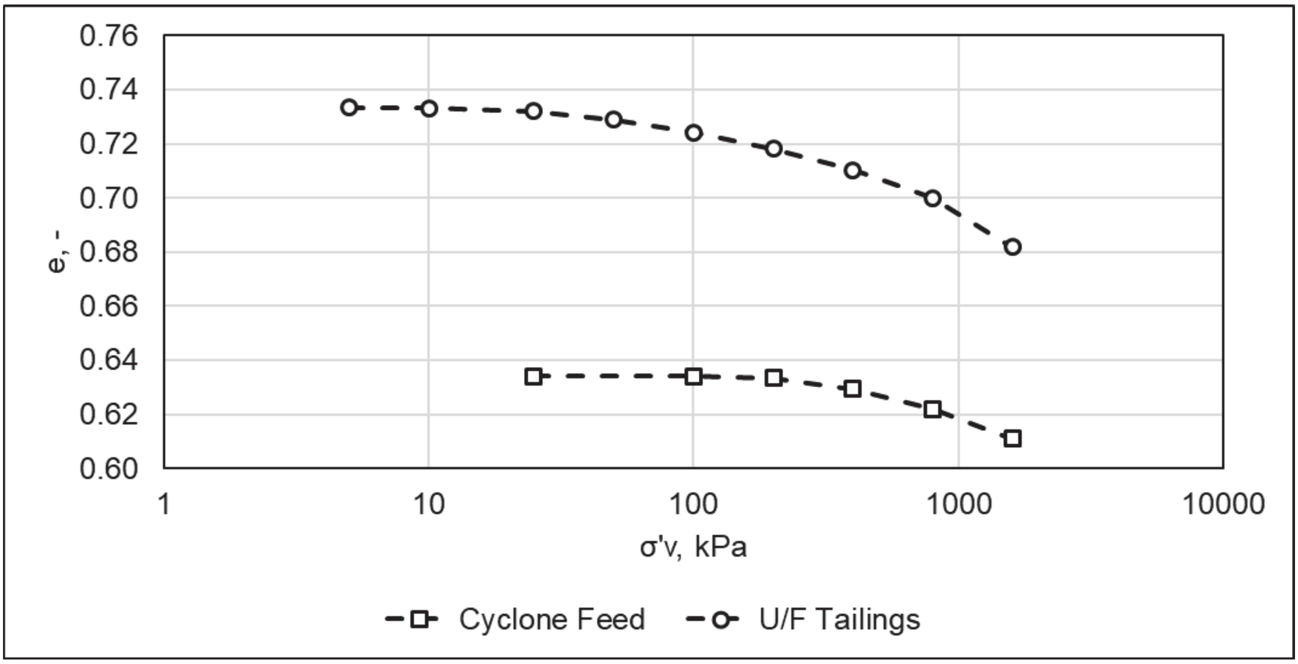

Figure 10: Consolidation void ratio vs vertical effective stress

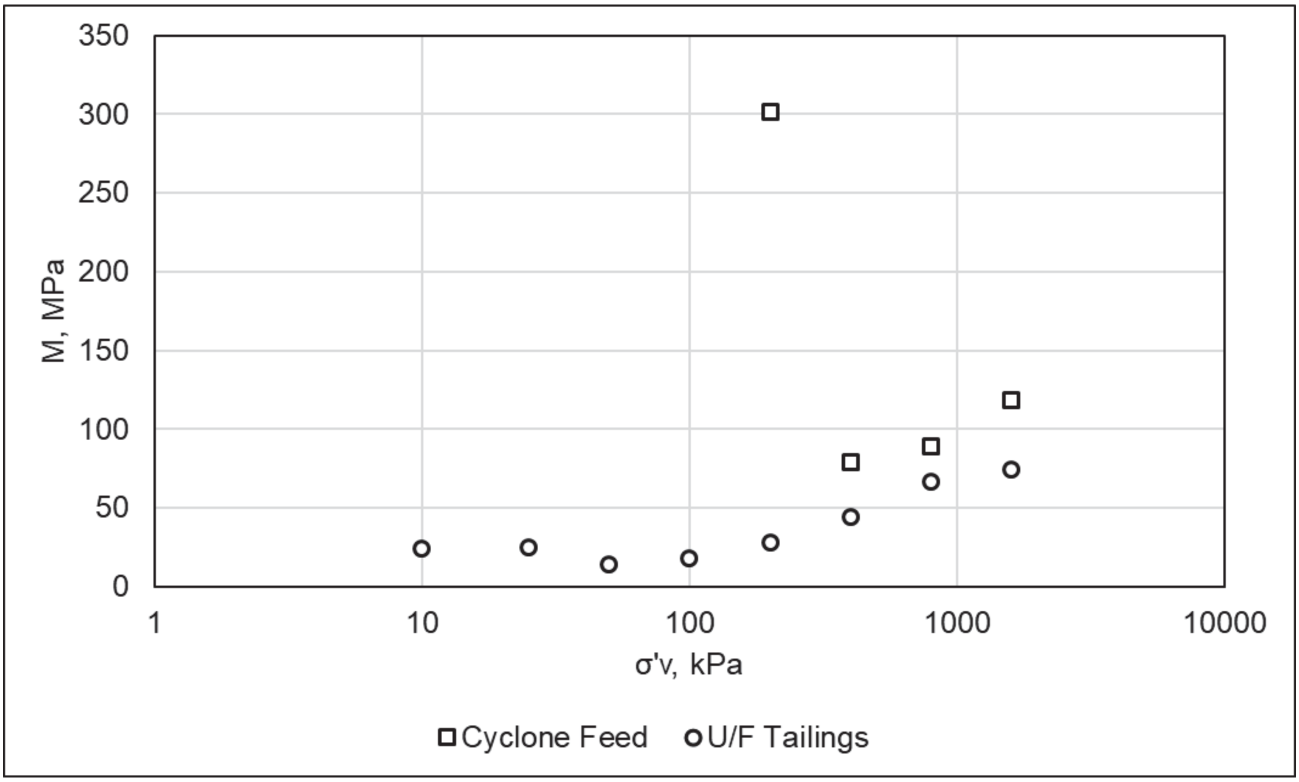

Figure 11: Consolidation constrained modulus vs vertical effective stress

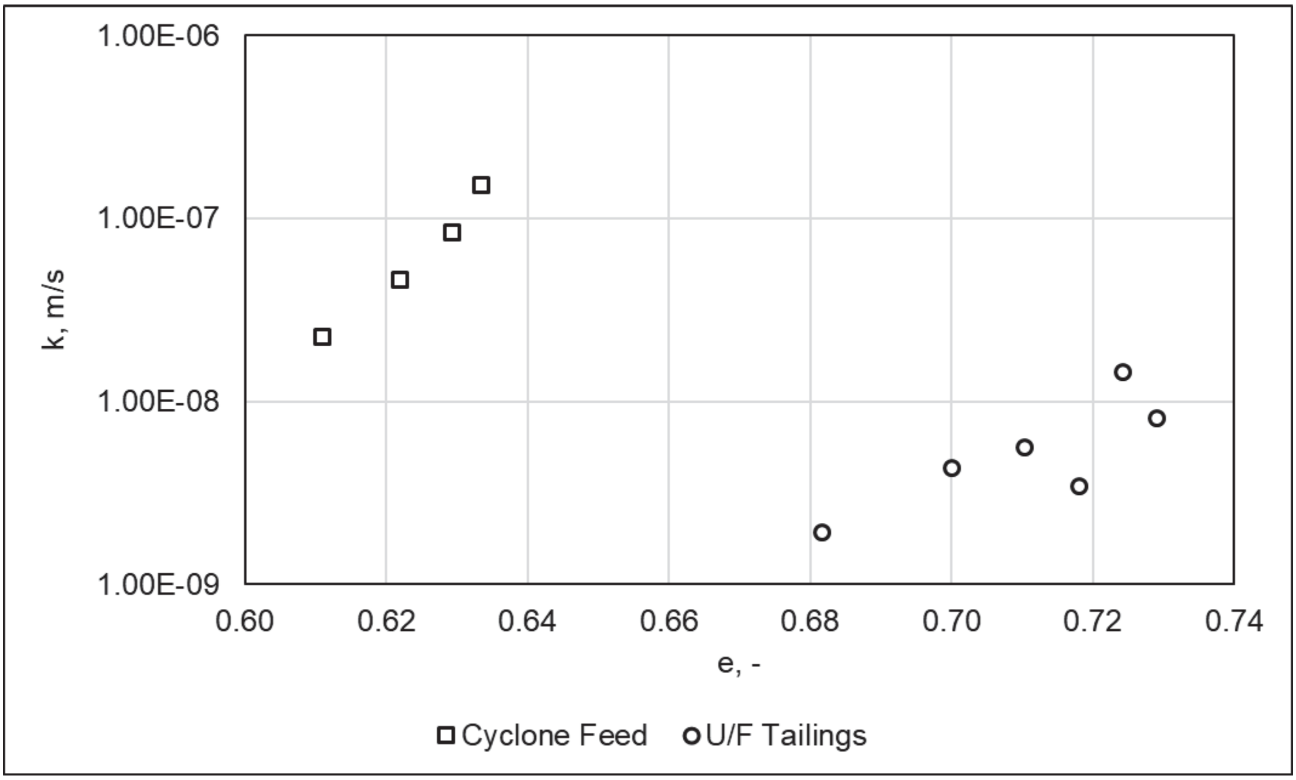

Figure 12: Measured hydraulic conductivity vs void ratio

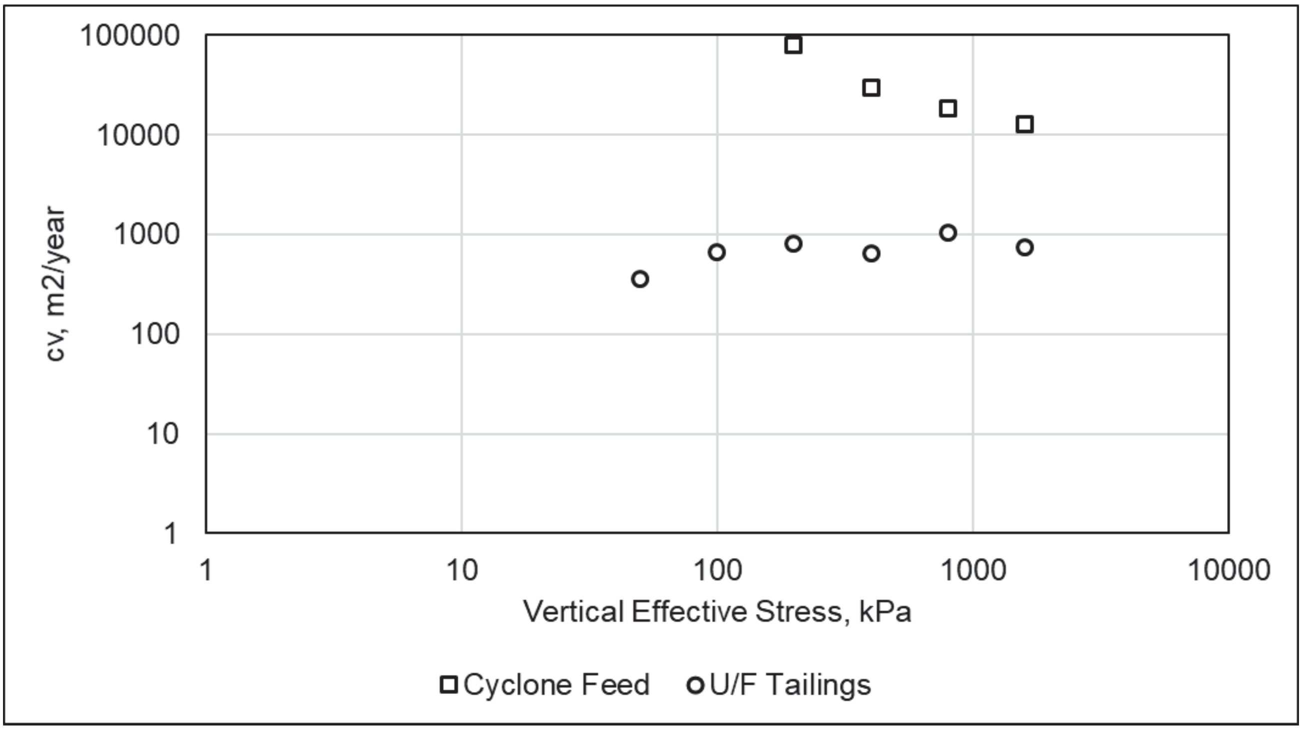

Figure 13: Coefficient of consolidation vs vertical effective stress

The Tails Cyclone Feed and the Tails Thickener U/F samples exhibit properties consistent with those expected for a compacted silt with different sand contents. The Tails Cyclone Feed is less compressible and has a hydraulic conductivity approximately one order of magnitude higher for the range of stresses tested. This results in a coefficient of consolidation for the Tails Cyclone Feed about an order of magnitude higher than that of the Tails Thickener U/F.

6.0 COMPARISON OF CSL AND COMPACTED MATERIALS

Golder has analysed the results of the Standard Maximum Dry Density (SMDD), CSL and consolidation testing, to assess the liquefaction potential of tailings when compacted in-pit. We have assumed that construction controls would be implemented to achieve a minimum SMDD of 95%, accepting that this can be difficult to achieve with filtered tailings, which is often placed wet of its optimum moisture content. Figure 14 and Figure 15 compare the consolidation line (CL) for a sample compacted to 95% SMDD with the CSL for the Tails Cyclone Feed and Tails Thickener U/F, respectively.

The consolidation testing for the Tails Cyclone Feed and Tails Thickener U/F, was carried out on samples compacted to 93% and 99%, respectively. For comparison purposes, the CL for both samples has been adjusted to model the results of a sample compacted 95% SMDD. This has been done by adjusting the starting void ratio to 95% SMDD and assuming that the adjusted CL is parallel to the tested CL. A coefficient of geostatic stress (K_0) of 0.5 was assumed for the purpose of the comparison. K_0 for the tailings may vary in pit and this would have a small effect on the results.

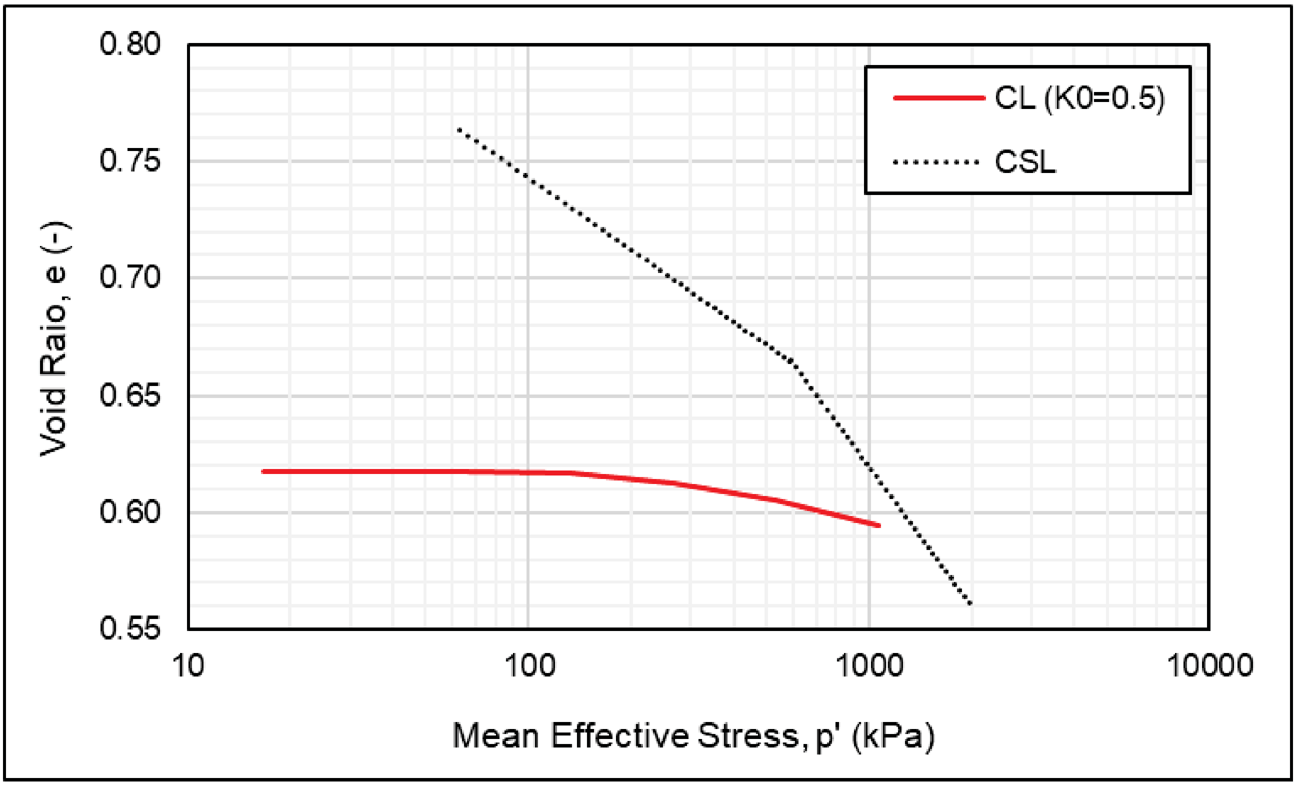

Figure 14: Comparison of consolidation line for Tails Cyclone Feed prepared to 95% of SMDD and CSL

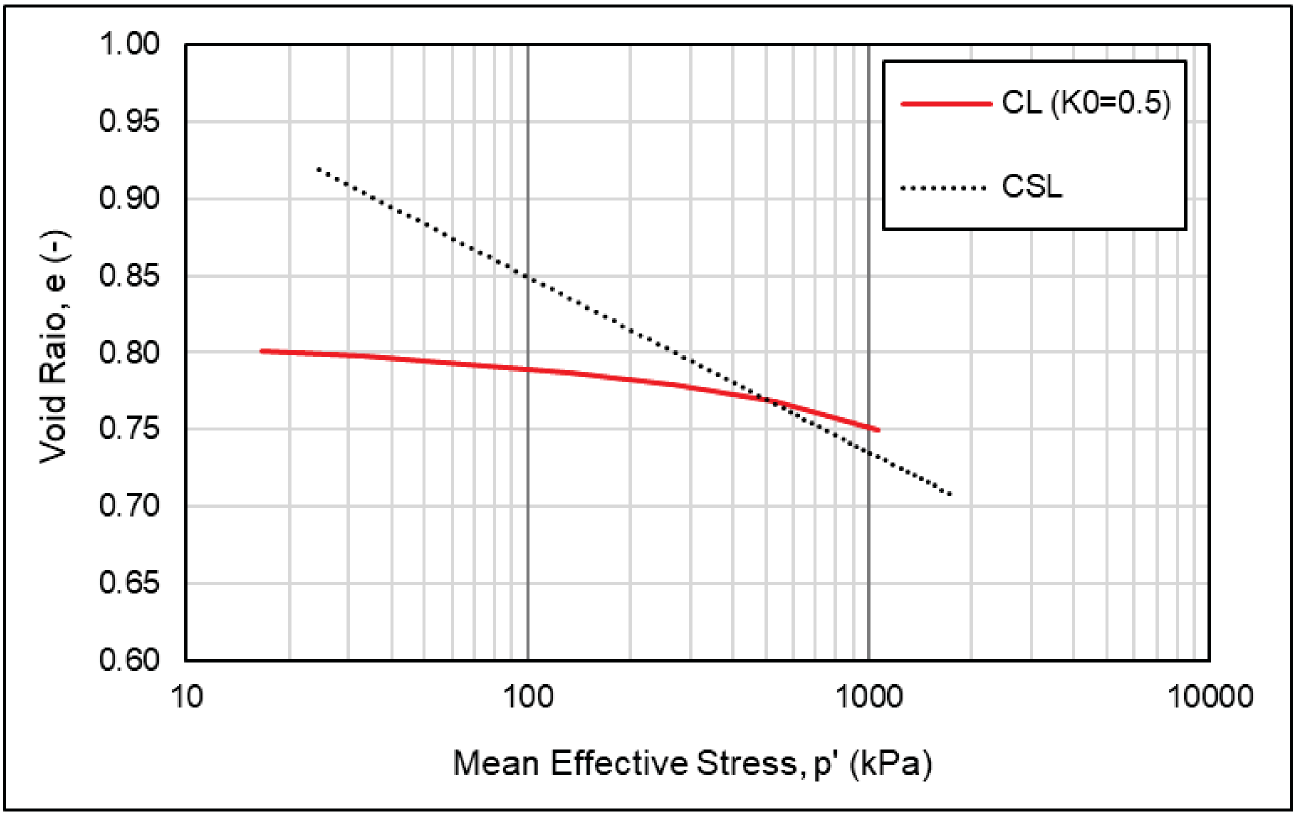

Figure 15: Comparison of consolidation line for Tails Thickener U/F prepared to 95% of SMDD and CSL

Assuming the Tails Cyclone Feed and Tails Thickener U/F samples are compacted to 95% of SMDD with a K_0 of 0.5, the samples exhibit contractive behaviour (ψ>-0.05) at vertical effective stresses of approximately 1000 kPa and 200 kPa, respectively. These stresses are lower than the maximum stress expected at the base of the Kintore Pit. On this basis, liquefaction of the compacted tailings above the adit cannot be ruled out if the tailings remain saturated. Additional measures should be considered to mitigate the risk of liquefaction.

7.0 IMPORTANT INFORMATION

Your attention is drawn to the document titled – "Important Information Relating to this Report", which is included in Appendix B of this report. The statements presented in that document are intended to inform a reader of the report about its proper use. There are important limitations as to who can use the report and how it can be used. It is important that a reader of the report understands and has realistic expectations about those matters. The Important Information document does not alter the obligations Golder Associates has under the contract between it and its client.

Golder Associates Pty Ltd

Riccardo Fanni
Tailings Engineer

David Anstey
Associate, Principal Tailings Engineer

YG/RF/DRA/hn

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https://golderassociates.sharepoint.com/sites/25201g/deliverables/004 - csl tailings testing/1896230-004-r-rev0-kintore pit final.docx

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Olson, S.M. and Stark, T.D. 2002. Liquefied strength ratio from liquefaction case histories. Canadian Geotechnical Journal, Vol. 39.

Robertson, P.K. 2010. Evaluation of flow liquefaction and liquefied strength using the cone penetration test. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 136(6).

Verdugo, R. (1992). The critical state of sands: Discussion. Geotechnique, 42(4), 655-663.

APPENDIX A

Laboratory Test Certificates

01 – INDEX AND SMDD

37 Kensington Street
East Perth
WA 6004

Client: Golder Associates Pty Ltd
Job number: 18_0911
Client ID: Broken Hill - Tails Cyclone Feed
Date analysed: 8/06/2018
Analysis: Absolute density by helium pycnometry following ASTM D5550

Sample preparation
A representative sub-sample was taken and oven dried at 110 °C prior to analysis.

Analysis
The sample was analysed using a Micromeritics Accupyc with helium gas (99.995%). The instrument was calibrated using a NIST standard prior to the analysis. The analysis was conducted 10 times to enable an average value and standard deviation to be quoted. The analyses were conducted at 21 °C.

Summary
The density value was determined to be:

Client ID	Lab ID	Density (g/cc)
Broken Hill - Tails Cyclone Feed	18_0911_01	3.0424 ±0.0009

The results are representative only of the sample provided.

Analyst: Hoklam Suen, B.Eng. (Metallurgy)

Reported: Hoklam Suen, B.Eng. (Metallurgy)

Approved: Michael Simeoni, B.Sc.(Chemistry), M.Sc. (Science Administration), Ph.D.

37 Kensington Street
East Perth
WA 6004

Client: Golder Associates Pty Ltd
Job number: 18_0944
Client ID: Broken Hill - Tails Thickener U/F
Date analysed: 8/06/2018
Analysis: Absolute density by helium pycnometry following ASTM D5550

Sample preparation
A representative sub-sample was taken and oven dried at 110 °C prior to analysis.

Analysis
The sample was analysed using a Micromeritics Accupyc with helium gas (99.995%). The instrument was calibrated using a NIST standard prior to the analysis. The analysis was conducted 10 times to enable an average value and standard deviation to be quoted. The analyses were conducted at 21 °C.

Summary
The density value was determined to be:

Client ID	Lab ID	Density (g/cc)
Broken Hill - Tails Thickener U/F	18_0944_01	3.0105 ±0.0031

The results are representative only of the sample provided.

Analyst: Hoklam Suen, B.Eng. (Metallurgy)

Reported: Hoklam Suen, B.Eng. (Metallurgy)

Approved: Michael Simeoni, B.Sc.(Chemistry), M.Sc. (Science Administration), Ph.D.

Percent Fines Report (-75µm only)

GOLDER

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www.golder.com
perthlab@golder.com.au

Client:	Broken Hill Operations Pty Ltd 130 Eyre Street Broken Hill NSW 2880		
Project:	Kintore Pit (Broken Hill) CSL Testing	**Date:**	11/06/18
Location:	RASP Mine	**Project No.:**	1896230

Test procedure: AS 1289.2.1.1, AS 1289.3.6.1 (75µm sieve only)

Laboratory Reference Number	180706
Sample Identification	Kintore Tails Cyclone Feed
Sample Description	Sandy SILT
Moisture Content (%)	5.2
Percent Fines (-75µm)	45

Notes:

Tested as received **PLF1-006 RL0 28/11/12**

Certificate Reference:	**1896230_180706_TR-180087_%FINES_REV0**
NATA	**NATA Accreditation No: 1961 Perth**
	Accredited for compliance with ISO/IEC 17025
	THIS DOCUMENT SHALL ONLY BE REPRODUCED IN FULL

Seán Lenihan

Sean Lenihan - Senior Laboratory Technician

Plasticity Index Test Report

GOLDER

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Client: Broken Hill Operations Pty Ltd
130 Eyre Street Broken Hill NSW 2880

Project: Kintore Pit (Broken Hill) CSL Testing **Date:** 11/06/18

Location: RASP Mine **Project No.:** 1896230

Test procedure: AS 1289.2.1.1,AS 1289 3.9.1, AS 1289.3.2.1, AS 1289.3.3.2 & AS 1289.3.4.1

Laboratory Reference Number	180706
Sample Identification	Kintore Tails Cyclone Feed
Sample Description	Sandy SILT
Liquid Limit (%)	22
Plastic Limit (%)	NO
Plasticity Index (%)	0
Linear Shrinkage (%)	0.0
Moisture Content (%)	ND
Sample History	Air Dried
Method of Preparation	Dry Sieved
Length of Shrinkage Mould (mm)	125
Cracking, Curling or Crumbling	No

N.D. = Not Determined **N.O. = Not Obtainable** **N.P. = Non Plastic**

Notes:

Tested as received **PLF1-041 RL0 21/11/17**

Certificate Reference: **1896230_180706_TR-180087_PI_Rev0**

NATA

NATA Accreditation No: 1961 Perth

Accredited for compliance with ISO/IEC 17025

Sean Lenihan

Sean Lenihan - Senior Laboratory Technician

Percent Fines Report (-75μm only)

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Client:	Broken Hill Operations Pty Ltd 130 Eyre Street Broken Hill NSW 2880		
Project:	Kintore Pit (Broken Hill) CSL Testing	**Date:**	11/06/18
Location:	RASP Mine	**Project No.:**	1896230

Test procedure: AS 1289.2.1.1, AS 1289.3.6.1 (75μm sieve only)

Laboratory Reference Number	180707
Sample Identification	Kintore Tails Thickener U/F
Sample Description	SILT (trace of sand)
Moisture Content (%)	12.1
Percent Fines (-75μm)	91

Notes:

Tested as received **PLF1-006 RL0 28/11/12**

Certificate Reference:	1896230_180707_TR-180087_%FINES_REV0
NATA	NATA Accreditation No: 1961 Perth Accredited for compliance with ISO/IEC 17025 THIS DOCUMENT SHALL ONLY BE REPRODUCED IN FULL

Sean Lenihan

Sean Lenihan - Senior Laboratory Technician

Plasticity Index Test Report

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perthlab@golder.com.au

Client:	Broken Hill Operations Pty Ltd 130 Eyre Street Broken Hill NSW 2880		
Project:	Kintore Pit (Broken Hill) CSL Testing	**Date:**	12/06/18
Location:	RASP Mine	**Project No.:**	1896230

Test procedure: AS 1289.2.1.1,AS 1289 3.9.1, AS 1289.3.2.1, AS 1289.3.3.2 & AS 1289.3.4.1

Laboratory Reference Number	180707
Sample Identification	Kintore Tails Thickener U/F
Sample Description	SILT (trace of sand)
Liquid Limit (%)	29
Plastic Limit (%)	24
Plasticity Index (%)	5
Linear Shrinkage (%)	1.0
Moisture Content (%)	ND
Sample History	Air Dried
Method of Preparation	Dry Sieved
Length of Shrinkage Mould (mm)	125
Cracking, Curling or Crumbling	No

N.D. = Not Determined **N.O. = Not Obtainable** **N.P. = Non Plastic**

Notes:

Tested as received **PLF1-041 RL0 21/11/17**

Certificate Reference: **1896230_180707_TR-180087_PI_Rev0**

NATA

NATA Accreditation No: 1961 Perth

Accredited for compliance with ISO/IEC 17025

Sean Lenihan

Sean Lenihan - Senior Laboratory Technician

Dry Density Moisture Content Relationship Report

In accordance with

AS 1289.5.1.1

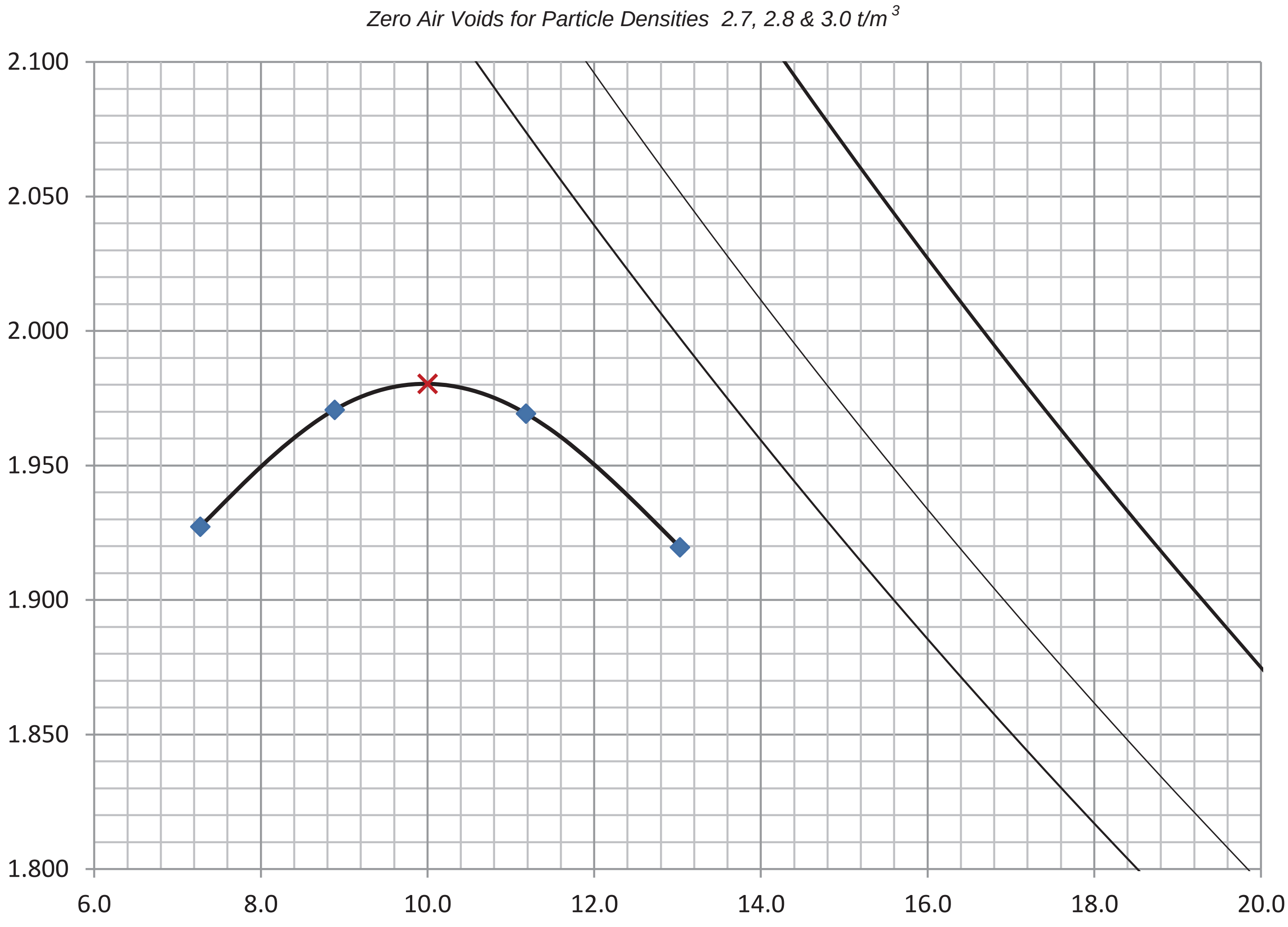
Perth Laboratory
84 Guthrie Street Osborne Park
Perth WA 6017
P: +61 8 9441 0700 F: +61 8 9441 0701
www.golder.com
perthlab@golder.com.au

Client:	Broken Hill Operations Pty Ltd	**Project No.:**	1896230
Address	130 Eyre Street Broken Hill NSW 2880	**Date:**	30/08/18
Project:	Kintore Pit (Broken Hill) CSL Testing		
Location:	RASP Mine		
Lab Ref No.:	180939	**Sample Id:**	Tails Cyclone Feed
		Depth:	-

AS 1726 - Soil Classification: Description: Sandy SILT

Test Procedure: AS 1289.5.1.1 Mould Type : A Type (1litre)

Oversize material excluded from test: 0% retained on the 19 sieve.



Maximum Dry Density 1.98 t/m^3

Optimum Moisture 10.0 %

Notes:

1. Tested as supplied.
2. Test performed on re-compacted sample due to insufficient material.
3. Air void lines designated by client at client's request

PLF1-008 RL2 24/08/2017

Certificate Reference: **1896230_180939_TR-180110_MDD_Rev0**

THIS DOCUMENT SHALL ONLY BE REPRODUCED IN FULL

Shannon Wai - Laboratory Technician

Dry Density Moisture Content Relationship Report

In accordance with

AS 1289.5.1.1

Perth Laboratory
84 Guthrie Street Osborne Park
Perth WA 6017
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www.golder.com
perthlab@golder.com.au

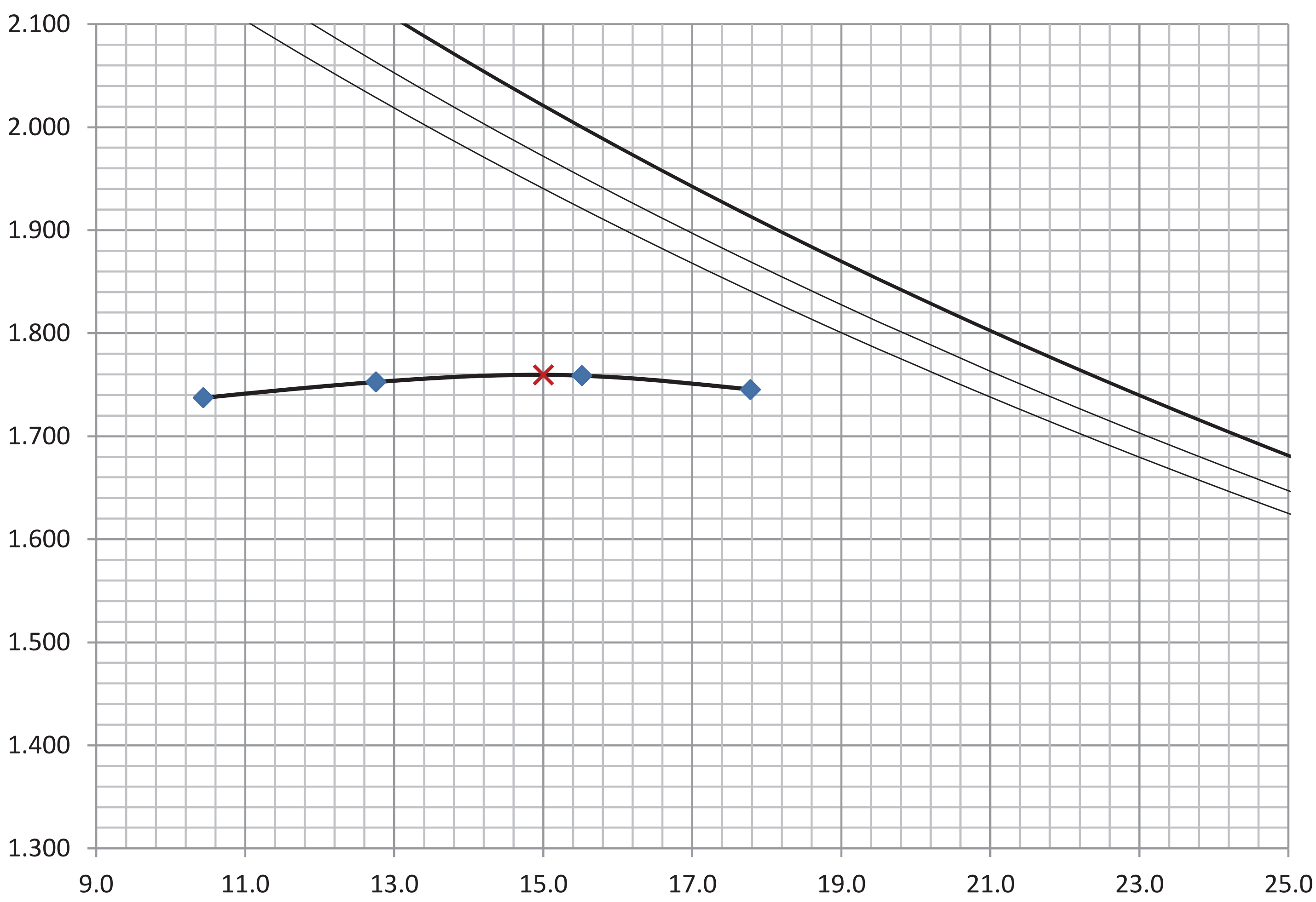
Client:	Broken Hill Operations Pty Ltd	**Project No.:**	1896230
Address	130 Eyre Street Broken Hill NSW 2880	**Date:**	30/08/18
Project:	Kintore Pit (Broken Hill) CSL Testing		
Location:	RASP Mine		
Lab Ref No.:	180940	**Sample Id:**	Tails Thickener U/F
		Depth:	-

AS 1726 - Soil Classification: Description: SILT (trace of sand)

Test Procedure: AS 1289.5.1.1 Mould Type : A Type (1litre)

Oversize material excluded from test: 0% retained on the 19 sieve.

Zero Air Voids for Particle Densities 2.8, 2.9 & 3.0 t/m³



Maximum Dry Density **1.76 t/m³**

Optimum Moisture **15.0 %**

Notes:

1. Tested as supplied.
2. Test performed on re-compacted sample due to insufficient material.
3. Air void lines designated by client at client's request

PLF1-008 RL2 24/08/2017

Certificate Reference: **1896230_180940_TR-180110_MDD_Rev0**

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Shannon Wai - Laboratory Technician

02 – CSL TESTING

Triaxial Test Report

Isotropically Consolidated Drained (CID)

GOLDER

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	28/05/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S1 Cyclone Feed - TX1

Initial Height (mm):	130.4	Final Liquor Content (%):	18.5%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	61.2	Final Dry Density (t/m^3):	1.95	B Response (%):	99%
Trimmings GWC (%):	4.8%	Final Void Ratio (-):	0.56	Mean Effective Consolidation Stress (kPa):	1101
Initial Dry Density (t/m^3):	1.47	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	1.00

Sample Before Test

Sample After Test

Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

THIS DOCUMENT SHALL ONLY BE REPRODUCED IN FULL

Triaxial Test Report

Isotropically Consolidated Drained (CID)

GOLDER

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	28/05/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S1 Cyclone Feed - TX1

Initial Height (mm):	130.4	Final Liquor Content (%):	18.5%	Strain Rate (mm/min):	0.03
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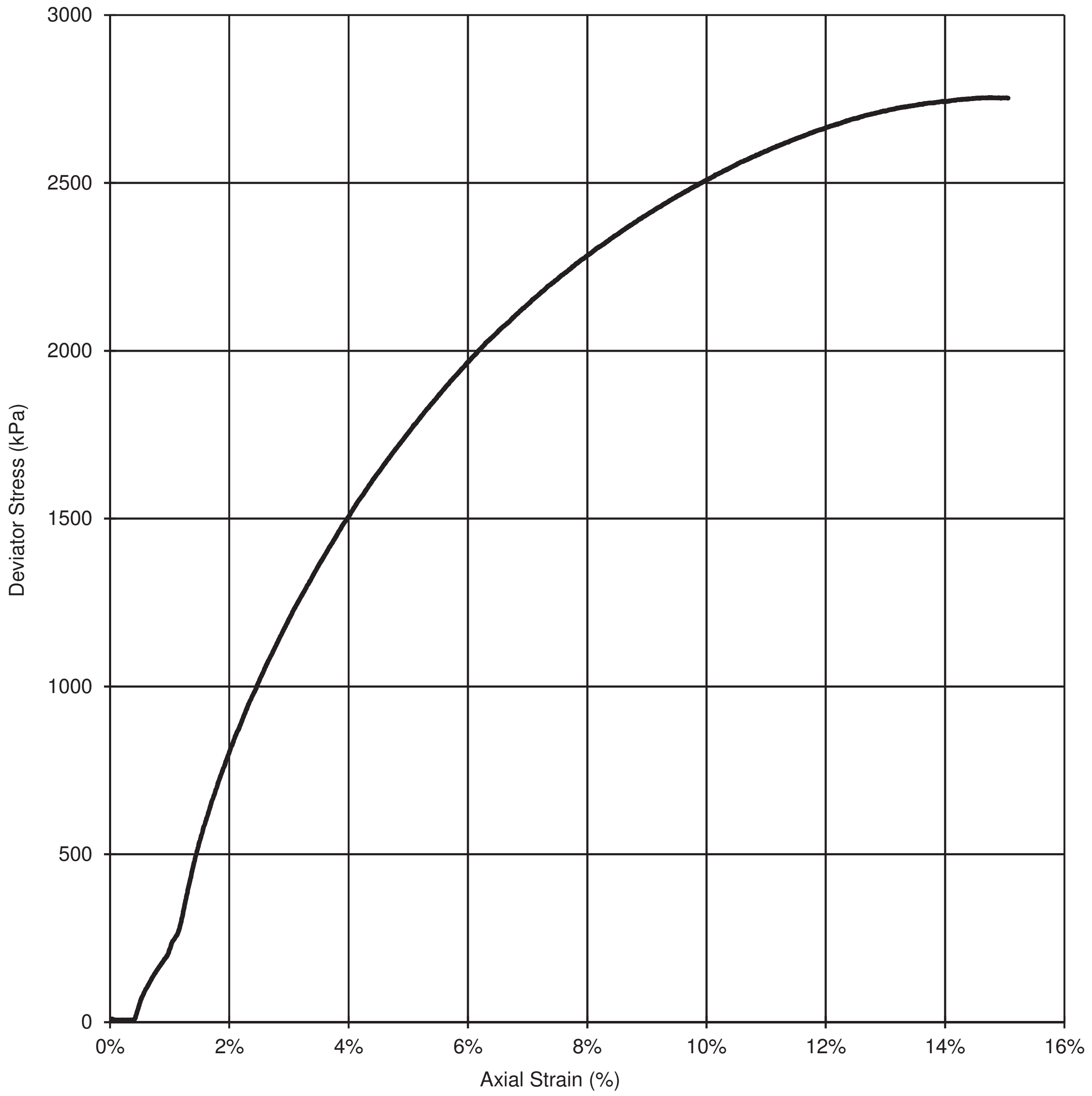
Trimmings GWC (%):	4.8%	Final Void Ratio (-):	0.56	Mean Effective Consolidation Stress (kPa):	1101
Initial Dry Density (t/m^3):	1.47	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	1.00



Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

Triaxial Test Report

Isotropically Consolidated Drained (CID)

GOLDER

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	28/05/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S1 Cyclone Feed - TX1

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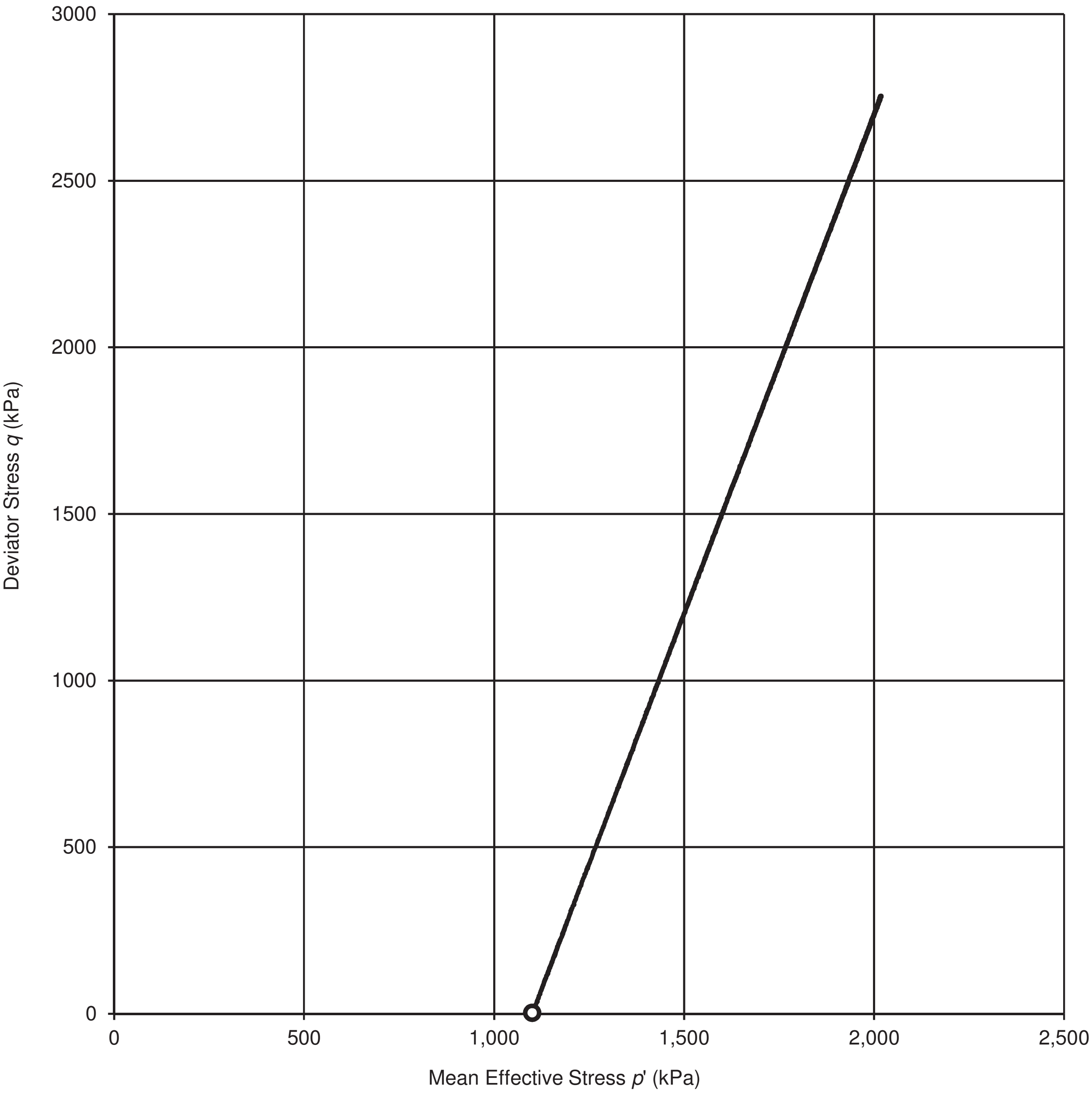
Trimmings GWC (%):	4.8%	Final Void Ratio (-):	0.56	Mean Effective Consolidation Stress (kPa):	1101
Initial Dry Density (t/m^3):	1.47	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	1.00



Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
THIS DOCUMENT SHALL ONLY BE REPRODUCED IN FULL		Reviewed by:	R. Fanni

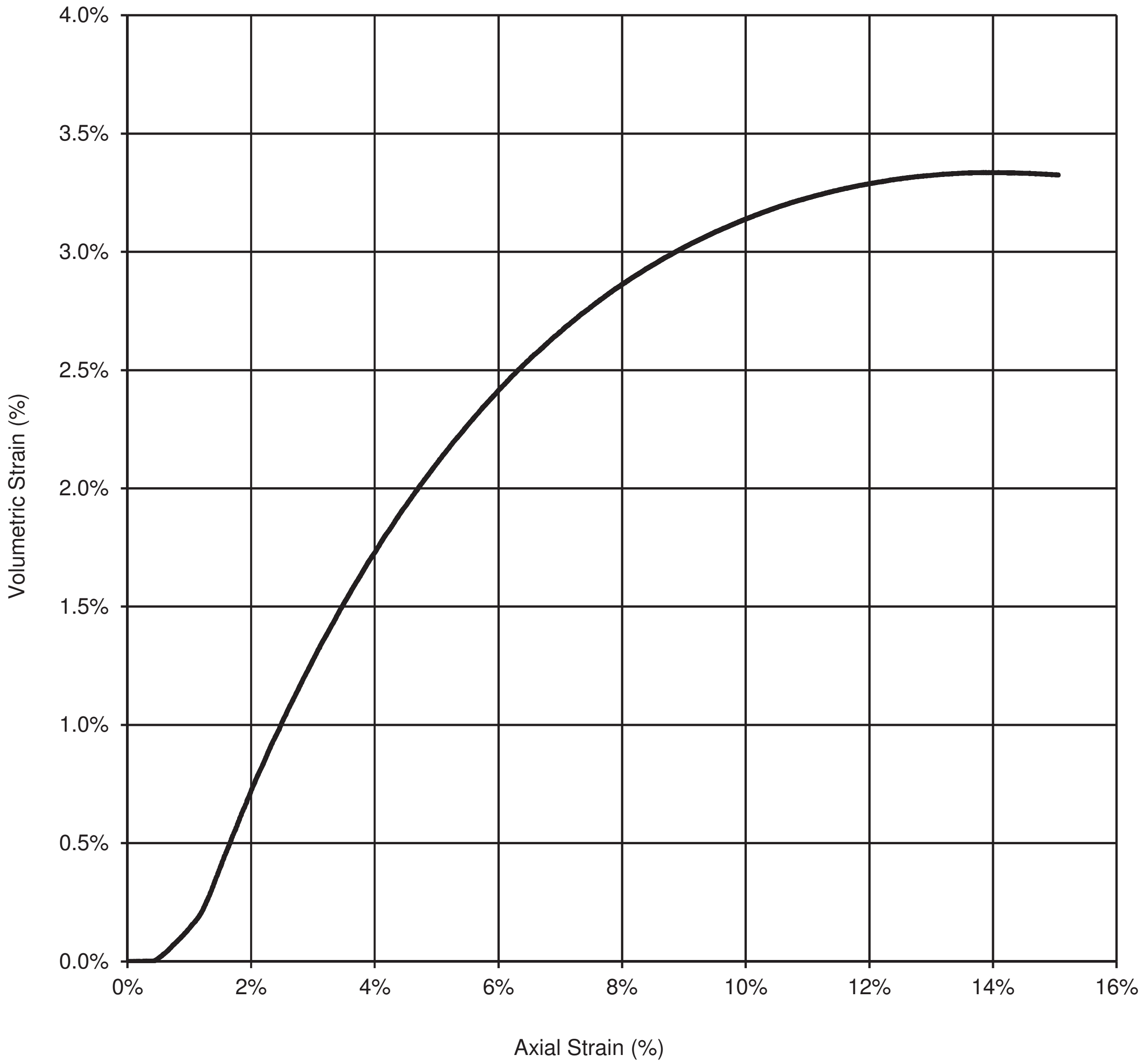
Triaxial Test Report

Isotropically Consolidated Drained (CID)

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	28/05/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S1 Cyclone Feed - TX1

Initial Height (mm):	130.4	Final Liquor Content (%):	18.5%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	61.2	Final Dry Density (t/m^3):	1.95	B Response (%):	99%
Trimmings GWC (%):	4.8%	Final Void Ratio (-):	0.56	Mean Effective Consolidation Stress (kPa):	1101
Initial Dry Density (t/m^3):	1.47	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	1.00



Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

Triaxial Test Report

Isotropically Consolidated Drained (CID)

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	28/05/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
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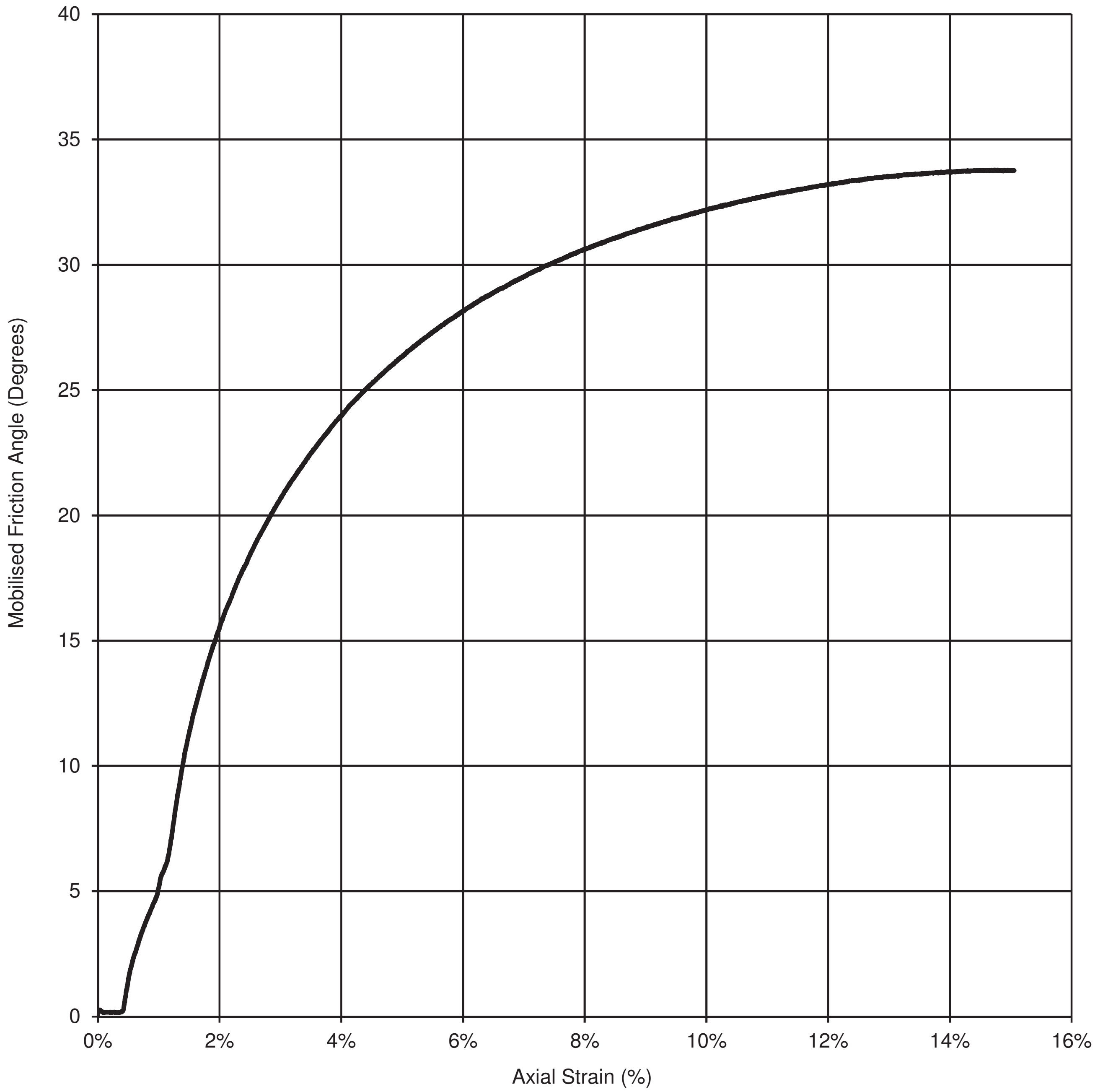


Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

Triaxial Test Report

Isotropically Consolidated Drained (CID)

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	30/05/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S1 Cyclone Feed - TX2

Initial Height (mm):	129.8	Final Liquor Content (%):	23.3%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	61.9	Final Dry Density (t/m^3):	1.78	B Response (%):	99%
Trimmings GWC (%):	4.8%	Final Void Ratio (-):	0.71	Mean Effective Consolidation Stress (kPa):	101
Initial Dry Density (t/m^3):	1.44	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	0.96

Sample Before Test

Sample After Test

Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

Triaxial Test Report

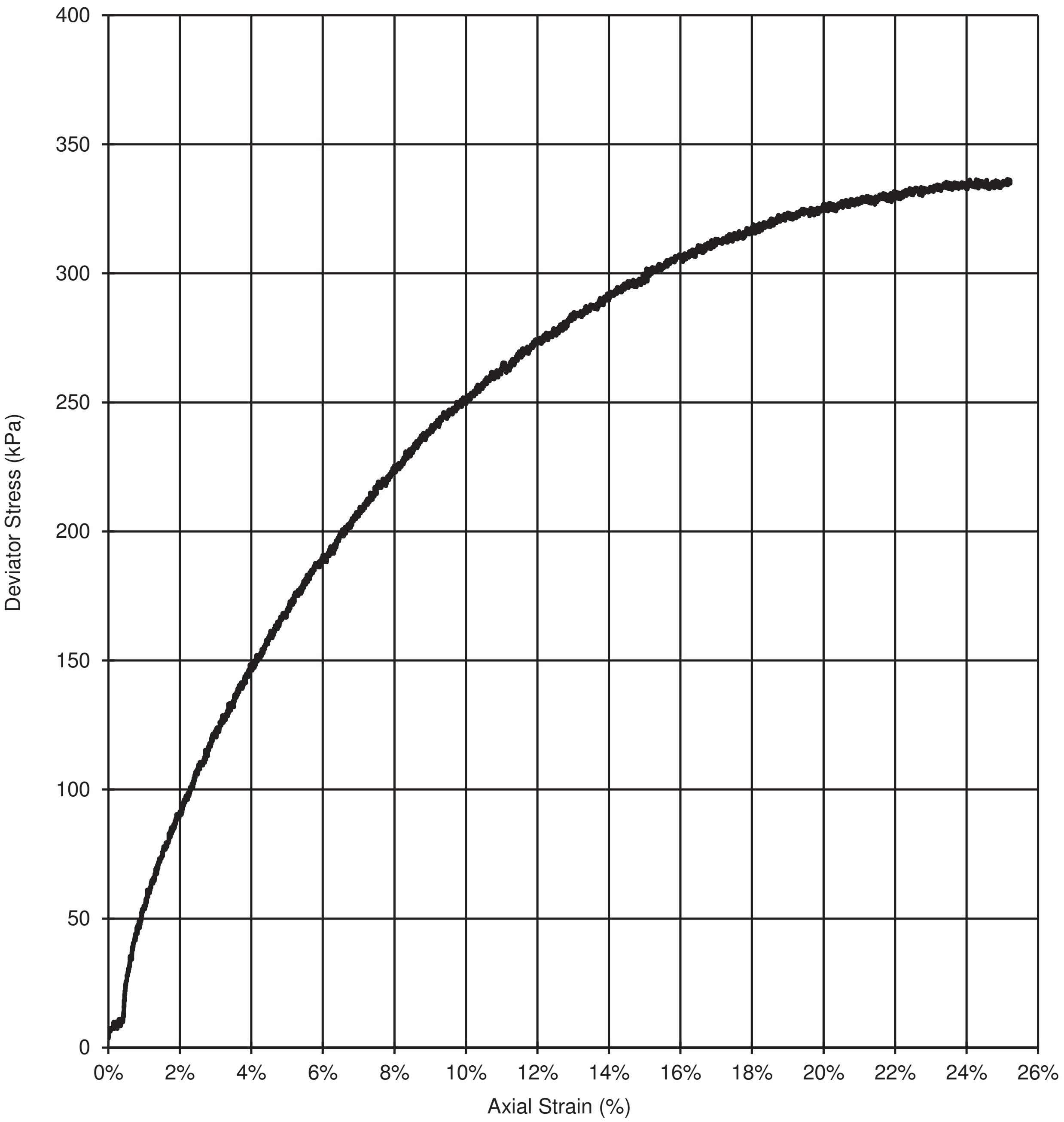
Isotropically Consolidated Drained (CID)

GOLDER

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	30/05/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S1 Cyclone Feed - TX2

Initial Height (mm):	129.8	Final Liquor Content (%):	23.3%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	61.9	Final Dry Density (t/m^3):	1.78	B Response (%):	99%
Trimmings GWC (%):	4.8%	Final Void Ratio (-):	0.71	Mean Effective Consolidation Stress (kPa):	101
Initial Dry Density (t/m^3):	1.44	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	0.96



Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

Triaxial Test Report

Isotropically Consolidated Drained (CID)

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	30/05/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
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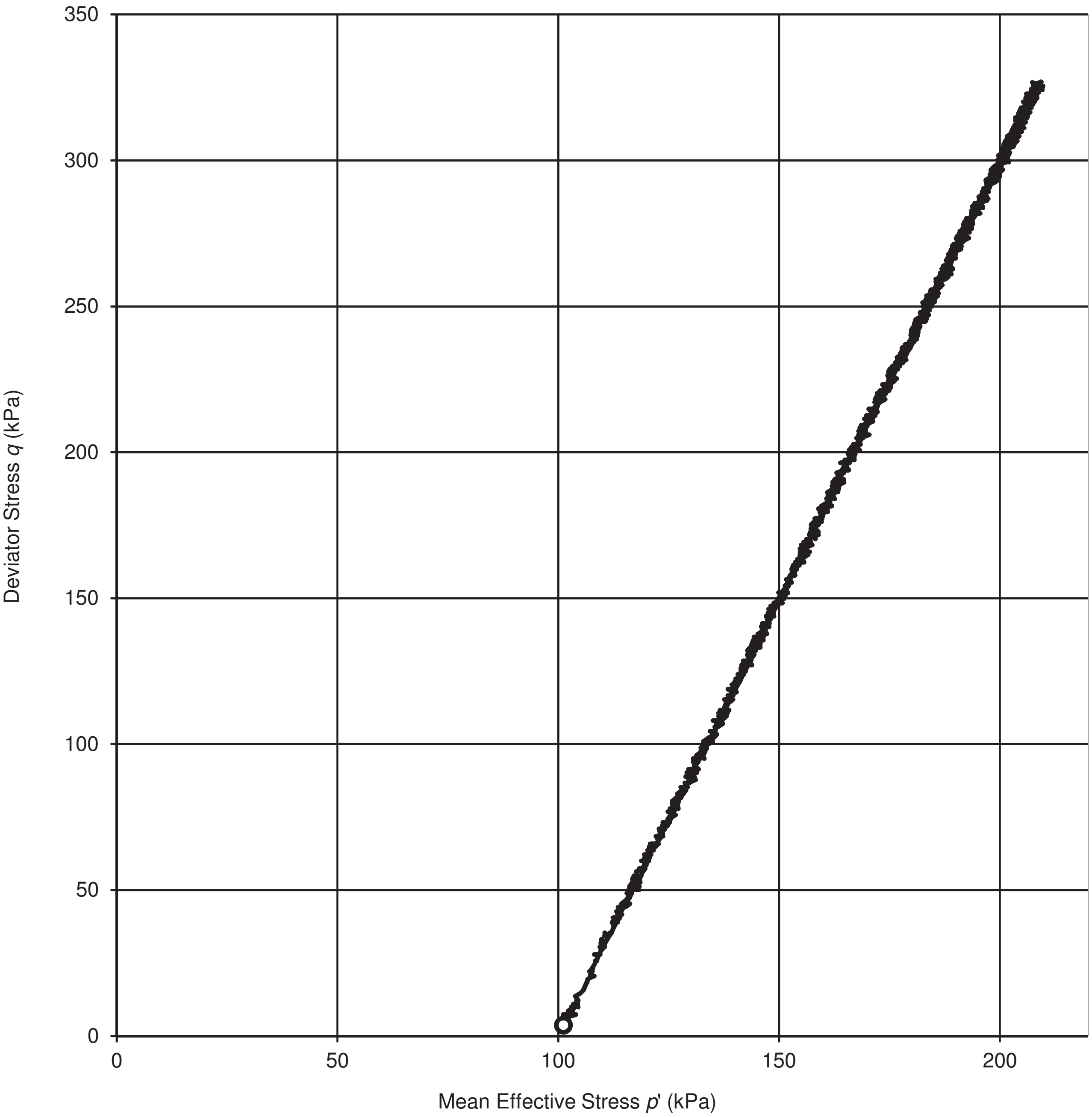
Trimmings GWC (%):	4.8%	Final Void Ratio (-):	0.71	Mean Effective Consolidation Stress (kPa):	101
Initial Dry Density (t/m^3):	1.44	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	0.96



Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

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Triaxial Test Report

Isotropically Consolidated Drained (CID)

GOLDER

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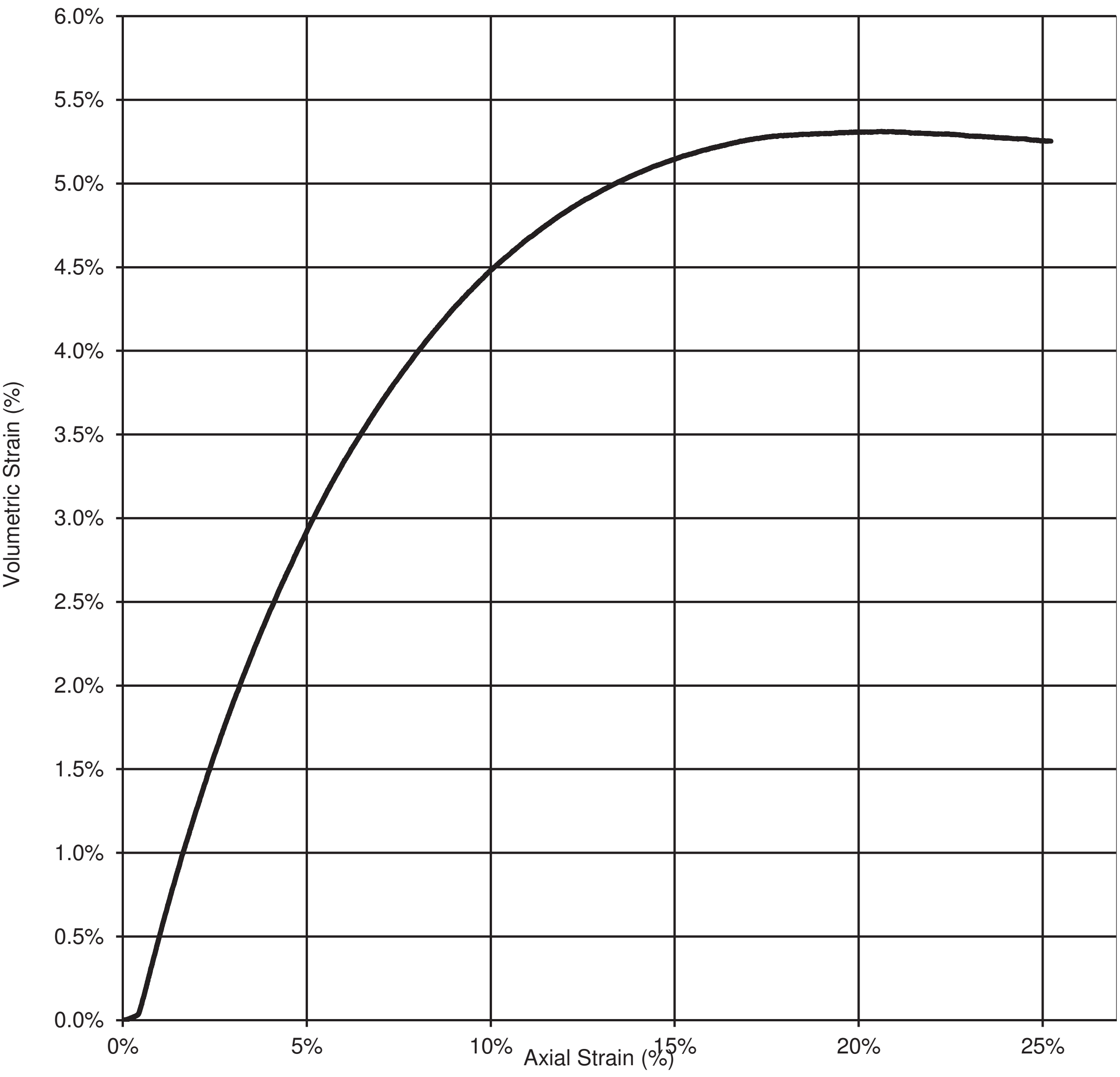
Client:	Broken Hill Operations Pty Ltd	**Date:**	30/05/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S1 Cyclone Feed - TX2

Initial Height (mm):	129.8	Final Liquor Content (%):	0.23	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	61.9	Final Dry Density (t/m^3):	1.78	B Response:	99%
Trimmings GWC (%)	0.048	Final Void Ratio	0.71	Mean Effective Consolidation Stress (kPa)	101
Initial Dry Density (t/m^3):	1.44	Final Liquor Solids Conc. (g/L)	-	Geostatic Stress Ratio K_0	0.96



Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

Triaxial Test Report

Isotropically Consolidated Drained (CID)

GOLDER
Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	30/05/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S1 Cyclone Feed - TX2

Initial Height (mm):	129.8	Final Liquor Content (%):	23.3%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	61.9	Final Dry Density (t/m^3):	1.78	B Response (%):	99%
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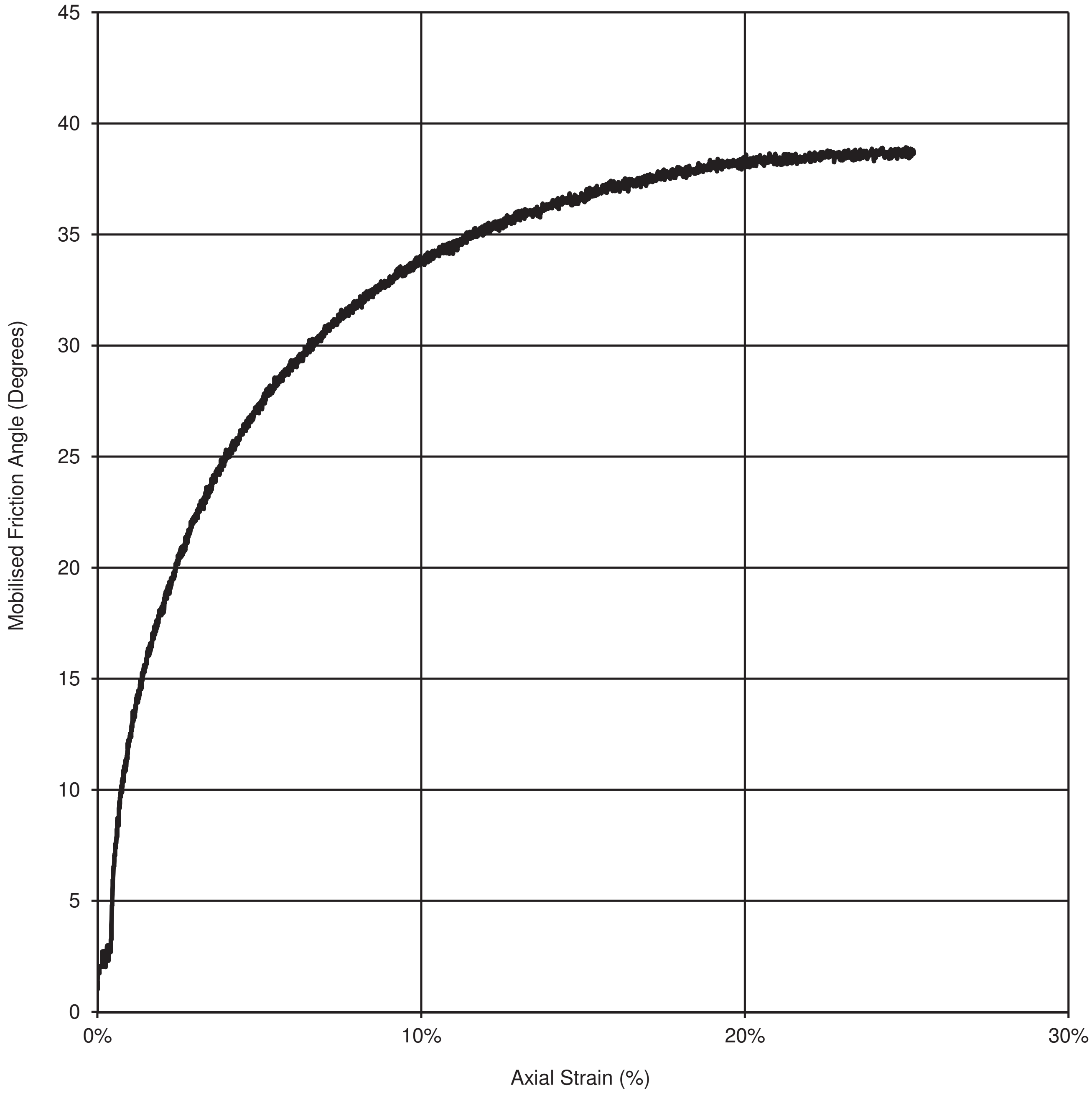


Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

Triaxial Test Report

Isotropically Consolidated Drained (CID)

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	30/05/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S1 Cyclone Feed - TX3

Initial Height (mm):	130.4	Final Liquor Content (%):	21.9%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	61.7	Final Dry Density (t/m^3):	1.83	B Response (%):	99%
Trimmings GWC (%):	4.8%	Final Void Ratio (-):	0.67	Mean Effective Consolidation Stress (kPa):	300
Initial Dry Density (t/m^3):	1.45	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	0.99

Sample Before Test

Sample After Test

Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

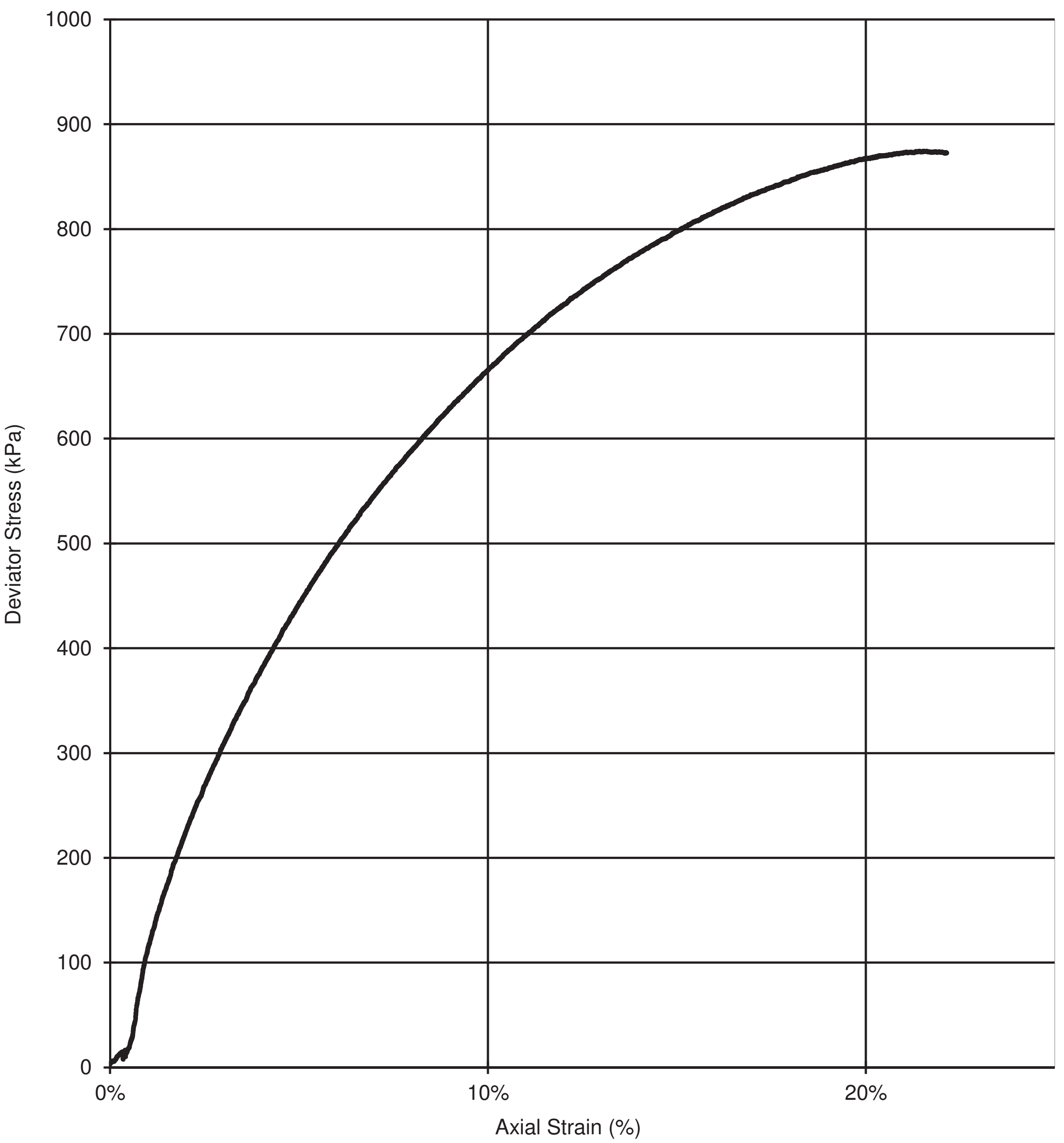
Triaxial Test Report

Isotropically Consolidated Drained (CID)

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	30/05/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S1 Cyclone Feed - TX3

Initial Height (mm):	130.4	Final Liquor Content (%):	21.9%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	61.7	Final Dry Density (t/m^3):	1.83	B Response (%):	99%
Trimmings GWC (%):	4.8%	Final Void Ratio (-):	0.67	Mean Effective Consolidation Stress (kPa):	300
Initial Dry Density (t/m^3):	1.45	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	0.99



Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

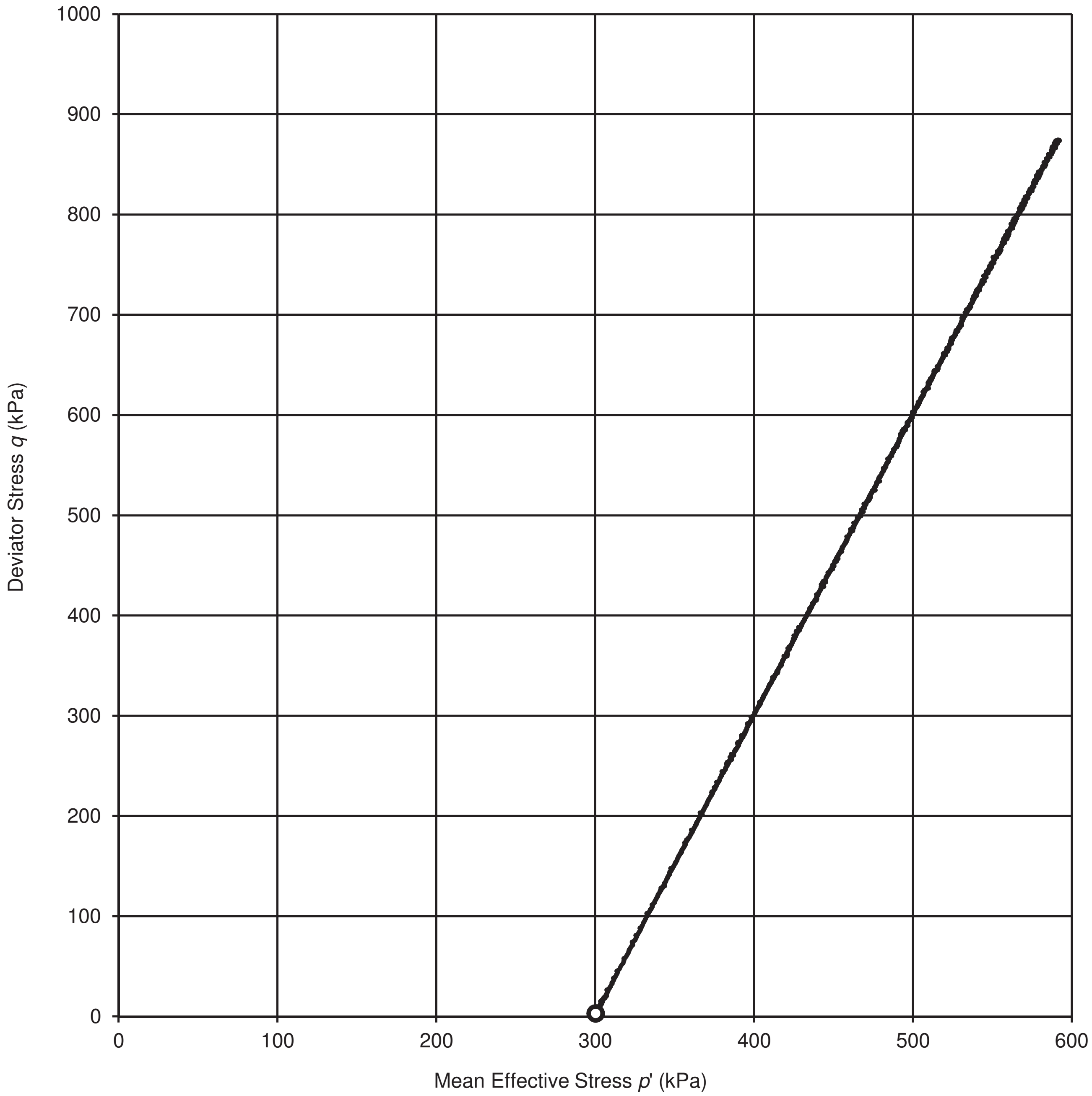
Triaxial Test Report

Isotropically Consolidated Drained (CID)

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	30/05/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S1 Cyclone Feed - TX3

Initial Height (mm):	130.4	Final Liquor Content (%):	21.9%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	61.7	Final Dry Density (t/m^3):	1.83	B Response (%):	99%
Trimmings GWC (%):	4.8%	Final Void Ratio (-):	0.67	Mean Effective Consolidation Stress (kPa):	300
Initial Dry Density (t/m^3):	1.45	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	0.99



Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

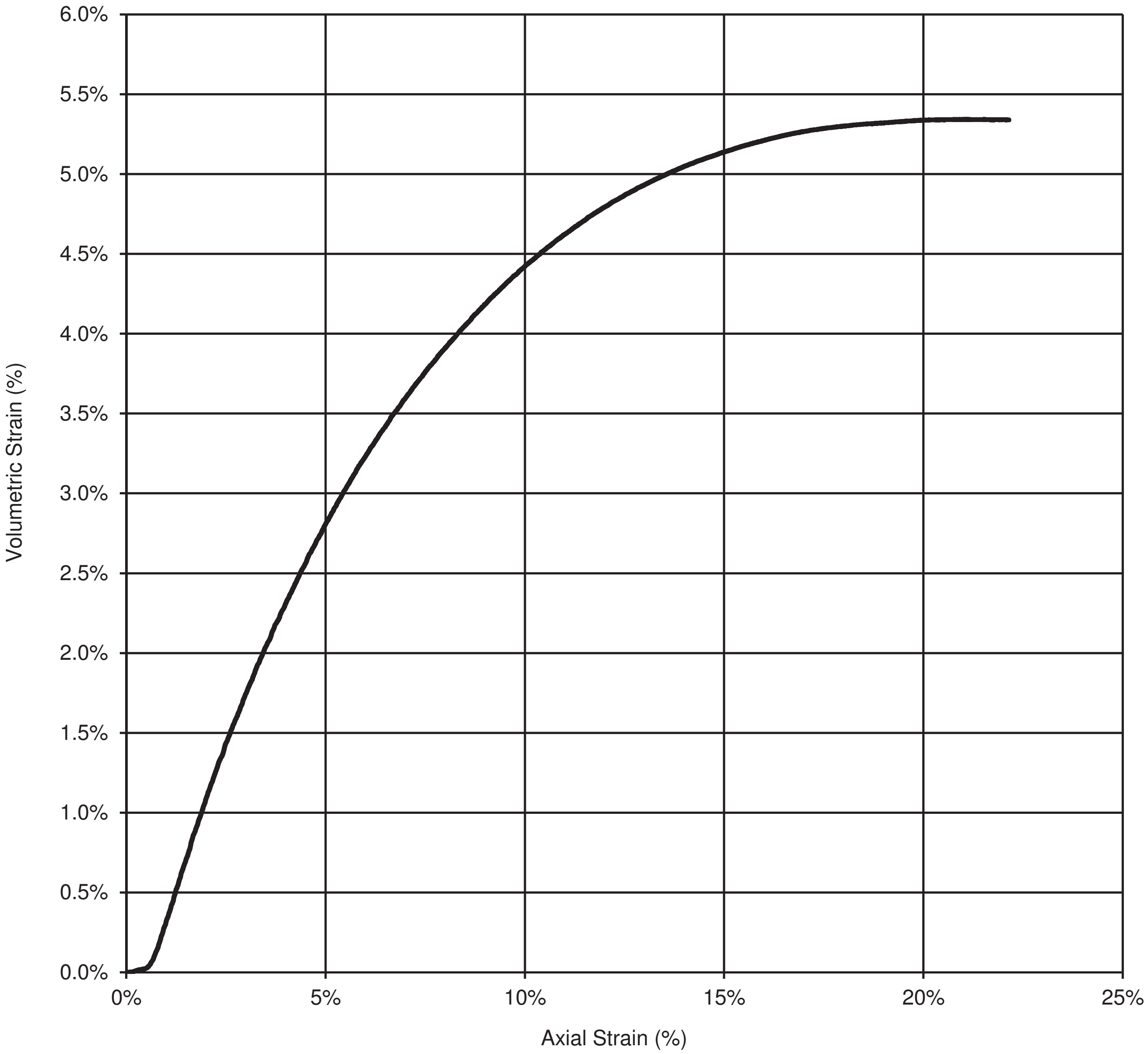
Triaxial Test Report

Isotropically Consolidated Drained (CID)

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	30/05/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S1 Cyclone Feed - TX3

Initial Height (mm):	130.4	Final Liquor Content (%):	0.22	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	61.7	Final Dry Density (t/m^3):	1.83	B Response:	99%
Trimmings GWC (%)	0.048	Final Void Ratio	0.67	Mean Effective Consolidation Stress (kPa)	300
Initial Dry Density (t/m^3):	1.45	Final Liquor Solids Conc. (g/L)	-	Geostatic Stress Ratio K_0	0.99



Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

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Triaxial Test Report

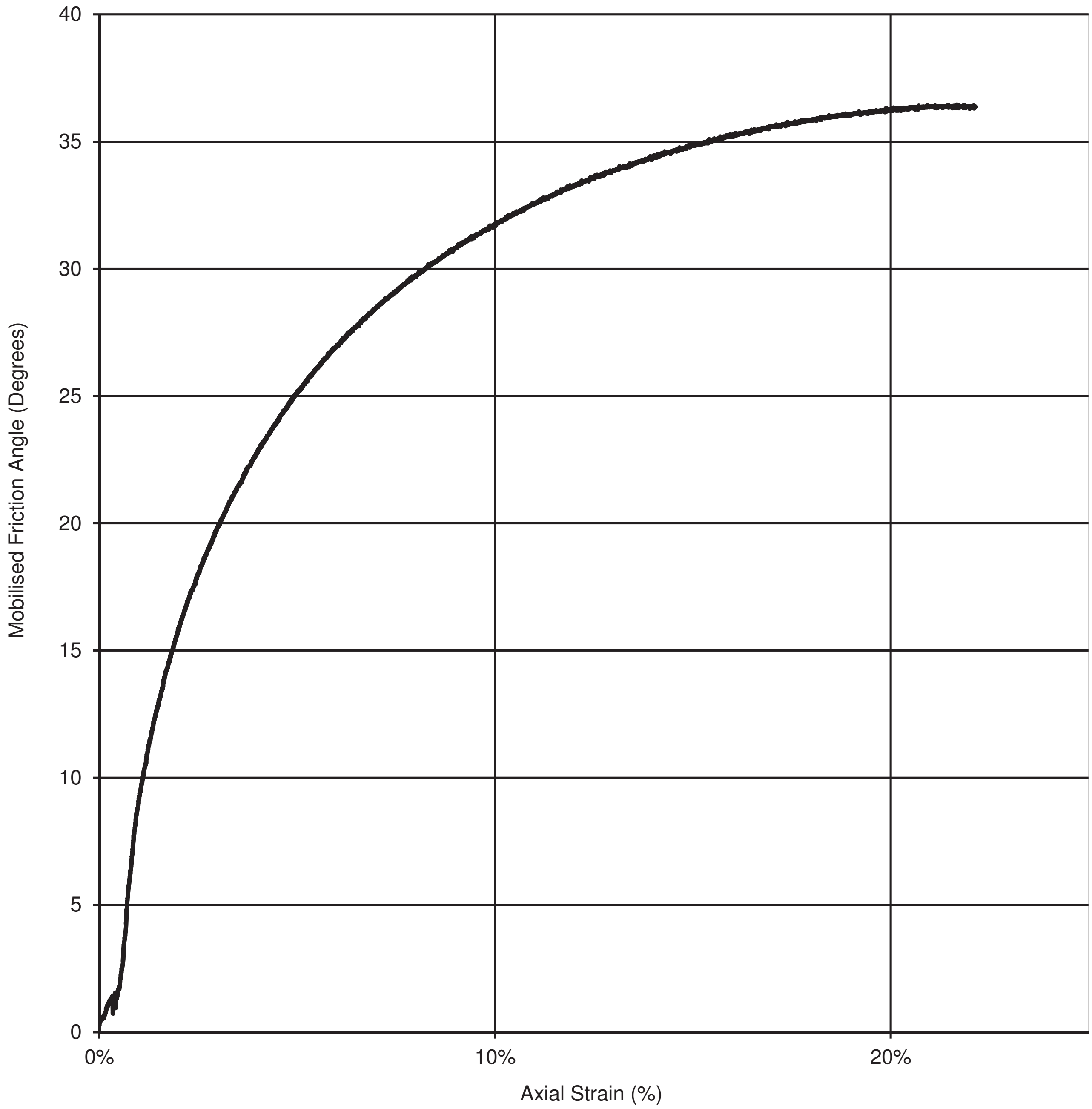
Isotropically Consolidated Drained (CID)

GOLDER

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	30/05/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S1 Cyclone Feed - TX3

Initial Height (mm):	130.4	Final Liquor Content (%):	22%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	61.7	Final Dry Density (t/m^3):	1.83	B Response (%):	99%
Trimmings GWC (%):	5%	Final Void Ratio (-):	0.67	Mean Effective Consolidation Stress (kPa):	300
Initial Dry Density (t/m^3):	1.45	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	0.99



Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

Triaxial Test Report

Isotropically Consolidated Undrained (CIU)

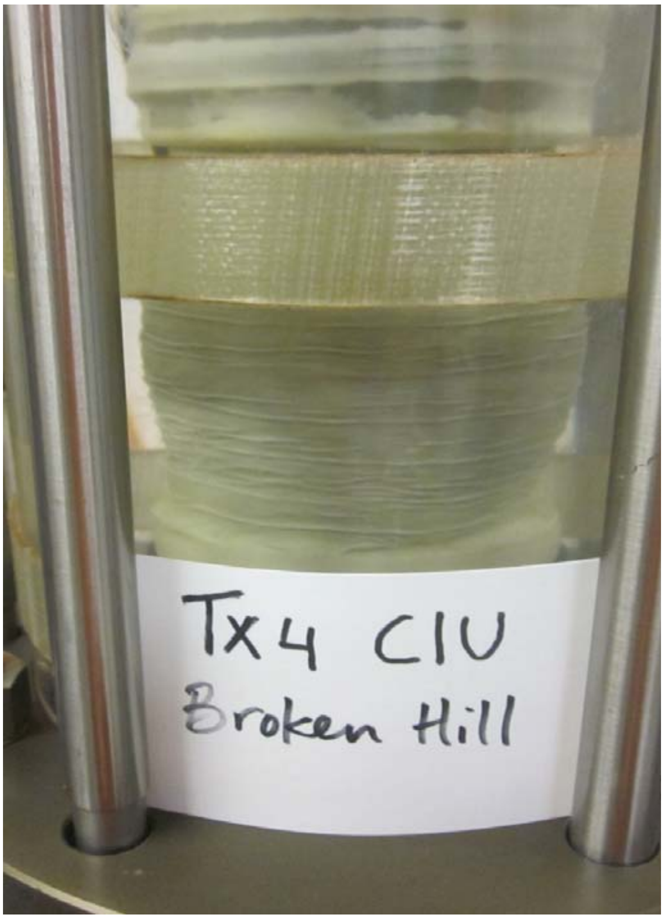
GOLDER

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	30/05/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S1 Cyclone Feed - TX4

Initial Height (mm):	129.1	Final Liquor Content (%):	25.1%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	61.8	Final Dry Density (t/m^3):	1.72	B Response (%):	99%
Trimmings GWC (%):	4.8%	Final Void Ratio (-):	0.76	Mean Effective Consolidation Stress (kPa):	301
Initial Dry Density (t/m^3):	1.45	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	1.00

Sample Before Test



Sample After Test

Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

Triaxial Test Report

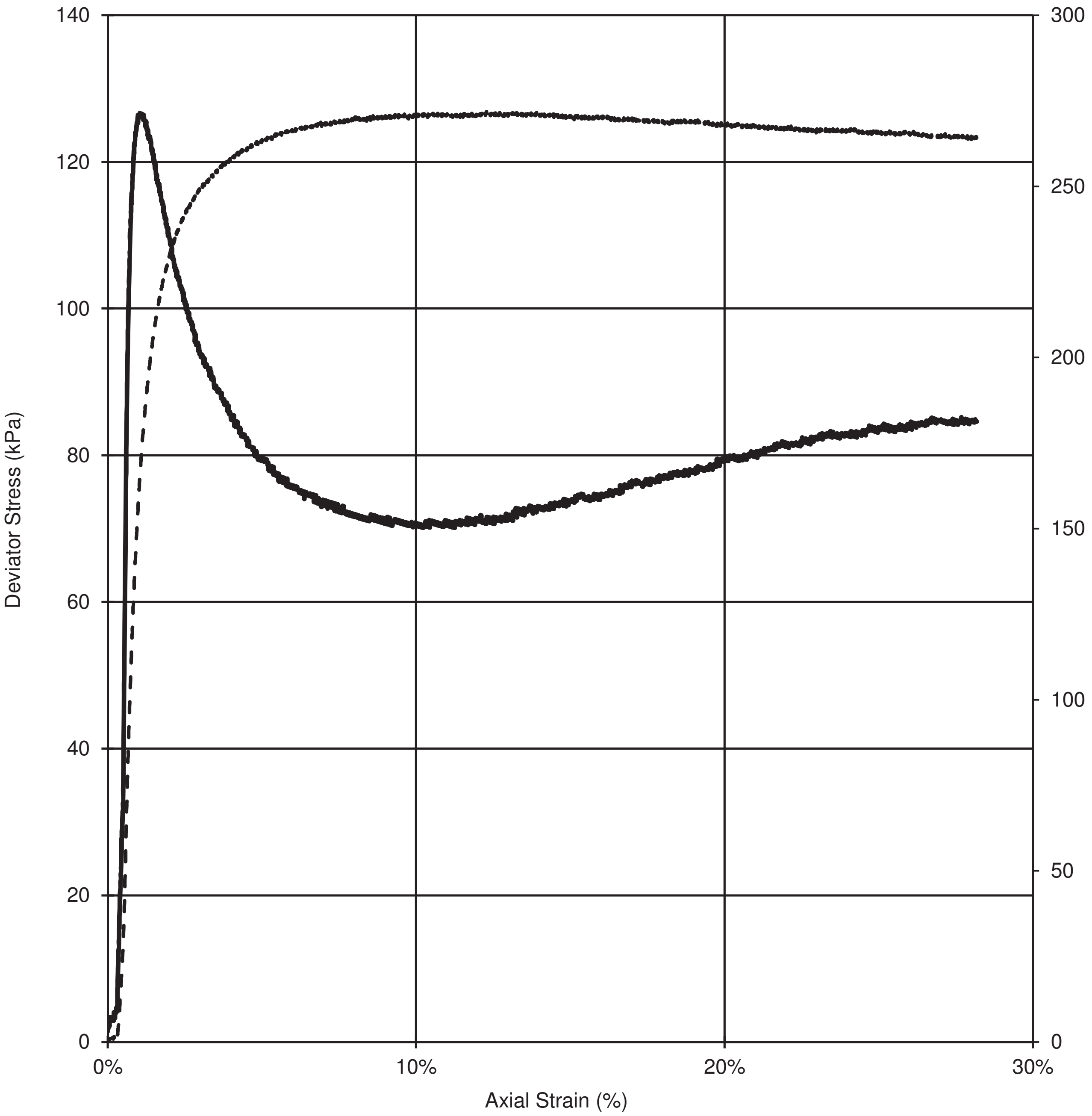
Isotropically Consolidated Undrained (CIU)

GOLDER

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	30/05/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S1 Cyclone Feed - TX4

Initial Height (mm):	129.1	Final Liquor Content (%):	25.1%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	61.8	Final Dry Density (t/m^3):	1.72	B Response (%):	99%
Trimmings GWC (%):	4.8%	Final Void Ratio (-):	0.76	Mean Effective Consolidation Stress (kPa):	301
Initial Dry Density (t/m^3):	1.45	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	1.00



Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

THIS DOCUMENT SHALL ONLY BE REPRODUCED IN FULL

Triaxial Test Report

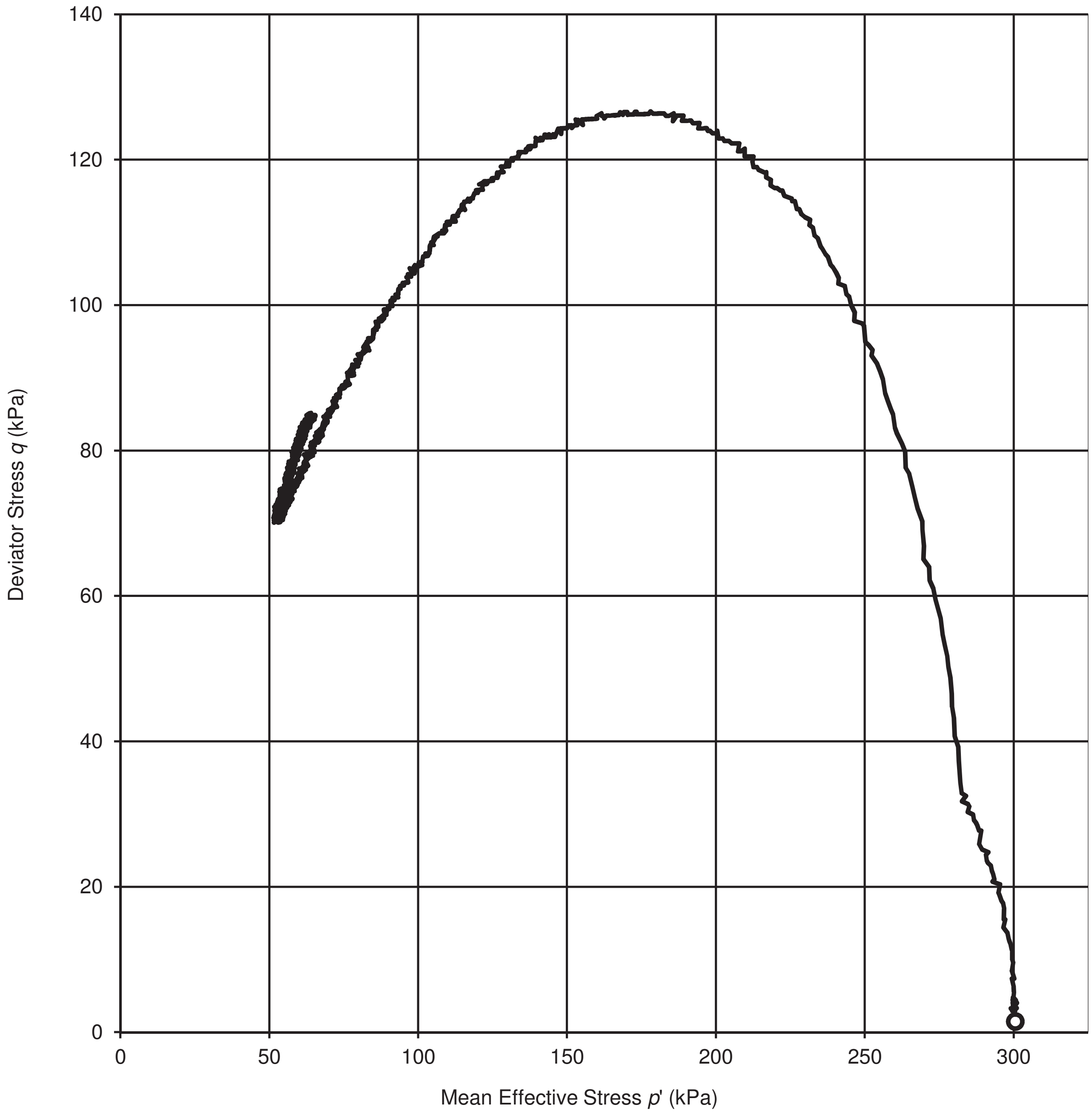
Isotropically Consolidated Undrained (CIU)

GOLDER

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	30/05/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S1 Cyclone Feed - TX4

Initial Height (mm):	129.1	Final Liquor Content (%):	25.1%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	61.8	Final Dry Density (t/m^3):	1.72	B Response (%):	99%
Trimmings GWC (%):	4.8%	Final Void Ratio (-):	0.76	Mean Effective Consolidation Stress (kPa):	301
Initial Dry Density (t/m^3):	1.45	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	1.00



Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

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Triaxial Test Report

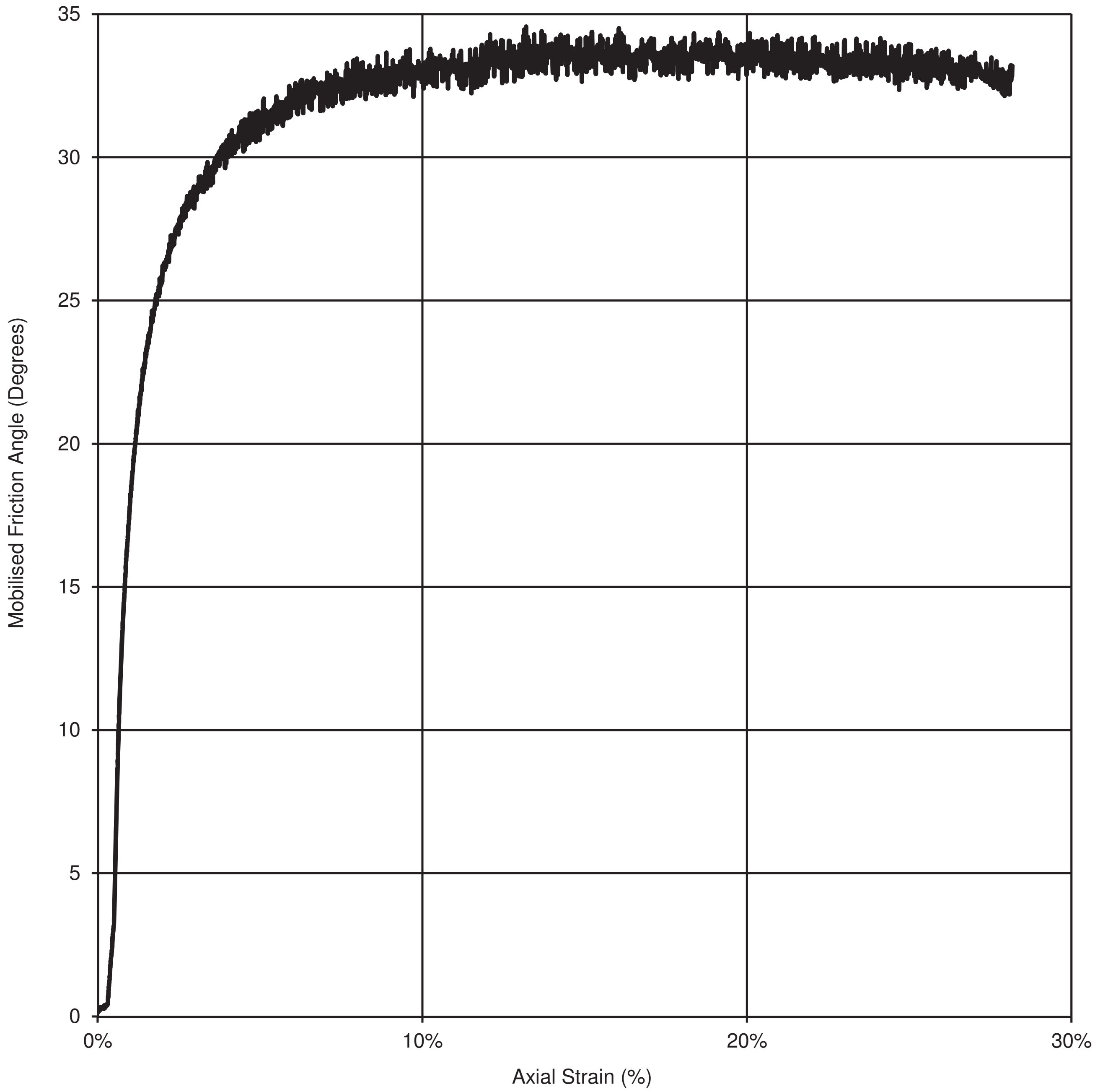
Isotropically Consolidated Undrained (CIU)

GOLDER

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	30/05/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S1 Cyclone Feed - TX4

Initial Height (mm):	129.1	Final Liquor Content (%):	25.1%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	61.8	Final Dry Density (t/m^3):	1.72	B Response (%):	99%
Trimmings GWC (%):	4.8%	Final Void Ratio (-):	0.76	Mean Effective Consolidation Stress (kPa):	301
Initial Dry Density (t/m^3):	1.45	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	1.00



Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

Triaxial Test Report

Isotropically Consolidated Drained (CID)

GOLDER
Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	2/06/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S2 Thickener U/F - TX1

Initial Height (mm):	128.6	Final Liquor Content (%):	27.2%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	59.4	Final Dry Density (t/m^3):	1.66	B Response (%):	99%
Trimmings GWC (%):	11.4%	Final Void Ratio (-):	0.82	Mean Effective Consolidation Stress (kPa):	101
Initial Dry Density (t/m^3):	1.17	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	0.96

Sample Before Test

Sample After Test

Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

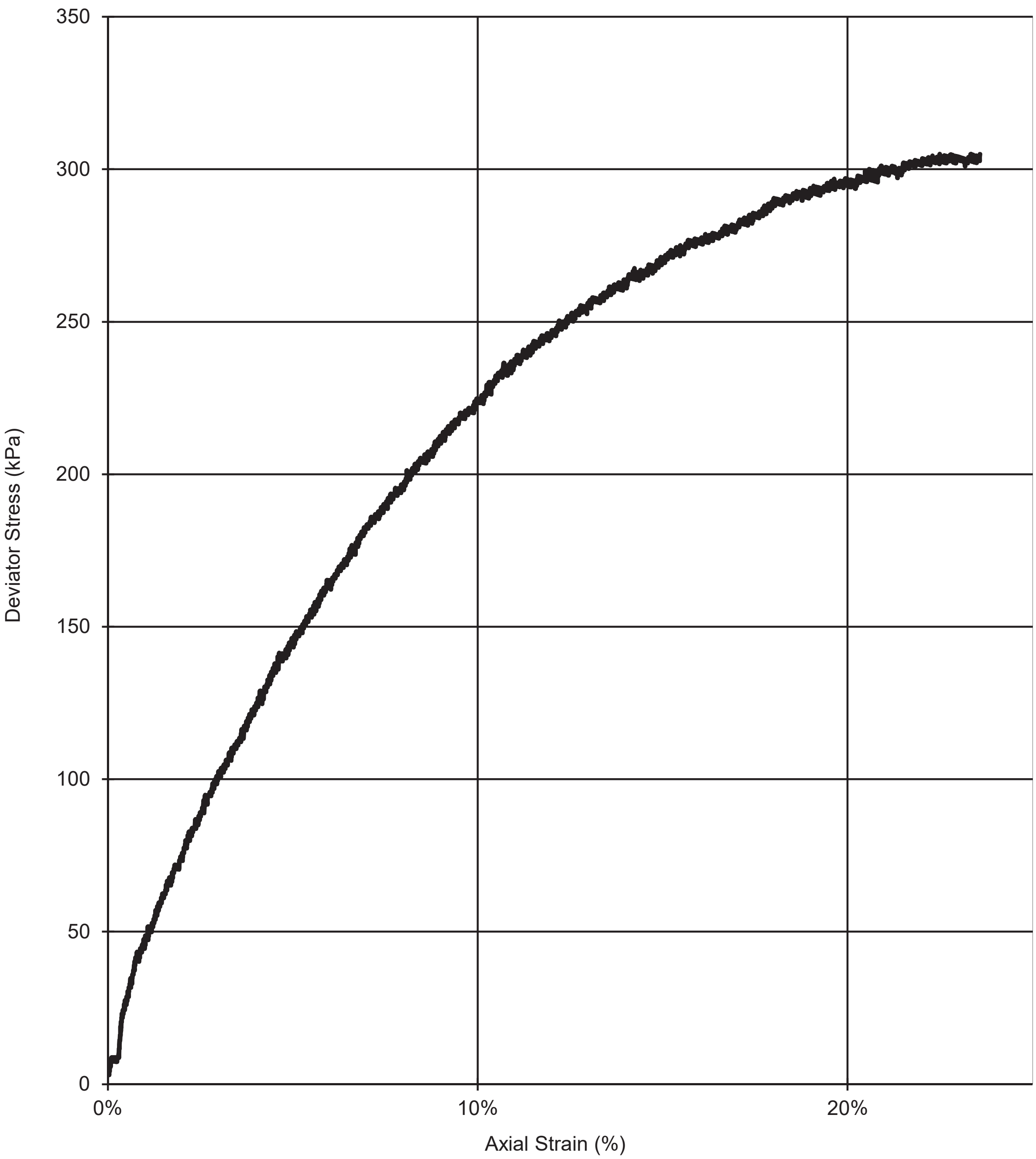
Triaxial Test Report

Isotropically Consolidated Drained (CID)

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	2/06/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S2 Thickener U/F - TX1

Initial Height (mm):	128.6	Final Liquor Content (%):	27.2%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	59.4	Final Dry Density (t/m^3):	1.66	B Response (%):	99%
Trimmings GWC (%):	11.4%	Final Void Ratio (-):	0.82	Mean Effective Consolidation Stress (kPa):	101
Initial Dry Density (t/m^3):	1.17	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	0.96



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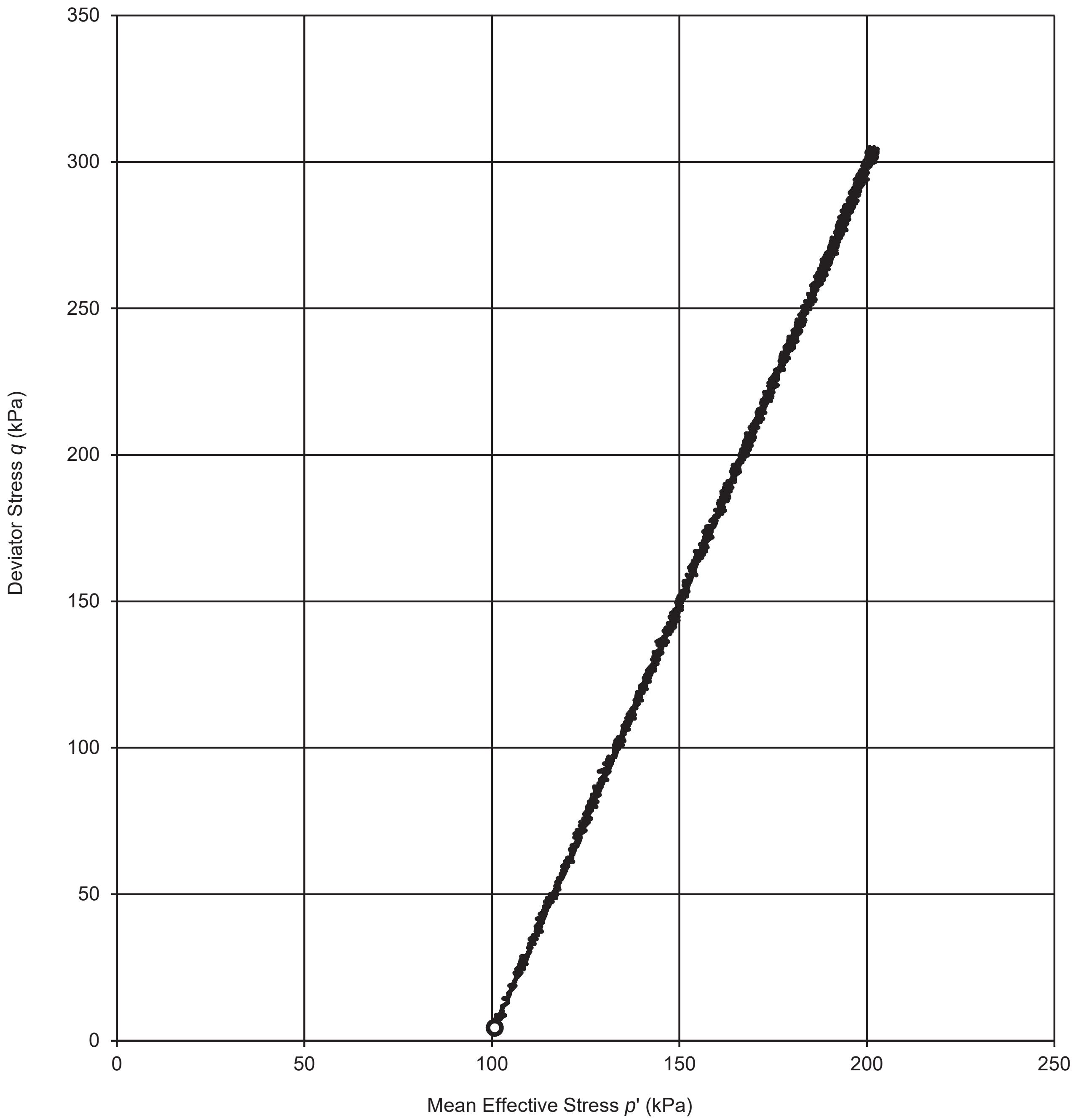
Triaxial Test Report

Isotropically Consolidated Drained (CID)

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	2/06/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S2 Thickener U/F - TX1

Initial Height (mm):	128.6	Final Liquor Content (%):	27.2%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	59.4	Final Dry Density (t/m^3):	1.66	B Response (%):	99%
Trimmings GWC (%):	11.4%	Final Void Ratio (-):	0.82	Mean Effective Consolidation Stress (kPa):	101
Initial Dry Density (t/m^3):	1.17	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	0.96



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		Reviewed by:	R. Fanni

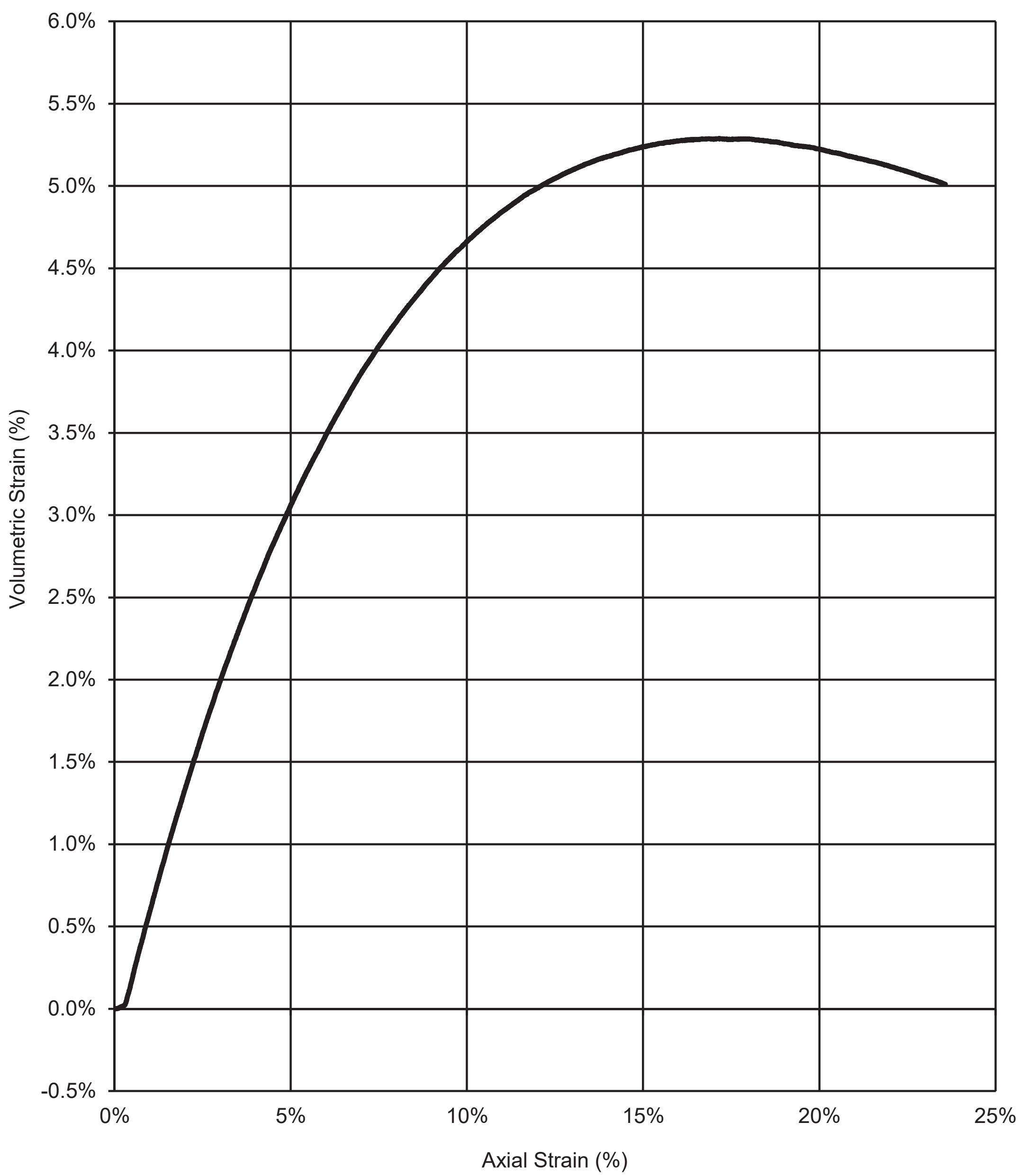
Triaxial Test Report

Isotropically Consolidated Drained (CID)

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	2/06/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S2 Thickener U/F - TX1

Initial Height (mm):	128.6	Final Liquor Content (%):	0.27	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	59.4	Final Dry Density (t/m^3):	1.66	B Response:	99%
Trimmings GWC (%)	0.1144	Final Void Ratio	0.82	Mean Effective Consolidation Stress (kPa	101
Initial Dry Density (t/m^3):	1.17	Final Liquor Solids Conc. (g/L	-	Geostatic Stress Ratio K_0	0.96



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		Reviewed by:	R. Fanni

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Triaxial Test Report

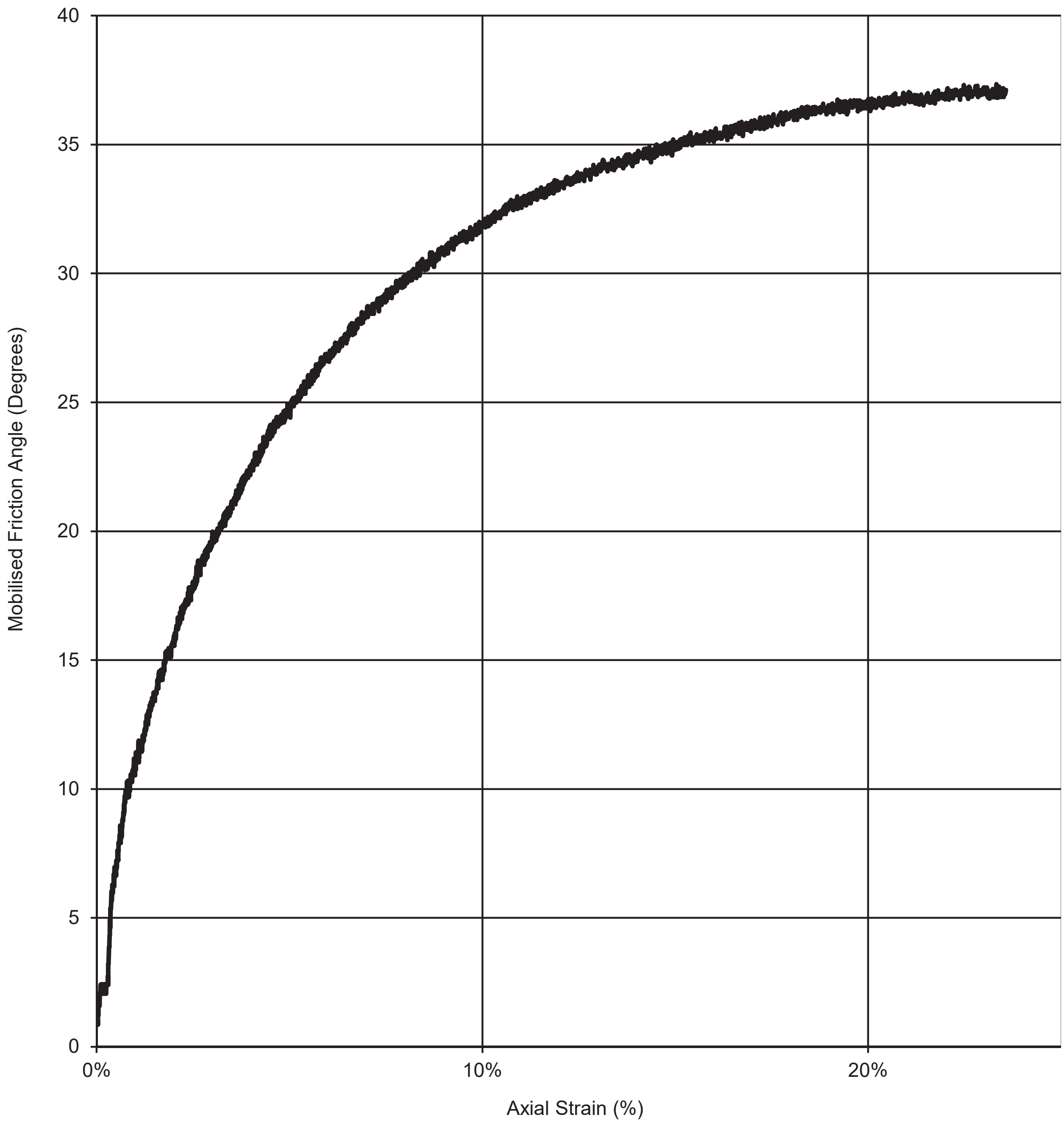
Isotropically Consolidated Drained (CID)

GOLDER

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	2/06/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S2 Thickener U/F - TX1

Initial Height (mm):	128.6	Final Liquor Content (%):	27.2%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	59.4	Final Dry Density (t/m^3):	1.66	B Response (%):	99%
Trimmings GWC (%):	11.4%	Final Void Ratio (-):	0.82	Mean Effective Consolidation Stress (kPa):	101
Initial Dry Density (t/m^3):	1.17	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	0.96



Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

Triaxial Test Report

Isotropically Consolidated Drained (CID)

GOLDER
Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	3/06/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S2 Thickener U/F - TX2

Initial Height (mm):	123.8	Final Liquor Content (%):	25.5%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	56.3	Final Dry Density (t/m^3):	1.70	B Response (%):	99%
Trimmings GWC (%):	11.4%	Final Void Ratio (-):	0.77	Mean Effective Consolidation Stress (kPa):	301
Initial Dry Density (t/m^3):	1.23	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	0.99

Sample Before Test

Sample After Test

Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

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Triaxial Test Report

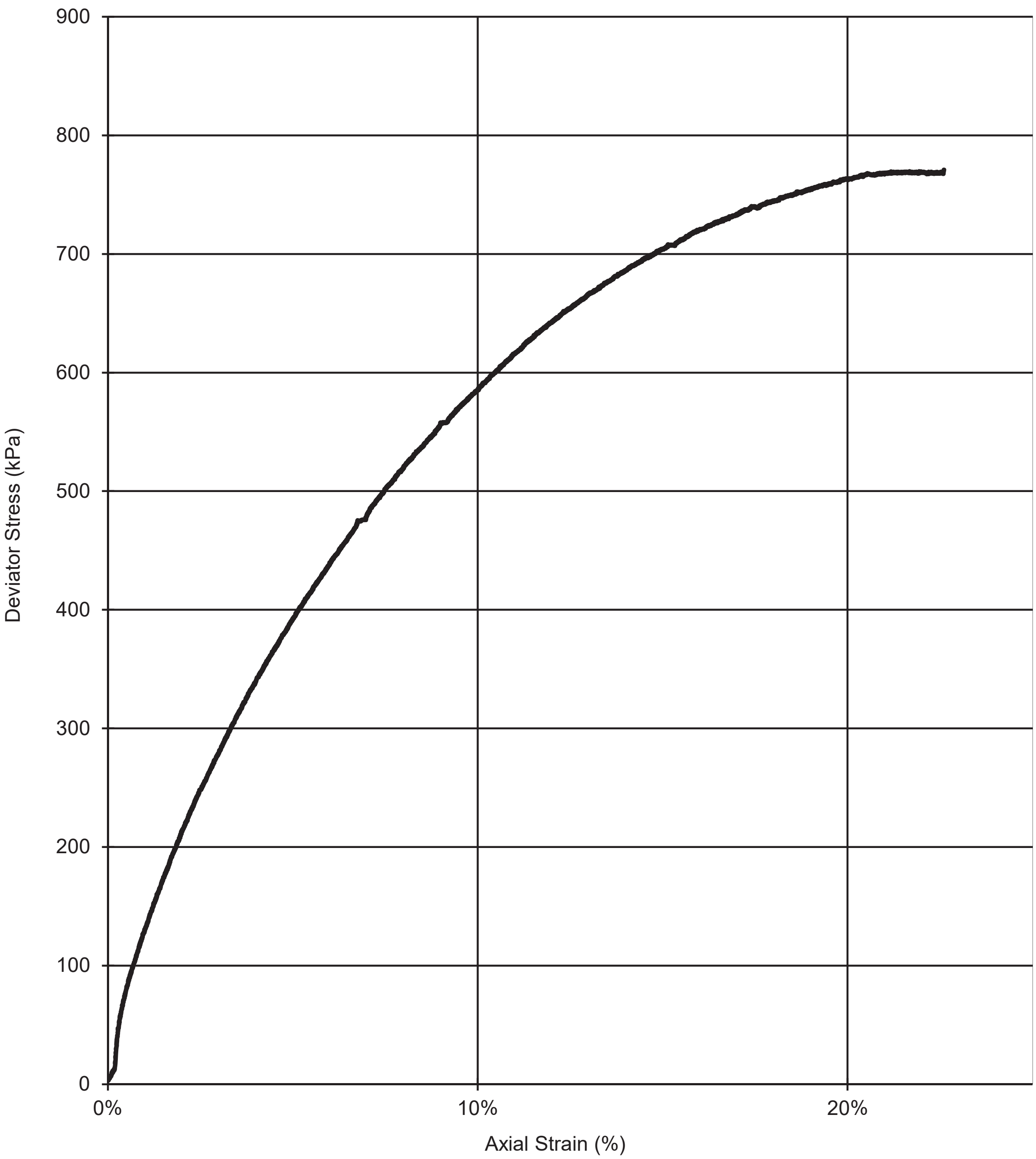
Isotropically Consolidated Drained (CID)

GOLDER

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	3/06/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S2 Thickener U/F - TX2

Initial Height (mm):	123.8	Final Liquor Content (%):	25.5%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	56.3	Final Dry Density (t/m^3):	1.70	B Response (%):	99%
Trimmings GWC (%):	11.4%	Final Void Ratio (-):	0.77	Mean Effective Consolidation Stress (kPa):	301
Initial Dry Density (t/m^3):	1.23	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	0.99



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Triaxial Test Report

Isotropically Consolidated Drained (CID)

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	3/06/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S2 Thickener U/F - TX2

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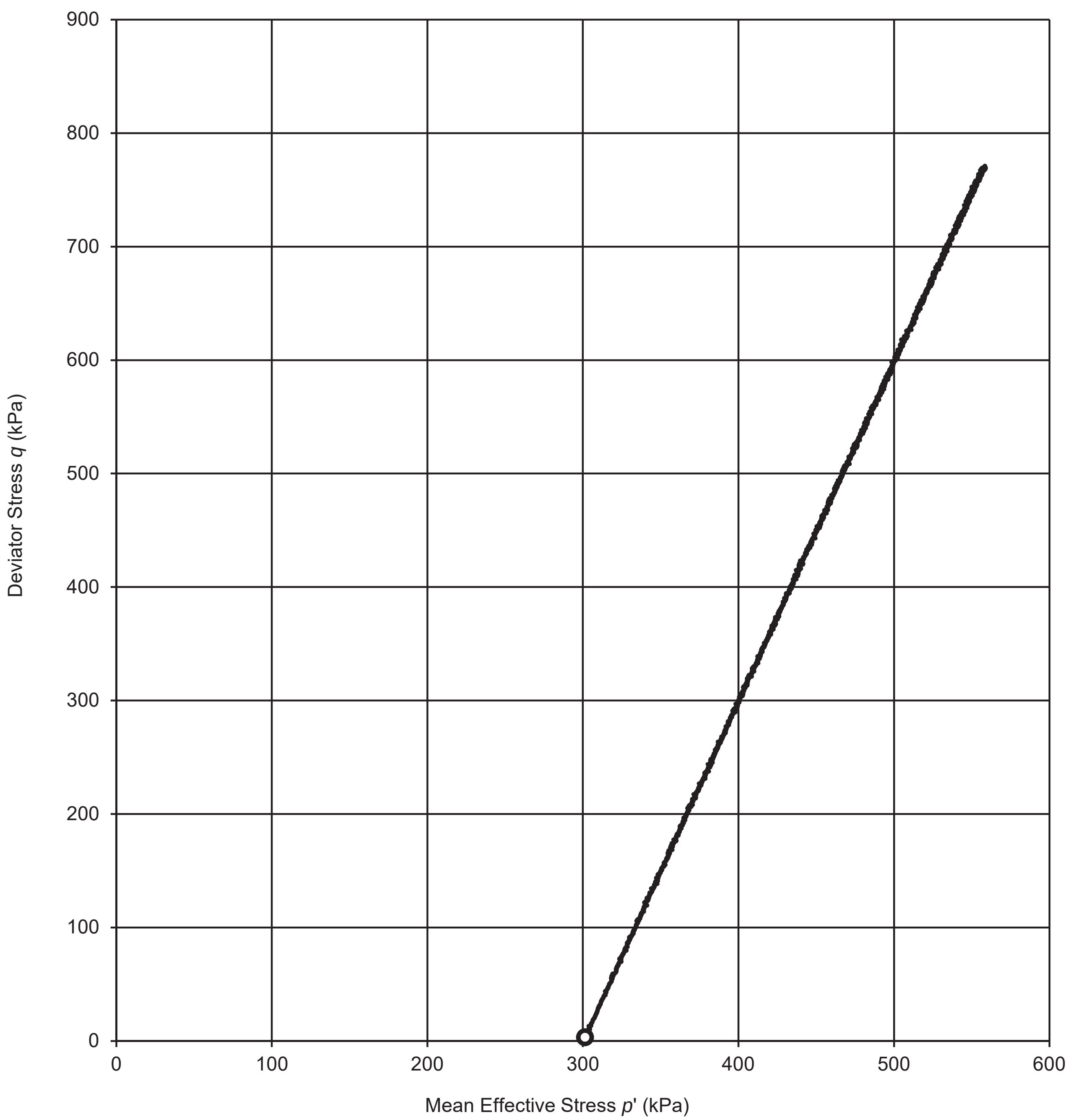
Trimmings GWC (%):	11.4%	Final Void Ratio (-):	0.77	Mean Effective Consolidation Stress (kPa):	301
Initial Dry Density (t/m^3):	1.23	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	0.99



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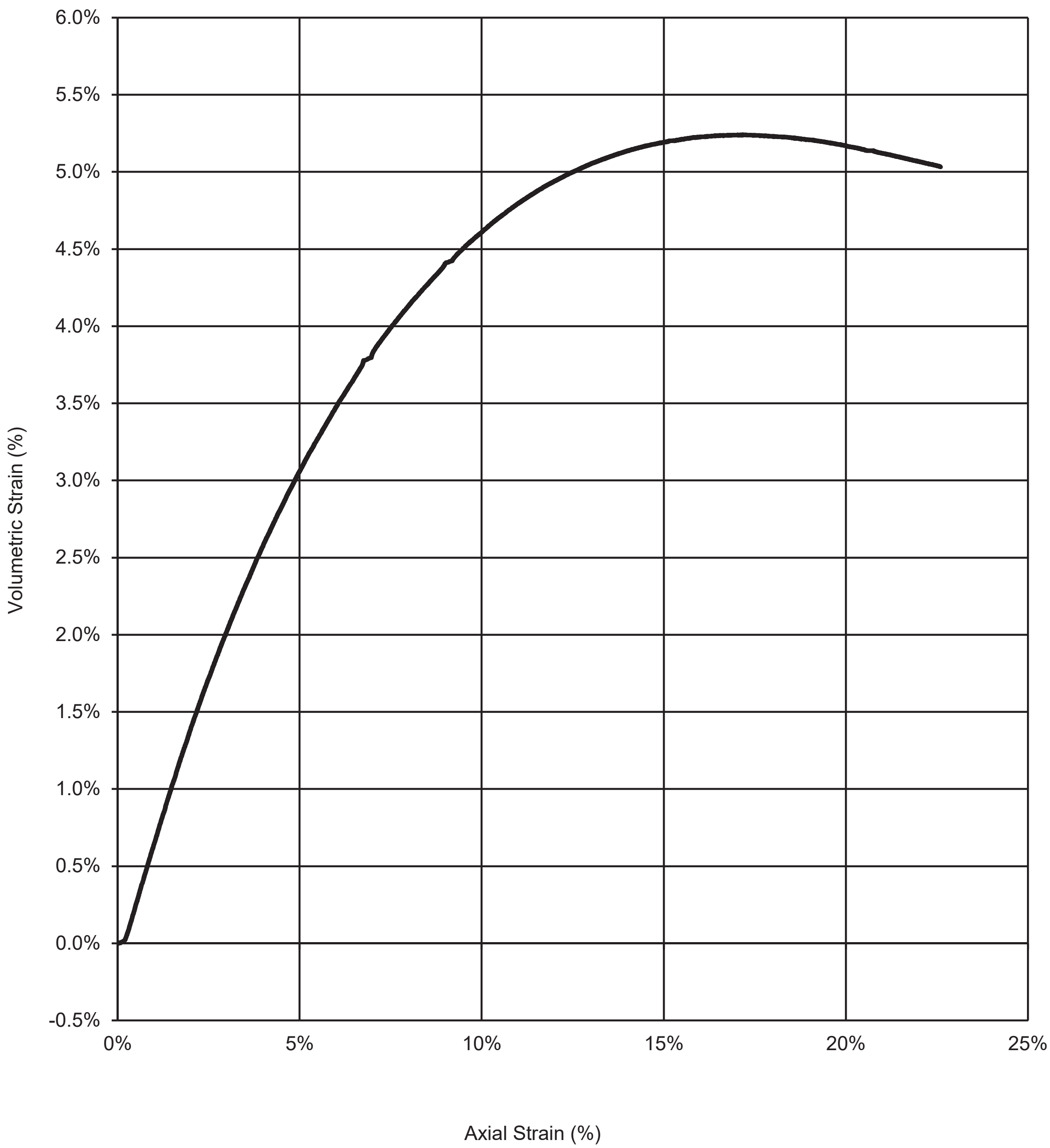
Triaxial Test Report

Isotropically Consolidated Drained (CID)

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	3/06/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S2 Thickener U/F - TX2

Initial Height (mm):	123.8	Final Liquor Content (%):	25.5%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	56.3	Final Dry Density (t/m^3):	1.70	B Response:	99%
Trimmings GWC (%)	0.1144	Final Void Ratio	0.77	Mean Effective Consolidation Stress (kPa)	301
Initial Dry Density (t/m^3):	1.23	Final Liquor Solids Conc. (g/L)	-	Geostatic Stress Ratio K_0	0.99



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Triaxial Test Report

Isotropically Consolidated Drained (CID)

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	3/06/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S2 Thickener U/F - TX2

Initial Height (mm):	123.8	Final Liquor Content (%):	25.5%	Strain Rate (mm/min):	0.03
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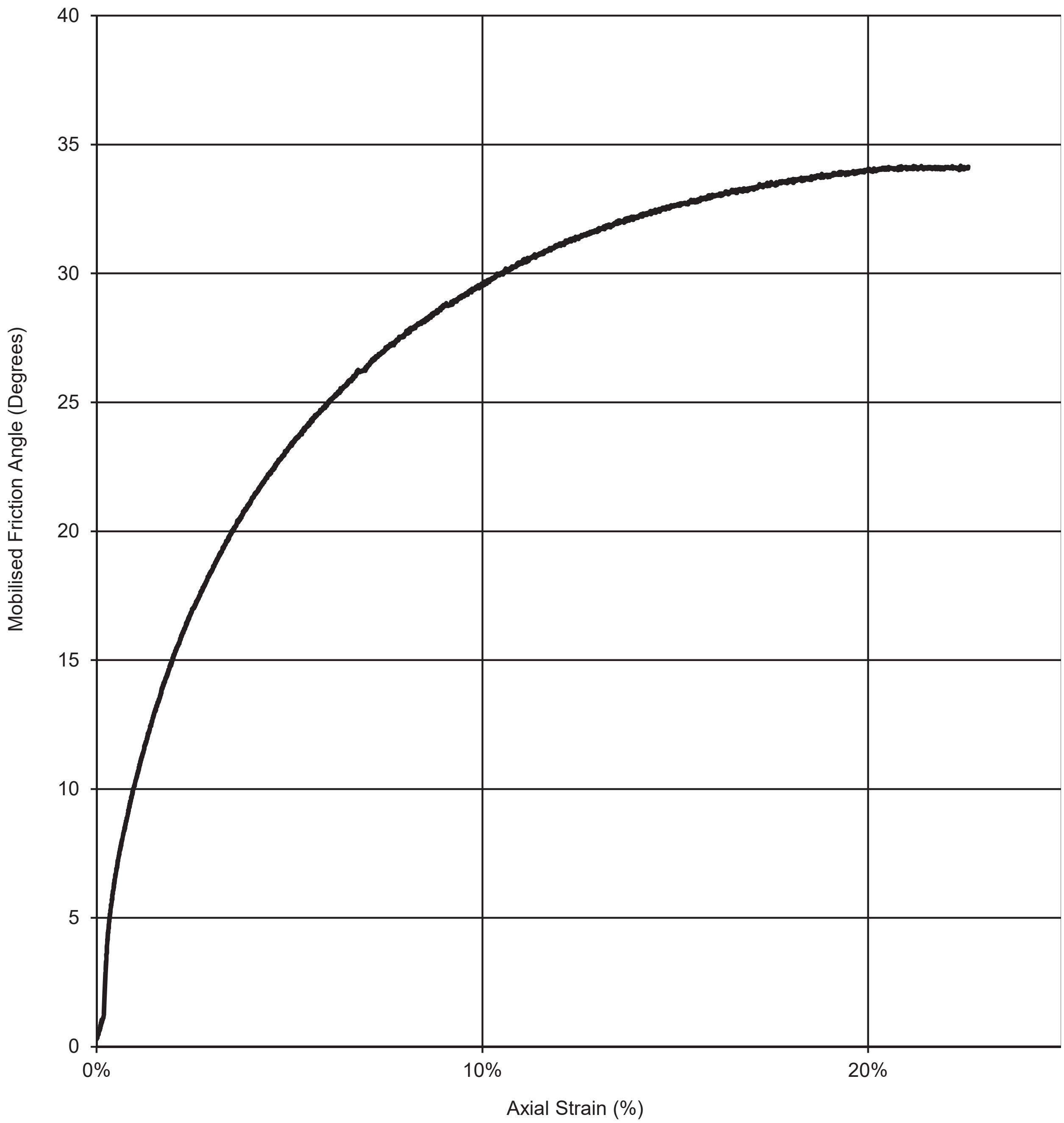
Trimmings GWC (%):	11.4%	Final Void Ratio (-):	0.77	Mean Effective Consolidation Stress (kPa):	301
Initial Dry Density (t/m^3):	1.23	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	0.99



Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
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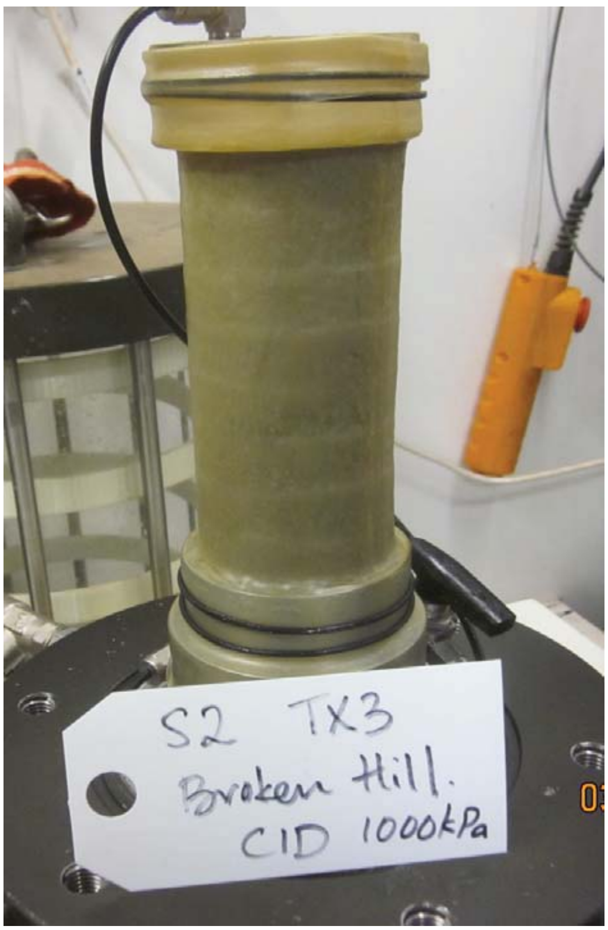
Triaxial Test Report

Isotropically Consolidated Drained (CID)

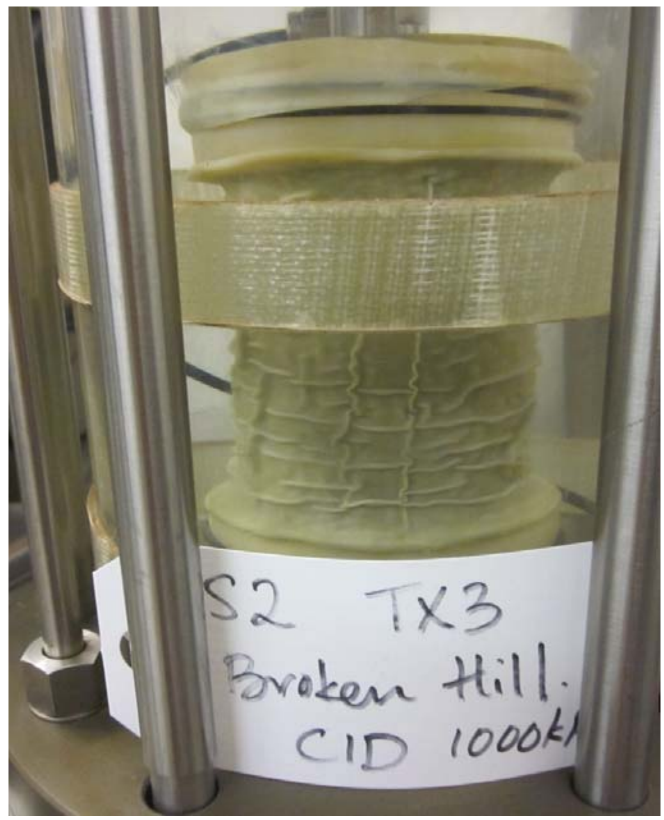
GOLDER
Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	4/06/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S2 Thickener U/F - TX3

Initial Height (mm):	128.3	Final Liquor Content (%):	23.4%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	59.2	Final Dry Density (t/m^3):	1.77	B Response (%):	99%
Trimmings GWC (%):	11.4%	Final Void Ratio (-):	0.70	Mean Effective Consolidation Stress (kPa):	1001
Initial Dry Density (t/m^3):	1.18	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	1.00



Sample Before Test



Sample After Test

Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

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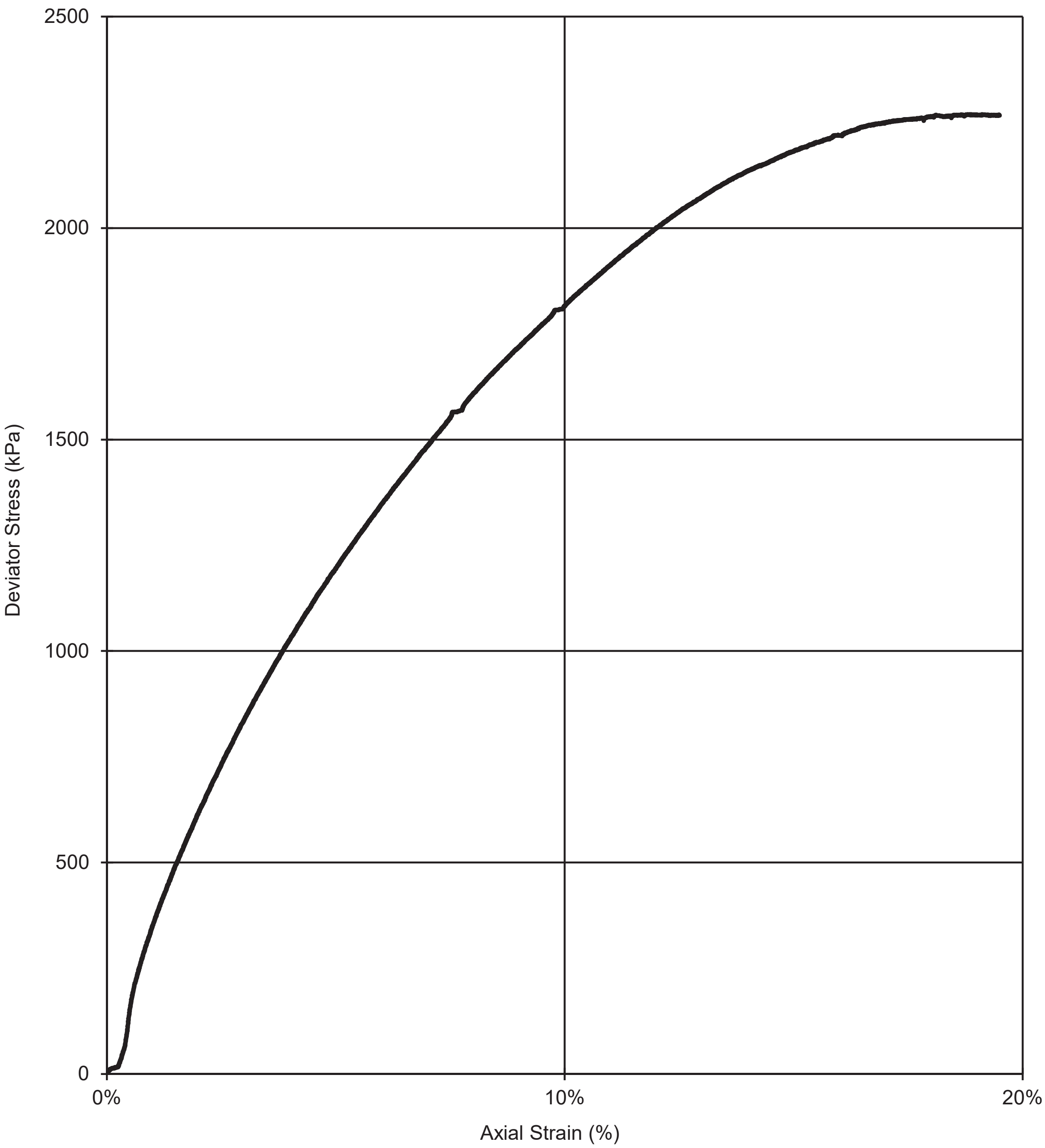
Triaxial Test Report

Isotropically Consolidated Drained (CID)

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	4/06/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S2 Thickener U/F - TX3

Initial Height (mm):	128.3	Final Liquor Content (%):	23.4%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	59.2	Final Dry Density (t/m^3):	1.77	B Response (%):	99%
Trimmings GWC (%):	11.4%	Final Void Ratio (-):	0.70	Mean Effective Consolidation Stress (kPa):	1001
Initial Dry Density (t/m^3):	1.18	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	1.00



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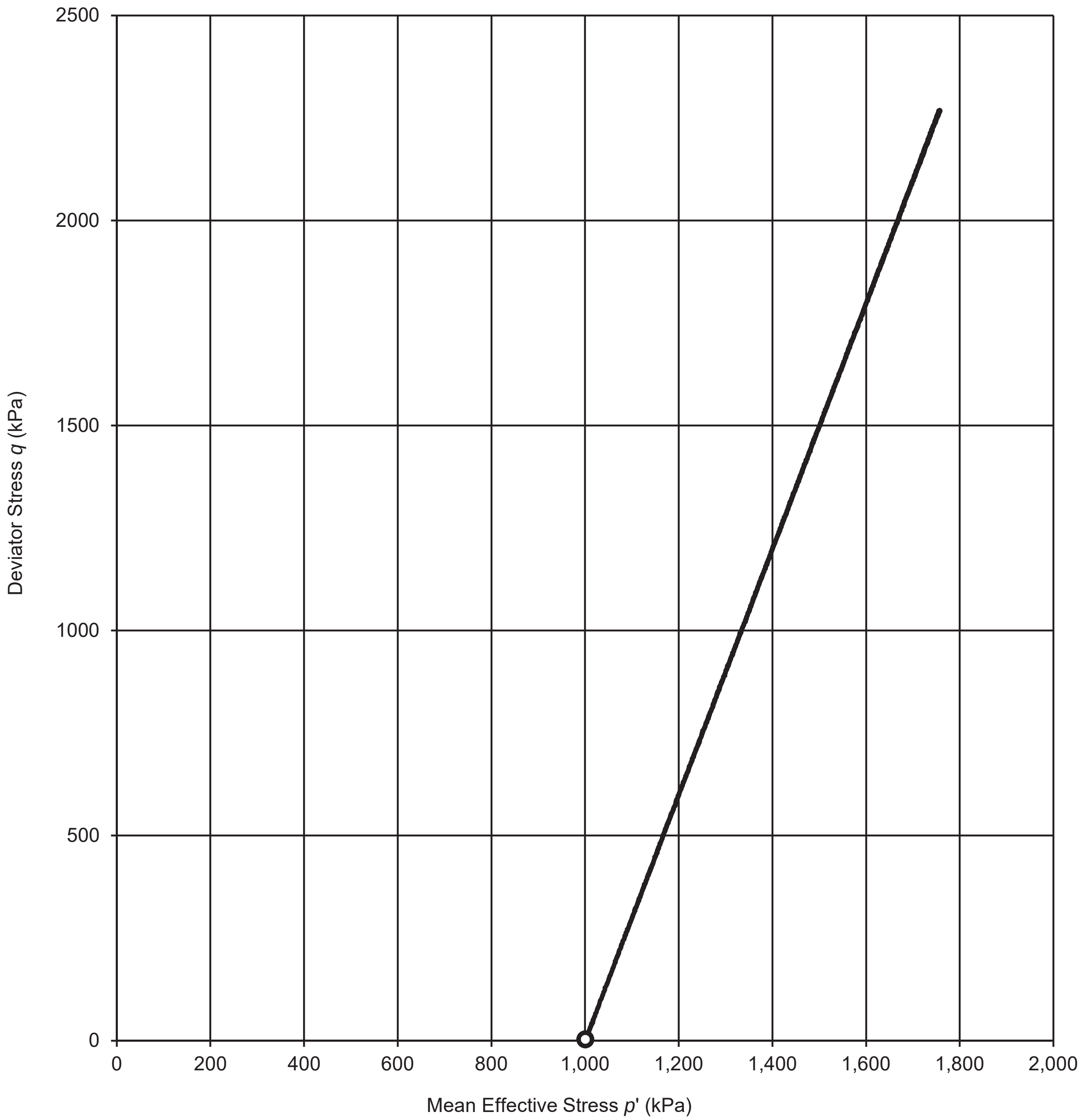
Triaxial Test Report

Isotropically Consolidated Drained (CID)

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	4/06/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S2 Thickener U/F - TX3

Initial Height (mm):	128.3	Final Liquor Content (%):	23.4%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	59.2	Final Dry Density (t/m^3):	1.77	B Response (%):	99%
Trimmings GWC (%):	11.4%	Final Void Ratio (-):	0.70	Mean Effective Consolidation Stress (kPa):	1001
Initial Dry Density (t/m^3):	1.18	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	1.00



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Triaxial Test Report

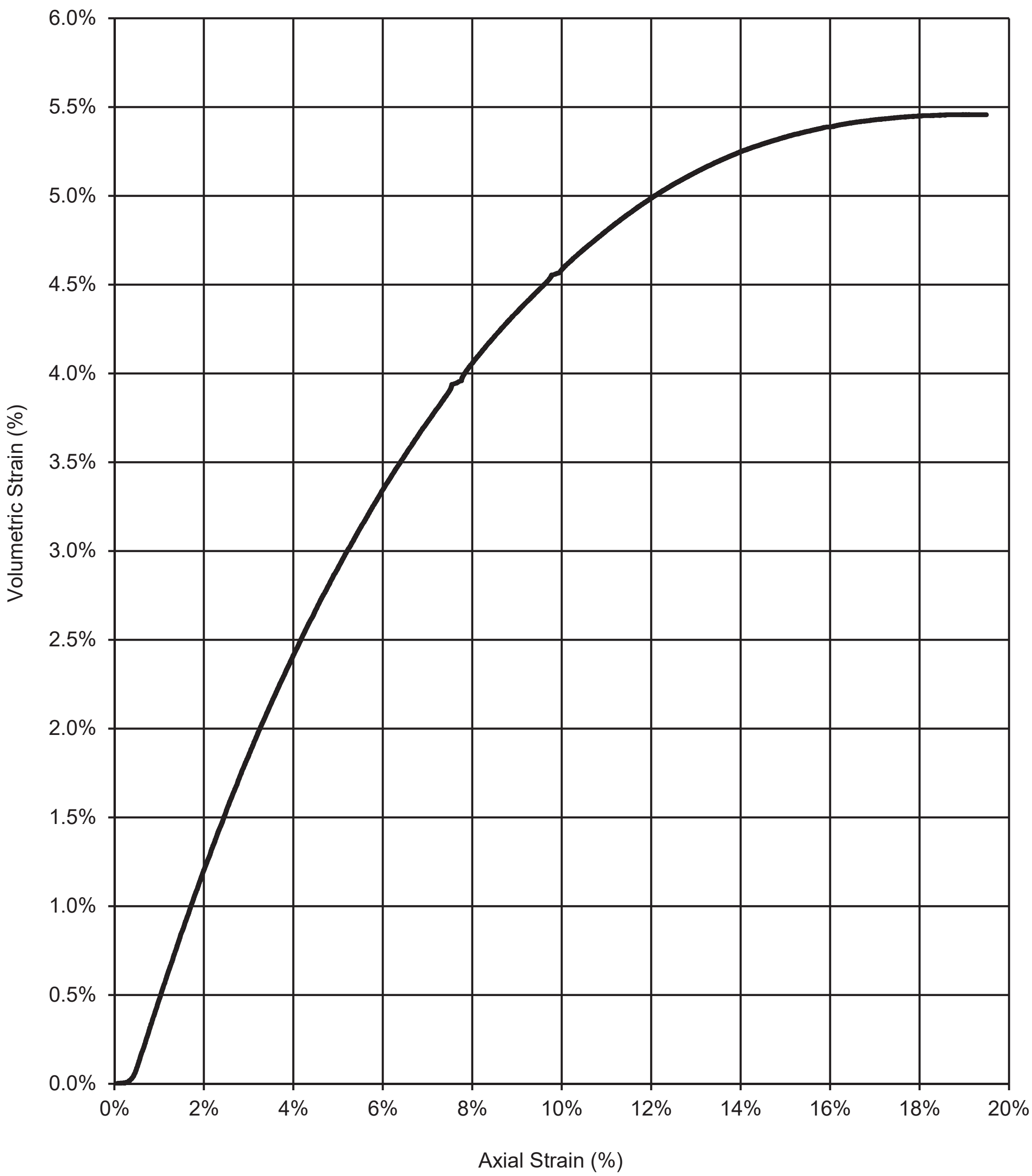
Isotropically Consolidated Drained (CID)

GOLDER

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	4/06/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S2 Thickener U/F - TX3

Initial Height (mm):	128.3	Final Liquor Content (%):	0.23	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	59.2	Final Dry Density (t/m^3):	1.77	B Response:	99%
Trimmings GWC (%)	0.114	Final Void Ratio	0.70	Mean Effective Consolidation Stress (kPa	1001
Initial Dry Density (t/m^3):	1.18	Final Liquor Solids Conc. (g/L	-	Geostatic Stress Ratio K_0	1.00



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Triaxial Test Report

Isotropically Consolidated Drained (CID)

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	4/06/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S2 Thickener U/F - TX3

Initial Height (mm):	128.3	Final Liquor Content (%):	23.4%	Strain Rate (mm/min):	0.03
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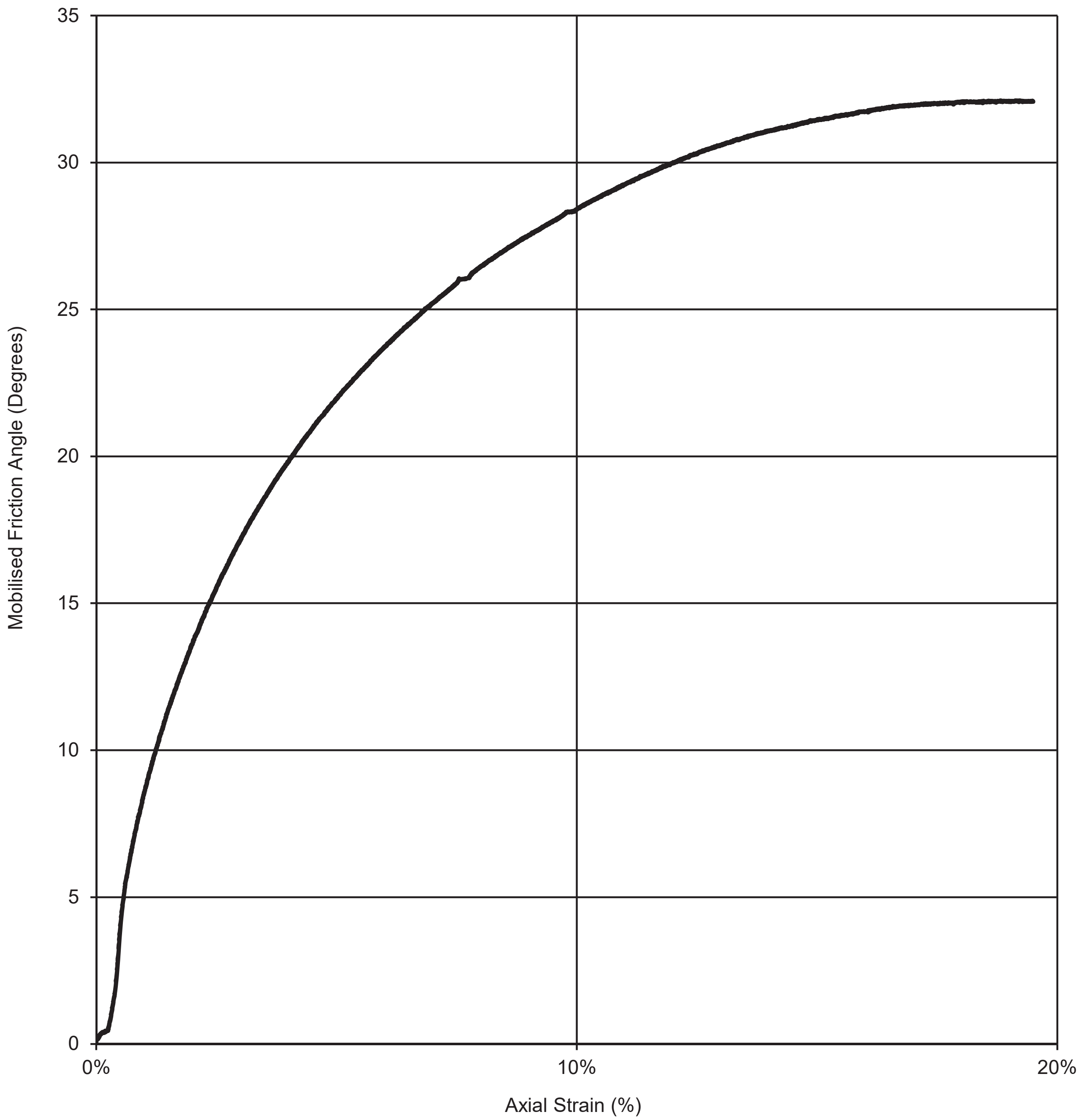
Trimmings GWC (%):	11.4%	Final Void Ratio (-):	0.70	Mean Effective Consolidation Stress (kPa):	1001
Initial Dry Density (t/m^3):	1.18	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	1.00



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		Reviewed by:	R. Fanni

Triaxial Test Report

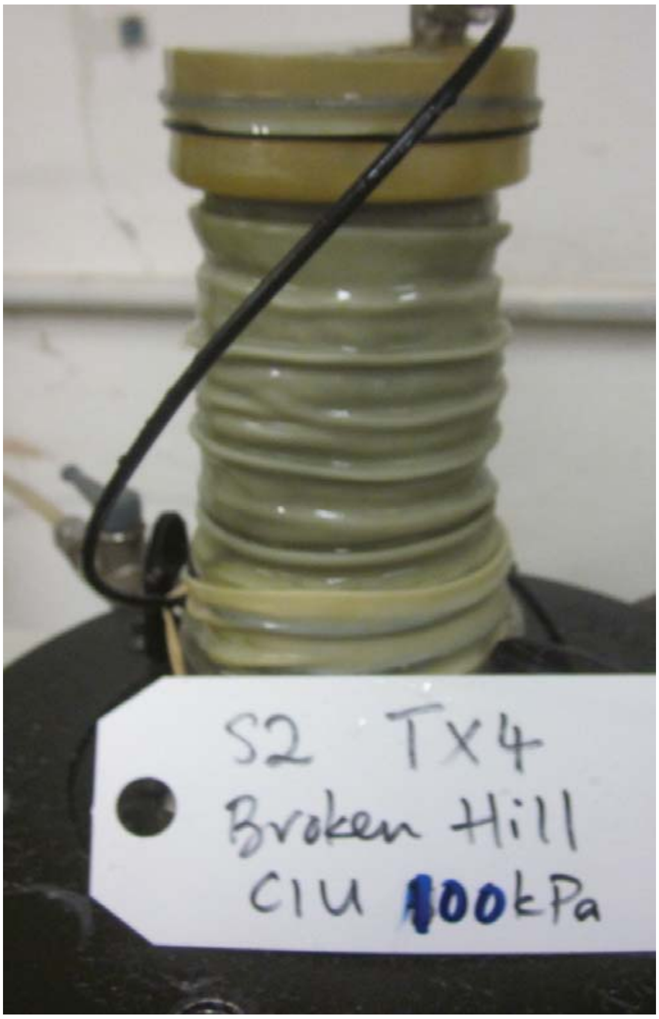
Isotropically Consolidated Undrained (CIU)

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	5/06/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S2 Thickener U/F - TX4

Initial Height (mm):	128.2	Final Liquor Content (%):	30.4%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	59.4	Final Dry Density (t/m^3):	1.57	B Response (%):	99%
Trimmings GWC (%):	11.4%	Final Void Ratio (-):	0.92	Mean Effective Consolidation Stress (kPa):	102
Initial Dry Density (t/m^3):	1.18	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	0.96

Sample Before Test



Sample After Test

Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

Triaxial Test Report

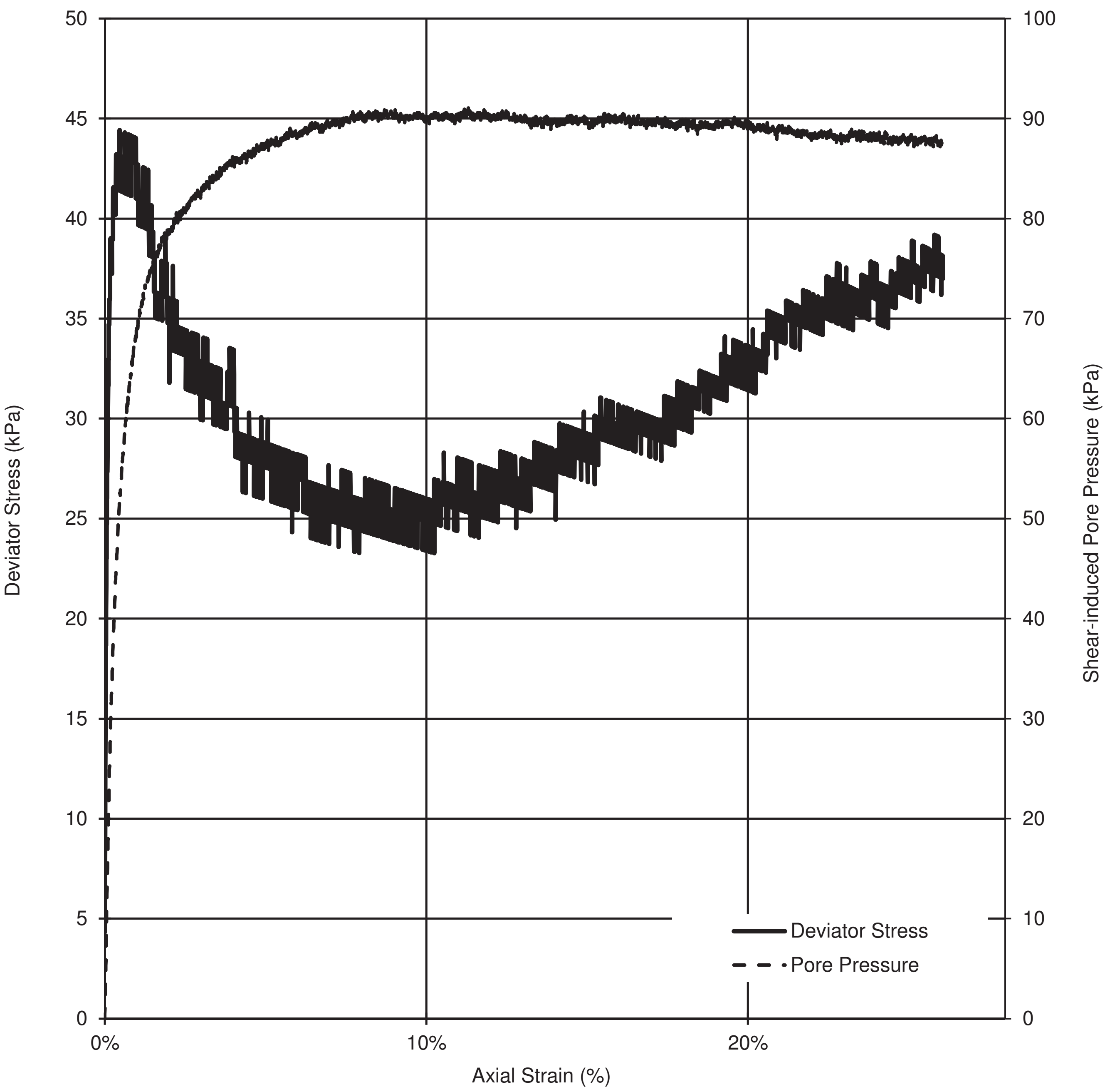
Isotropically Consolidated Undrained (CIU)

GOLDER

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	5/06/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S2 Thickener U/F - TX4

Initial Height (mm):	128.2	Final Liquor Content (%):	30.4%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	59.4	Final Dry Density (t/m^3):	1.57	B Response (%):	99%
Trimmings GWC (%):	11.4%	Final Void Ratio (-):	0.92	Mean Effective Consolidation Stress (kPa):	102
Initial Dry Density (t/m^3):	1.18	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	0.96



Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
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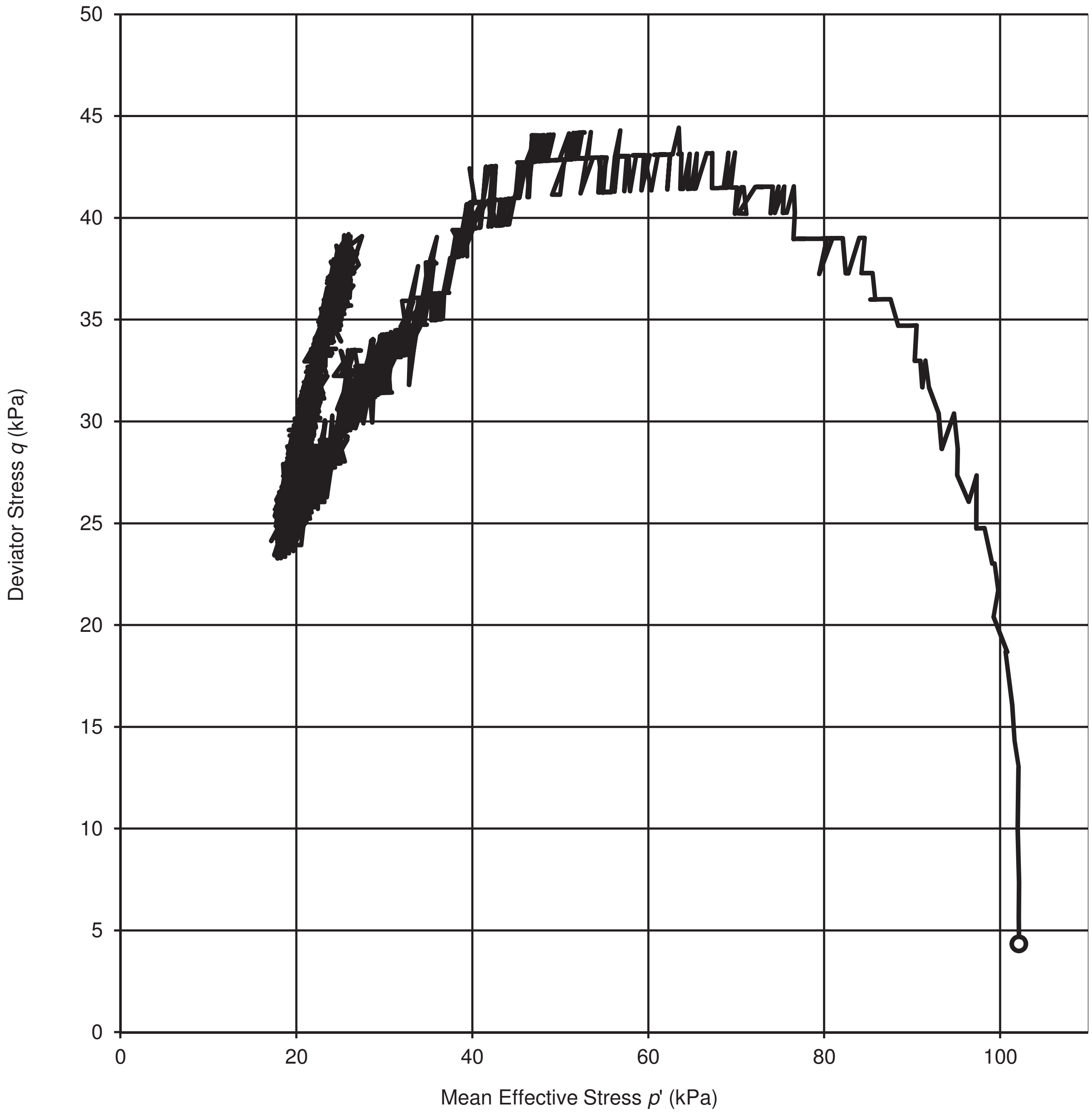
Triaxial Test Report

Isotropically Consolidated Undrained (CIU)

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	5/06/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S2 Thickener U/F - TX4

Initial Height (mm):	128.2	Final Liquor Content (%):	30.4%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	59.4	Final Dry Density (t/m^3):	1.57	B Response (%):	99%
Trimmings GWC (%):	11.4%	Final Void Ratio (-):	0.92	Mean Effective Consolidation Stress (kPa):	102
Initial Dry Density (t/m^3):	1.18	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	0.96



Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

THIS DOCUMENT SHALL ONLY BE REPRODUCED IN FULL

Triaxial Test Report

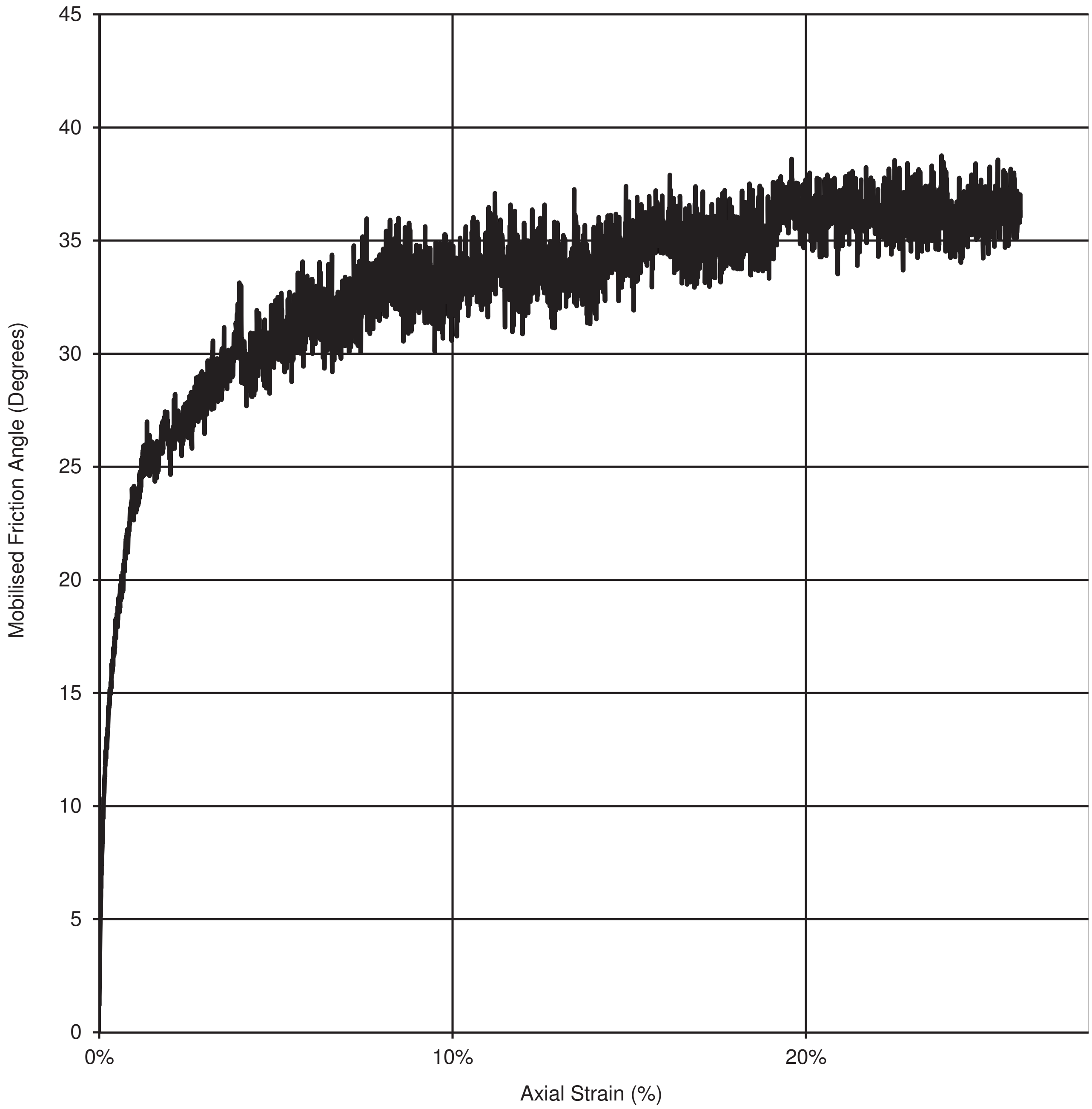
Isotropically Consolidated Undrained (CIU)

GOLDER

Perth Laboratory
84 Guthrie Street, Osborne Park

Client:	Broken Hill Operations Pty Ltd	**Date:**	5/06/2018
Address:	130 Eyre Street Broken Hill NSW 2880	**Project No.:**	1896230
Project:	Kintore Pit (Broken Hill) CSL Testing	**Sample ID:**	S2 Thickener U/F - TX4

Initial Height (mm):	128.2	Final Liquor Content (%):	30.4%	Strain Rate (mm/min):	0.03
Initial Diameter (mm):	59.4	Final Dry Density (t/m^3):	1.57	B Response (%):	99%
Trimmings GWC (%):	11.4%	Final Void Ratio (-):	0.92	Mean Effective Consolidation Stress (kPa):	102
Initial Dry Density (t/m^3):	1.18	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):	0.96



Preparation Notes:	Sample was moist tamped to a loose condition	Tested by:	K. Koh
		Reviewed by:	R. Fanni

THIS DOCUMENT SHALL ONLY BE REPRODUCED IN FULL

03 – CONSOLIDATION

Perth Laboratory
84 Guthrie Street Osborne Park, Perth WA 6017
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www.golder.com perthlab@golder.com.au

Consolidometer Test Report

Client: Broken Hill Operations Pty Ltd
130 Eyre Street Broken Hill NSW 2880

Date: 13/08/2018

Project: Kintore Pit (Broken Hill) CSL Testing

Project No.: 1896230

Sample Identification: Cyclone Tailings Feed

Test procedure: In-house
Specimen Type: Tailings
Test Conditions: Top drainage of specimen while undergoing compression
Sample Diameter (mm): 71

Specimen Properties:

Solids
Type: Tailings
Particle Density (t/m^3): 3.04 (measured)

Fluid
Type: Decant fluid
Initial dry density t/m^3: 1.85
Suspended solids concentration (g/l): Not determined

Preparation description: Sample compacted in three layers of same height to a total height of approximately 60 mm. Sample saturated prior to loading.

Test conditions:

Vertical Effective Pressure σv' (kPa)	Void Ratio e (-)	Dry Density ρd (t/m^3)	Permeability k (m/s)	Confining Modulus M (kPa)	Coefficient of Volume Compressibility m_v (m^2/MN)	Coefficient of Consolidation Cv (m^2/yr)
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
25	0.634	1.86	-	-	-	-
100	0.634	1.86	-	-	-	-
200	0.633	1.86	1.5E-07	301480	0.003	78745.72
400	0.629	1.87	8.4E-08	78792	0.013	29823.97
800	0.622	1.88	4.6E-08	88742	0.011	18539.33
1600	0.611	1.89	2.2E-08	118226	0.008	12955.53
400	0.615	1.88	-	-	-	-
100	0.619	1.88	-	-	-	-
25	0.621	1.88	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-

Notes:
Coefficient of consolidation calculated from the constant head permeability testing.

Tested by:	I. Orea
Reviewed by:	R. Fanni

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www.golder.com perthlab@golder.com.au

Consolidometer Test Report

Client:	Broken Hill Operations Pty Ltd 130 Eyre Street Broken Hill NSW 2880	**Date:**	13/08/2018
Project:	Kintore Pit (Broken Hill) CSL Testing	**Project No.:**	1896230

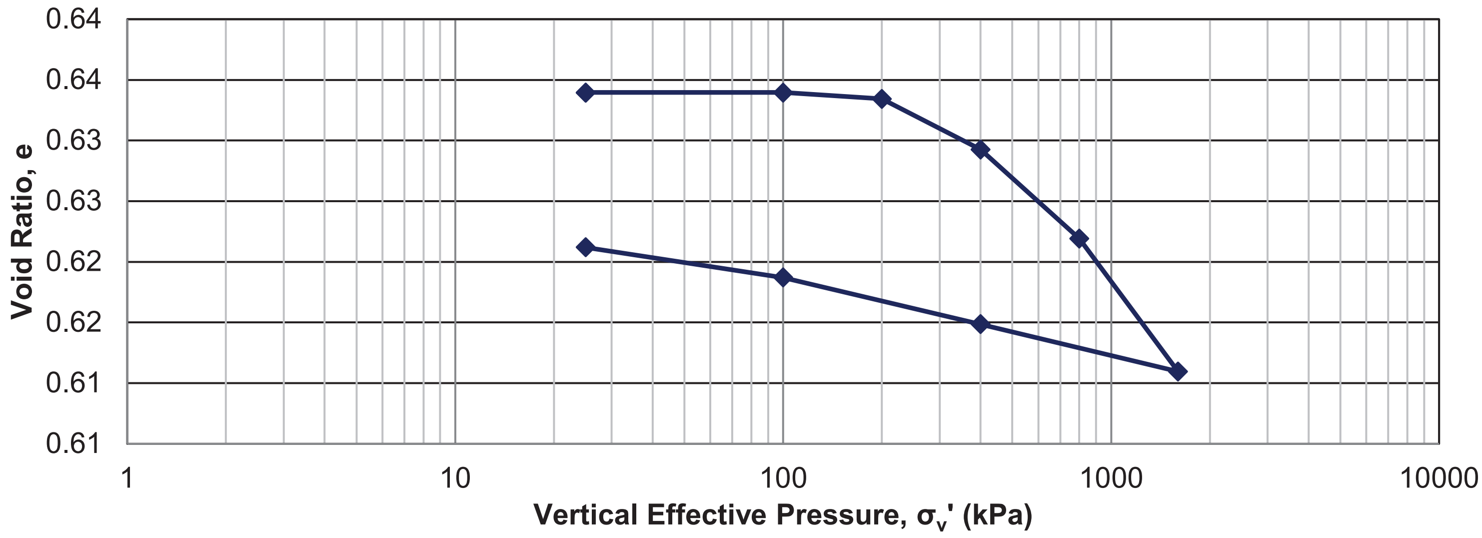
Sample Identification: Cyclone Tailings Feed

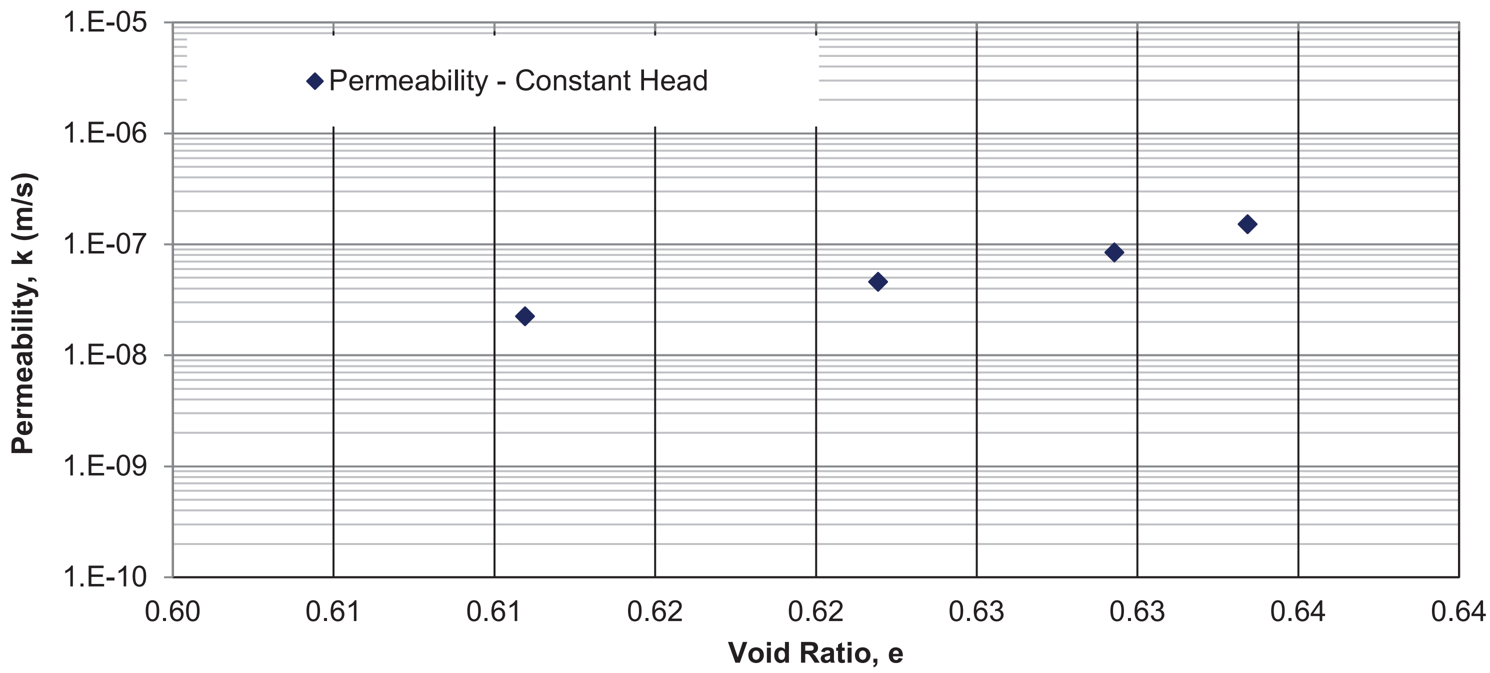
Test procedure: In-house
Specimen Type: Tailings
Test Conditions: Top drainage of specimen while undergoing compression
Sample Diameter (mm): 71

Specimen Properties:

Solids
Type: Tailings
Particle Density (t/m^3): 3.04 (measured)

Fluid
Type: Decant fluid
Initial dry density t/m^3: 1.85
Suspended solids concentration (g/l): Not determined





Notes: Coefficient of consolidation calculated from the constant head permeability testing.	Tested by:	I. Orea
	Reviewed by:	R. Fanni

GOLDER

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Consolidometer Test Report

Client: Broken Hill Operations Pty Ltd
130 Eyre Street Broken Hill NSW 2880

Date: 22/08/2018

Project: Kintore Pit (Broken Hill) CSL Testing

Project No.: 1896230

Sample Identification: U/F Tailings

Test procedure: In-house
Specimen Type: Tailings
Test Conditions: Top drainage of specimen while undergoing compression
Sample Diameter (mm): 71

Specimen Properties:

Solids
Type: Tailings
Particle Density (t/m^3): 3.01 (measured)

Fluid
Type: Decant fluid
Initial dry density t/m^3: 1.74
Suspended solids concentration (g/l): Not determined

Preparation description: Sample compacted in three layers of the same height to a total initial height of ≈ 60 mm. Sample saturated prior to loading.

Test conditions:

Vertical Effective Pressure σv' (kPa)	Void Ratio e (-)	Dry Density ρd (t/m^3)	Permeability k (m/s)	Confining Modulus M (kPa)	Coefficient of Volume Compressibility m_v (m^2/MN)	Coefficient of Consolidation Cv (m^2/yr)
5	0.73	1.74	-	-	-	-
10	0.73	1.74	-	24027	-	-
25	0.73	1.74	-	24708	-	-
50	0.73	1.74	8.1E-09	13985	0.1	362.93
100	0.72	1.75	1.4E-08	18317	0.1	663.87
200	0.72	1.75	3.5E-09	28255	0.0	814.13
400	0.71	1.76	5.6E-09	44134	0.0	643.44
800	0.70	1.77	4.3E-09	66350	0.02	1059.26
1600	0.68	1.79	1.9E-09	74288	0.01	744.15
400	0.69	1.78	-	-	-	-
100	0.69	1.78	-	-	-	-
25	0.70	1.78	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-

Notes:
Coefficient of consolidation calculated from the constant head permeability testing.

Tested by:	I. Orea
Reviewed by:	R. Fanni

Perth Laboratory
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www.golder.com perthlab@golder.com.au

Consolidometer Test Report

Client:	Broken Hill Operations Pty Ltd 130 Eyre Street Broken Hill NSW 2880	**Date:**	22/08/2018
Project:	Kintore Pit (Broken Hill) CSL Testing	**Project No.:**	1896230

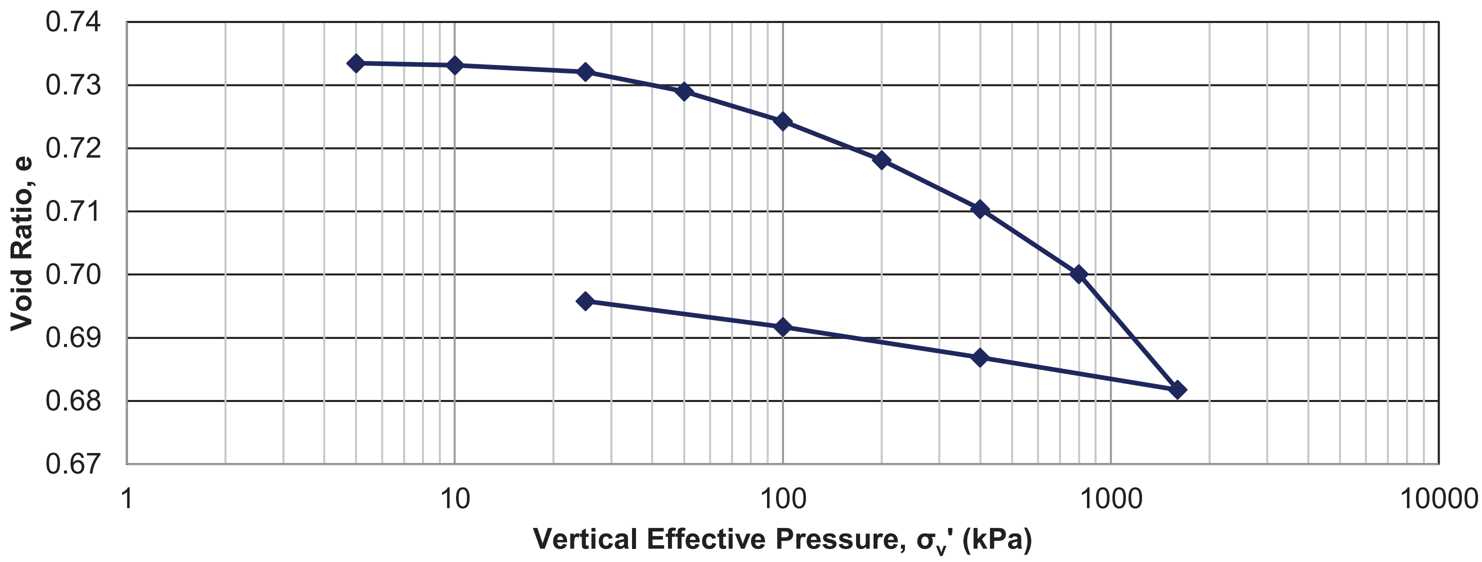
Sample Identification: U/F Tailings

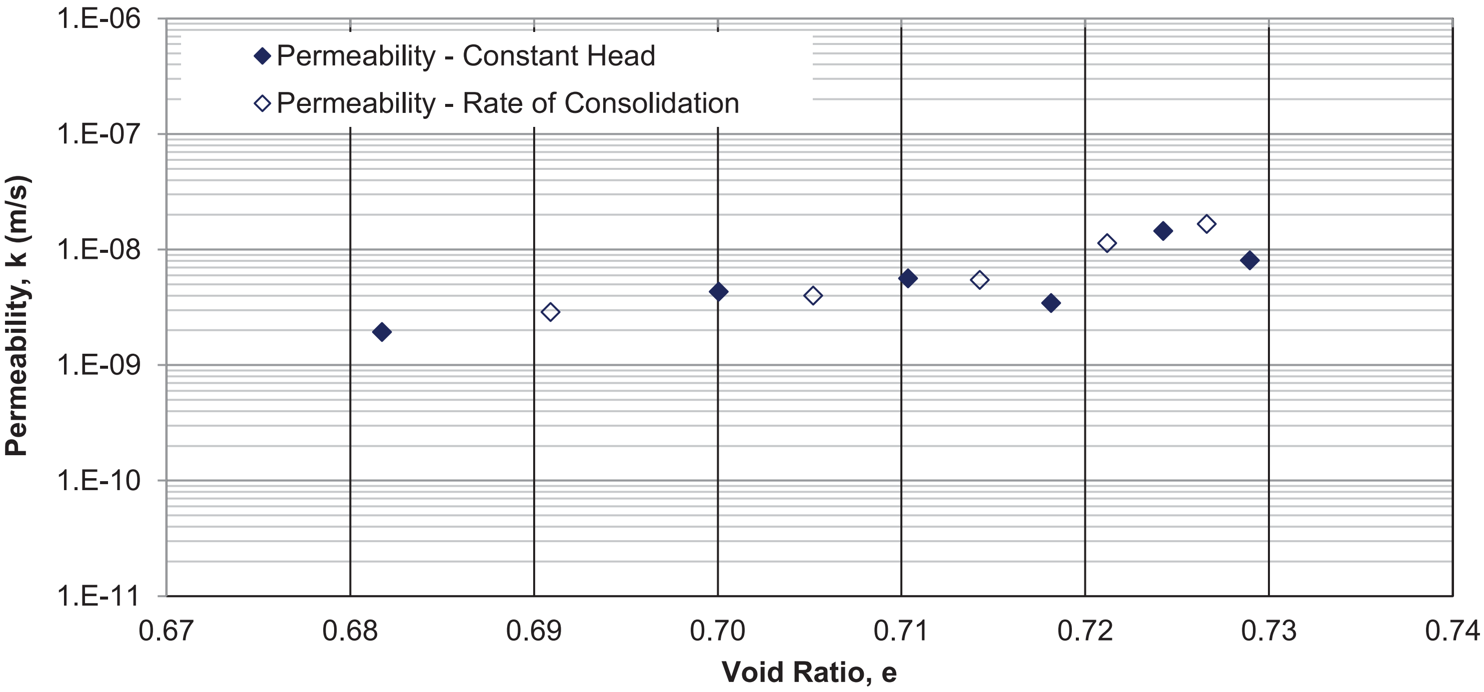
Test procedure: In-house
Specimen Type: Tailings
Test Conditions: Top drainage of specimen while undergoing compression
Sample Diameter (mm): 71

Specimen Properties:

Solids
Type: Tailings
Particle Density (t/m^3): 3.01 (measured)

Fluid
Type: Decant fluid
Initial dry density t/m^3: 1.74
Suspended solids concentration (g/l): Not determined





Notes:
Coefficient of consolidation calculated from the constant head permeability testing.

Tested by:	I. Orea
Reviewed by:	R. Fanni

APPENDIX B

Important Information Relating to this Report

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This Report has been prepared in the context of the circumstances and purposes referred to in, or derived from, the Contract and Golder accepts no responsibility for use of the Report, in whole or in part, in any other context or circumstance or for any other purpose.

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Having regard to the matters referred to in the previous paragraphs on this page in particular, carrying out the Services has allowed Golder to form no more than an opinion as to the actual conditions at any relevant location. That opinion is necessarily constrained by the extent of the information collected by Golder or otherwise made available to Golder. Further, the passage of time may affect the accuracy, applicability or usefulness of the opinions, assessments or other information in this Report. This Report is based upon the information and other circumstances that existed and were known to Golder when the Services were performed and this Report was prepared. Golder has not considered the effect of any possible future developments including physical changes to any relevant location or changes to any laws or regulations relevant to such location.

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Any uncertainty as to the extent to which this Report can be used or relied upon in any respect should be referred to Golder for clarification

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APPENDIX E

‘Kintore Pit: Preliminary Mine Plug Design’ ref: 1896230-047-R-Rev1, dated 13 August 2020.

REPORT

Kintore Pit: Preliminary Mine Plug design

RASP Project, Broken Hill

Submitted to:

Broken Hill Operations Pty Ltd
Eyre Street
Broken Hill
NSW

Submitted by:

Golder Associates Pty Ltd
Building 7, Botanicca Corporate Park, 570 – 588 Swan Street, Richmond, Victoria 3121, Australia

+61 3 8862 3500

1896230-047-R-Rev1

13 August 2020

Distribution List

1 Copy -Broken Hill Operations Pty Ltd

1 Copy- Golder Associates Pty Ltd

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TABLES

FIGURES

1.0 INTRODUCTION

Broken Hill Operations Pty Ltd (BHOP) owns and operates the RASP zinc-lead mine in Broken Hill, NSW. Ore is recovered from an underground mining operation and is processed on surface in the Processing Plant. Tailings from the plant is currently placed in a thickened slurry form into the Blackwood Pit located within the mine lease area. The tailings surface elevation is approaching the final design elevation and BHOP plans to transition tailings placement from Blackwood to the nearby Kintore Pit.

Underground mining operations are currently located to the north and south-west of the Kintore Pit and the operational areas are accessed via a decline through a portal at the base of the Kintore Pit. The operational areas are also connected by a mine access tunnel (MLD Drive) that joins the decline and passes below the base of the Kintore Pit. Historic mine plans show that shallow mine workings partially underlie the Kintore Pit base, with numerous old vertical shafts located within the footprint of the pit.

Following a risk assessment workshop held at the mine, it was agreed that the underground mine workings need to be isolated from potential inrush from the proposed Kintore Pit Tailing Storage Facility (TSF). From the risk assessment workshop it was also agreed that the tailings deposition operation in Kintore pit would change to a dewatered tailings to reduce the risk of liquefaction and inrush of tailings from the pit. The tailings deposition operation would be an earthworks operation, with dewatered tailings to be placed and compacted in Kintore pit. The use of dewatered tailings was the key tailings migration risk reduction measure to be implemented for tailings operation in Kintore pit.

Golder conducted critical state testing on the BHOP tailings to assess the required critical void ratio (and hence density) the tailings needs to achieve to manage the risk of liquefaction of the tailings. The tailings testing is reported in Golder report reference 1896230-004-R-Rev0. From the testing it was concluded that full stream tailings compacted to at least 95 % Standard dry density is unlikely to be contractive and hence not be liquefiable up to a confining pressure of approximately 1000 kPa. This confining pressure is equivalent to a compacted tailings thickness of 53 m.

BHOP also conducted an extensive internal review of available historical mine workings records to understand the potential pathways from Kintore pit into the active mine workings. From the review it was concluded that the available historical mine workings records may not include all the old workings. In addition to the risk reduction measure of dewatered tailings, the risk would be further reduced if the active workings are separated from the general area of historical mine workings around Kintore pit. Mine plugs are proposed to be installed selectively and progressively to separate the historical mine workings from the active mine workings. The timing of the plug construction is proposed to be linked to the progress of tailings filling in Kintore pit.

To further reduce the possibility of water accumulation within the tailings in Kintore pit it was decided that the base of the pit would include a drainage layer. The plugs would be drained plugs, allowing water to pass through the plugs, with the intent of the plugs being to retain any potential rapid migration of tailings, if they were to liquefy.

BHOP has prepared a detailed report titled '***Inrush and Inundation Pathways from TSF3 - Rasp Mine_final_V2***' which documents the risks, paths and proposed locations of mine plugs (herein referred to as '*inrush repot*').

Golder Associates Pty Ltd (Golder) was appointed by BHOP to develop preliminary designs for the plug locations. This report presents a preliminary design for the plugs. The designs were prepared using available geotechnical data presented in the inrush report and additional correspondence from BHOP via emails.

2.0 BACKGROUND INFORMATION

2.1 Configuration of Kintore Pit

BHOP provided a contour plan of the Kintore Pit which also showed the location of the decline and underlying MLD Drive tunnel and various reports related to the estimated extent of the historic mine workings. Collapsed old mine workings were also observed in the north-eastern pit sidewall, with a collapsed stope noted to be partially filled with tailings at an elevation of approximately RL 275 m...

A waste rock stockpile is being placed into the southern end of the pit. A north-south section through the pit is shown in Figure 1. The waste rock stockpile has been formed at the south end of the pit with a relatively small plateau area next to the pit access ramp and a continuous north slope that extends from plateau down to the pit floor. The pit sidewalls have been formed as a series of batters with generally small benches with overall average sidewall slopes of about 40°.

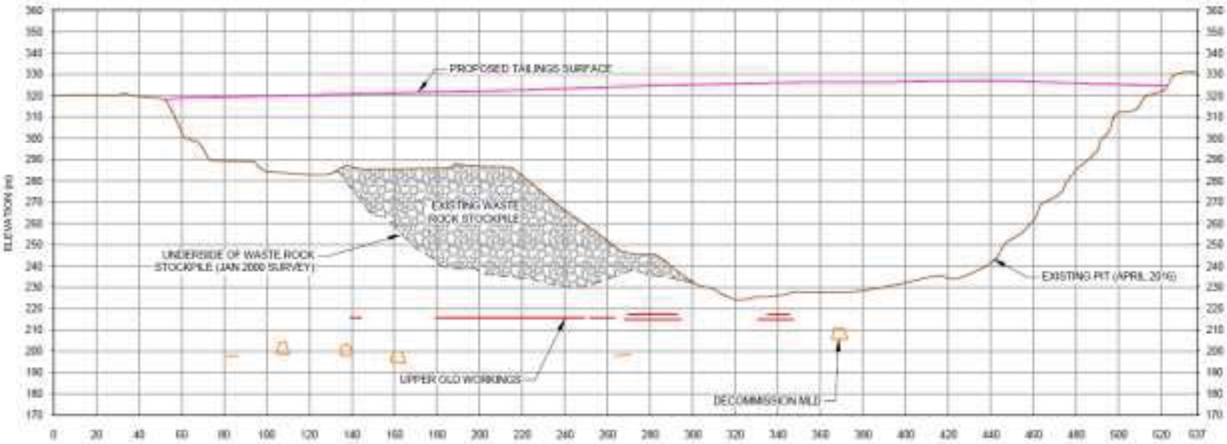

Figure 1: North-South section through the Pit

2.2 Filling Schedule

Tailings deposition is proposed to continue in Blackwood pit until it reaches capacity. The tailings filling schedule is currently under review and may include alternative tailings placement in Blackwood pit and Kintore pit.

The intent is to place and compact tailings by earthworks methods only into the Kintore Pit. The tailings will be dewatered to a moisture content at which no free water is present (suitable for compaction) and then deposited into the Kintore Pit. The method of dewatering/drying the tailings is under development, with various options being considered.

The pit configuration and current layout of the waste rock stockpile results in a relatively small surface area initially being available for deposition of tailings from the pit floor up to top of waste rock stockpile, above which the volume and surface area increases significantly. The bottom of the pit will be prepared to include a drainage layer to collect and remove any remnant seepage from the compacted tailings and base of the pit. The bottom of the pit will also be filled with waste rock to above the crown level of the existing portal to provide a rockfill buffer between the adit and the bottom of placed tailings as well as a rockfill bridging layer over the pit floor where old mine workings exist. The initial rockfill layer is also designed to create a suitable surface area to start tailings placement in the pit.

3.0 SITE GEOLOGY

A summary of the geology of the Broken Hill mining area is presented in a Department of Mineral Resources NSW document (Ref 2). The ore consists of massive recrystalised zinc and lead sulphides hosted within Hores Gneiss and a sub-unit of Polosi Gneiss in Broken Hill Group rocks. The central part of the ore body outcropped on surface as lenses of highly sheared and disrupted rock (the Broken Hill), which then plunges steeply to the north and moderately to the south. The deposits were extensively reworked and modified by metamorphism and shearing.

The Australian Earthquake Map (Ref 3) shows a peak ground acceleration (PGA) of 0.2g for the 1 in 10,000 AEP earthquake in the Broken Hill area.

4.0 PLUG DESIGN CONSIDERATIONS

4.1 Underground Mine Plug

The inrush report details the potential pathways for ingress into Rasp Mine's underground workings as a result of placing tailings into Kintore Pit and identifies the locations required to effectively isolate these pathways from current or currently proposed active mine workings through the installation of underground mine plug/engineered barriers and establishment of Inrush Control Zones. The following six engineered barriers or underground mine plugs were identified in the BHOP inrush report as shown in Figure 2.

1) Portal Plug
2) Western Min Decline near MLD Intersection
3) Dickenson's Shaft Western Min. Decline below SP3
4) 1000 ft Level East of Parkbay
5) Block 11 Access Incline east of ladderway intersection
6) 1480 Access Drive West of intersection with airway

Figure 2 (copied from the inrush report) shows the minimum required mine plugs locations to isolate the inrush potential by separating the Main Lode (previously mined) from Western Mineralisation workings (current and proposed mine areas). Note that the 1480 Access Drive West location referenced in the inrush report is being installed separate to the current assessment as a risk management structure related to existing old workings around the Blackwood pit TSF. The design of that plug is included in this report for completeness of the plug designs and is understood will be installed before Kintore pit is commissioned.

The inrush report also indicates that if access to specific Main Lode areas is critical for the Life of Mine strategy, additional barriers and strategies will be required. In addition to these mine plugs, there are two internal rises identified as an inrush risk if left open. These are the MLD-1270 rise and the BLK 11 exhaust rise. It is understood from the inrush report that these rises will be backfilled with cement stabilised fill as part of related mine plug construction, and any related mine ventilation changes that relate to the specific plugs to be installed.

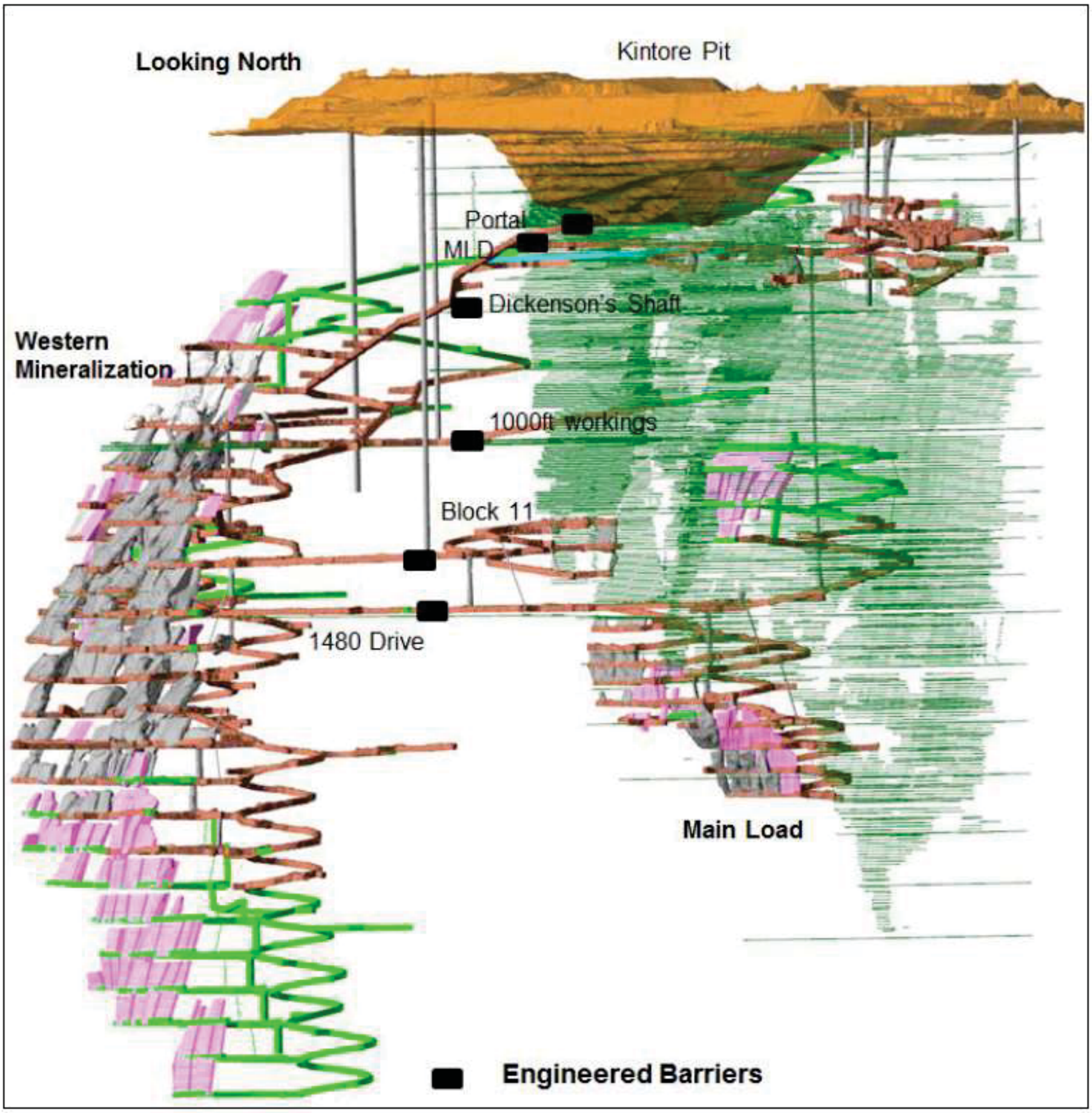

Figure 2: Location of underground mine plugs (extract of Figure 2 from inrush report)

The proposed locations and elevations of mine plugs in the inrush report are summarised in Table 1. The tunnel dimensions of the plug locations are understood to be the same for all plugs. The tunnel dimensions are a nominal width of 5.0 m and a height from floor to tunnel crown arch of 5.5 m. The “surface” datum referred to the inrush report was indicated to be a reduced elevation of 10333 m (email from David Matthews on 2 July 2020), with the existing mine portal entrance elevation (referenced to the same mine survey datum) indicted to be at a reduced elevation of 10228.8 m (email of 14 July 2020).

Table 1: Summary of the location of the mine plugs (from inrush report)

Mine Plug	Easting (m)	Northing (m)	Reduced Level (m)
Portal Plug	1365	9727	10226
Western Min Decline near MLD Intersection	1148	9962	10212
Dickenson's Shaft Western Min Decline below SP3	1149	9903	10 145*
1000 ft Level East of Parkbay	2052	9612	10 046*
Block 11 Access Incline east of ladderway intersection	1698	9451	9944
1480 Access Drive West of intersection with airway	1514	9600	9900

*Email from David Matthews on 2 July 2020

Easting and Northing is relative to local Mine Grid.

4.1.1 Portal Plug

The proposed Portal plug is located at coordinate of 972m N, 1365mE and 10226 m RL below the existing mine portal elevation in Kintore Pit as shown in Figure 3. Photographs of the tunnel area to be plugged are presented in Figure 4.

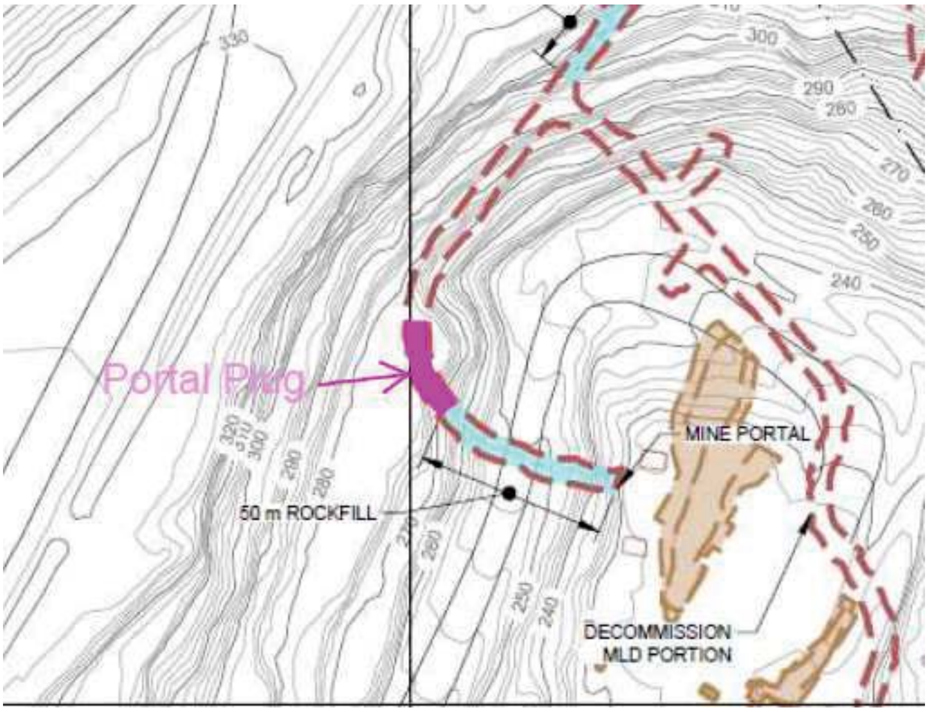

Figure 3: Location of Portal Plug

Figure 4: Photos of Portal Plug location

4.1.2 Western Min Decline near MLD Intersection

Plug location and photographs of tunnel at the Western Min Decline near MLD Intersection is presented in Figure 5 and Figure 6 respectively.

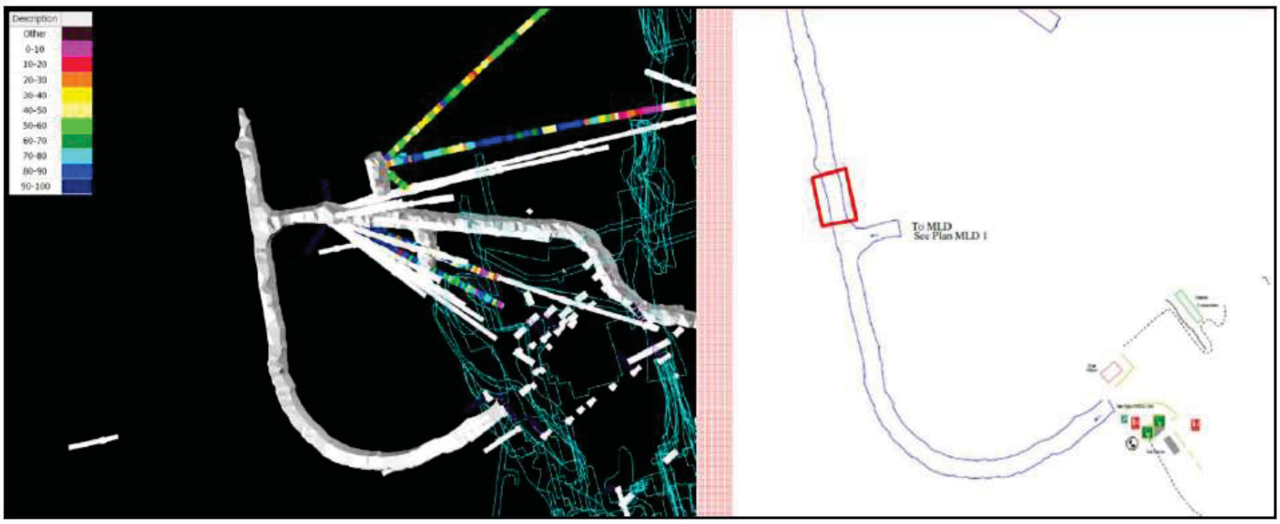

Figure 5: Location of Western Min Decline near MLD Intersection Mine Plug (extract from inrush report)

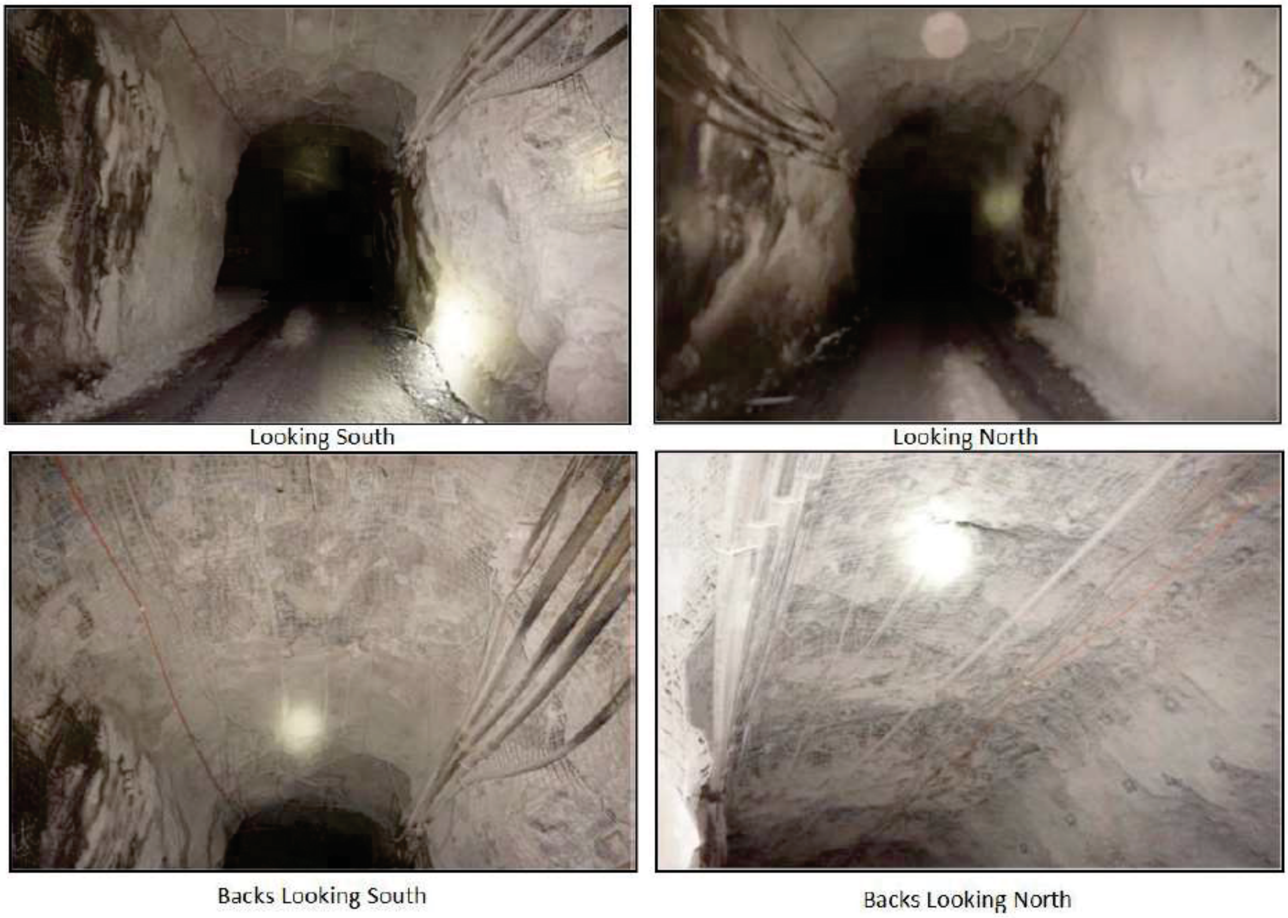

Figure 6: Photos of Western Min Decline near MLD Intersection Mine Plug location (extract from inrush report)

4.1.3 Dickenson's Shaft Western Min Decline below SP3

Dickenson's Shaft Western Min Decline below SP3 plug location is shown in Figure 7 and photograph of the tunnel area to be plugged is presented in Figure 8.

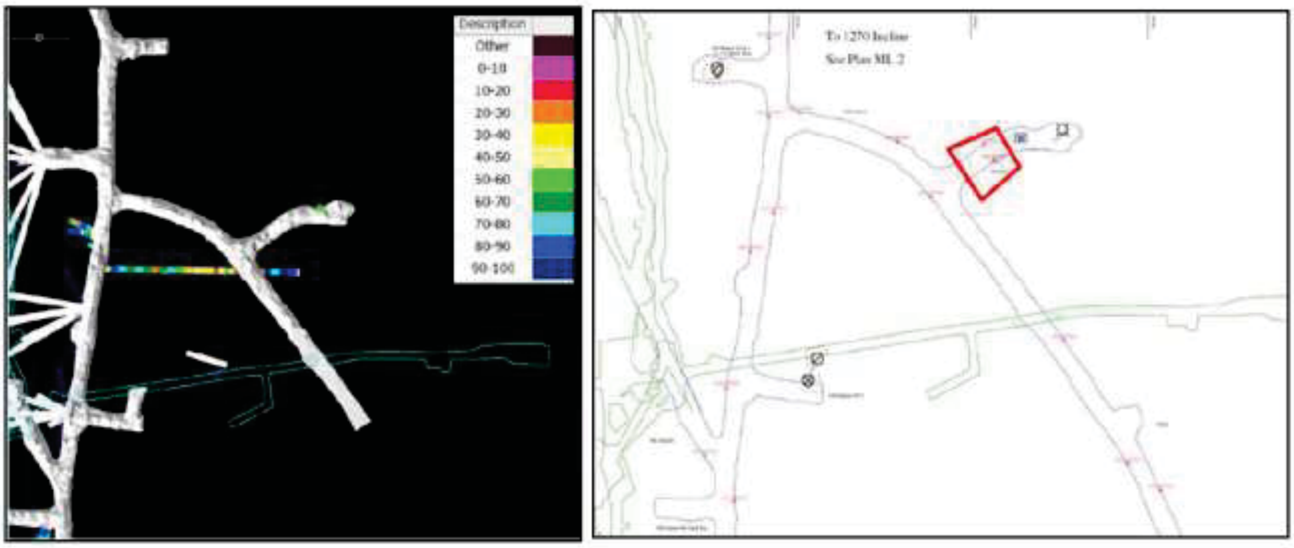

Figure 7: Location of Dickenson's Shaft Western Min Decline below SP3 (extract from inrush report)

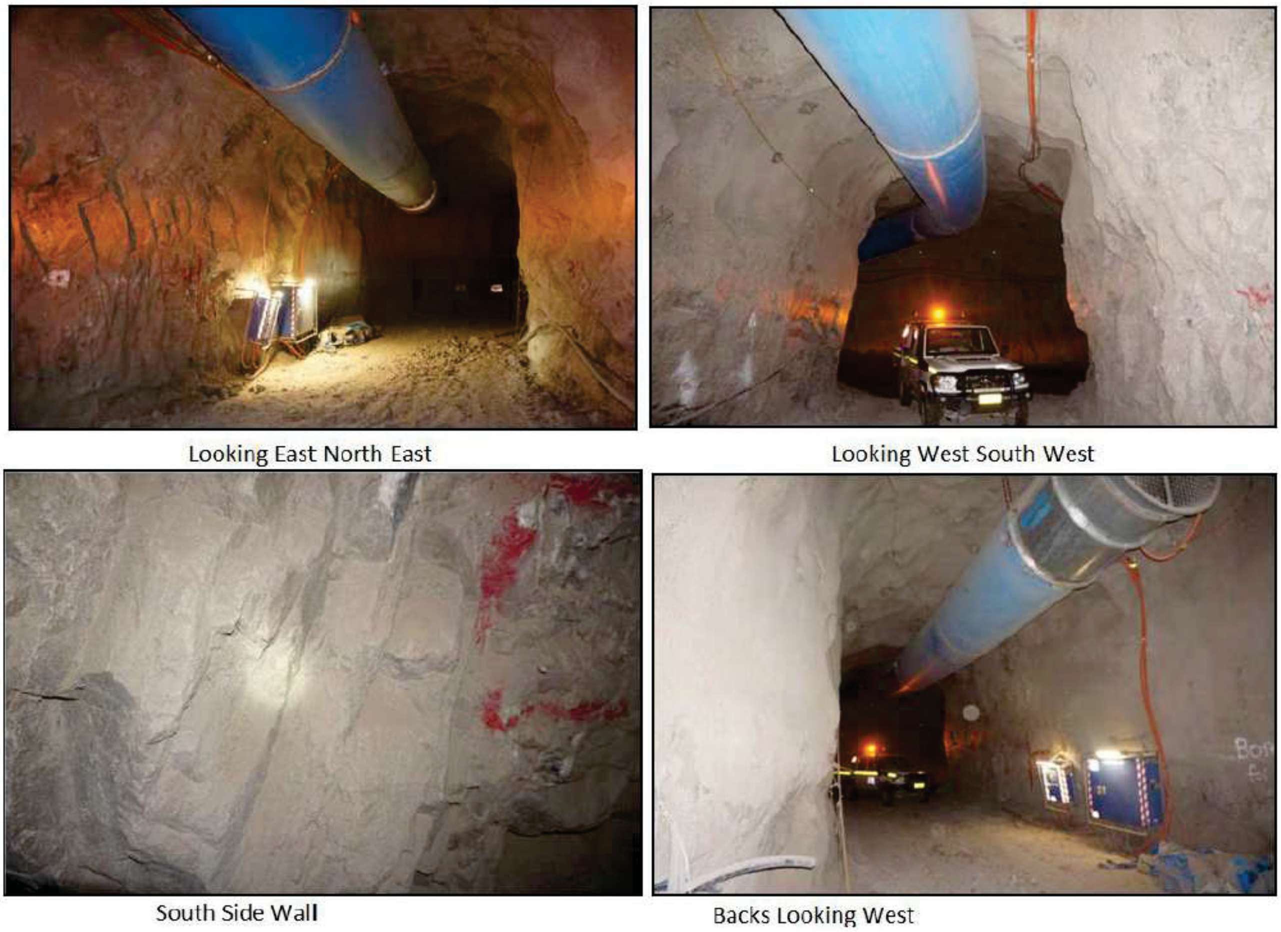

Figure 8: Photographs of Dickenson's Shaft Mine Plug location (extract from inrush report)

4.1.4 1000 ft Level East of Park bay

Figure 9 shows the location of 1000 ft Level East of Parkbay plug. Photographs of the proposed tunnel sections to be plugged is presented in Figure 10. Photographs show damp area due to presence of sump in this area. It is understood that the tailing pressure will be applied from right side of the plug (as shown on below figures).

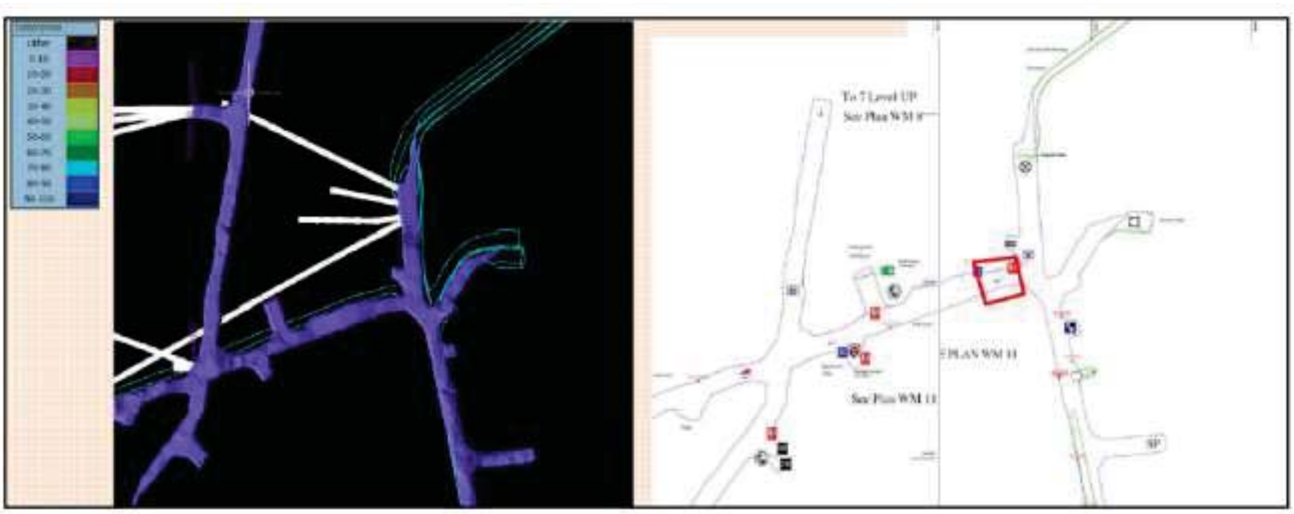

Figure 9: Location of 1000 ft Level East of Parkbay Mine Plug (extract from inrush report)

Figure 10: Photos of 1000 ft Level East of Parkbay Mine Plug Location (extract from inrush report)

4.1.5 Block 11 Access Incline east of ladderway intersection

Location of Block 11 plug is presented in layout plan shown in Figure 11. The tunnel section to be plugged is presented in photographs shown in Figure 12.

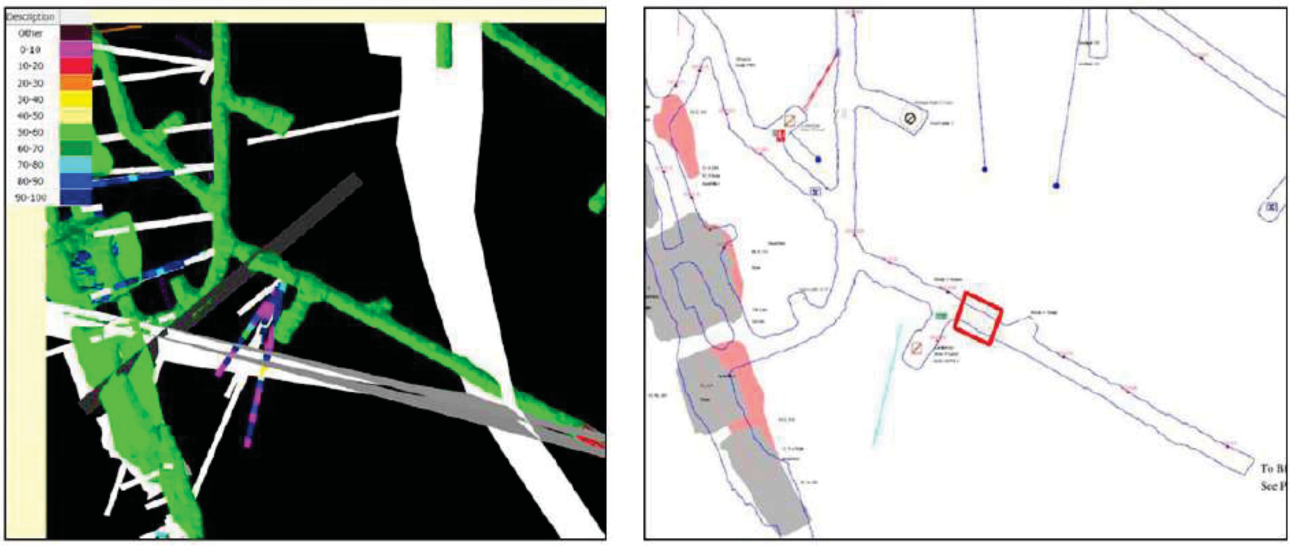

Figure 11: Location of Block 11 Mine Plug (extract from inrush report)

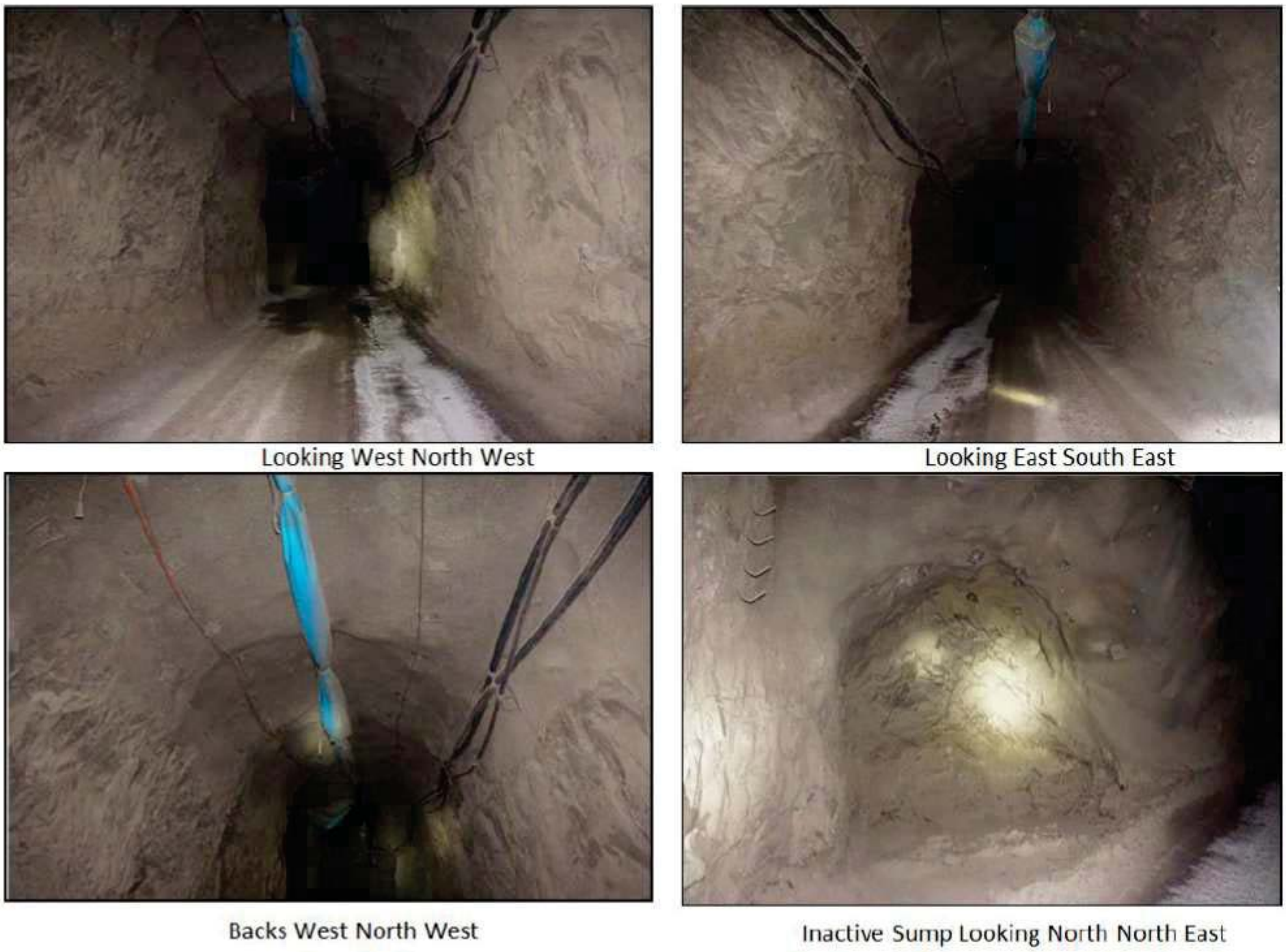

Figure 12: photos of Block 11 Mine Plug Location (extract from inrush report)

4.1.6 1480 Access Drive West of intersection with airway

Location of 1480 Access Drive plug is presented in Figure 13. Photographs showing the tunnel sections at this to be plugged is presented in Figure 14.

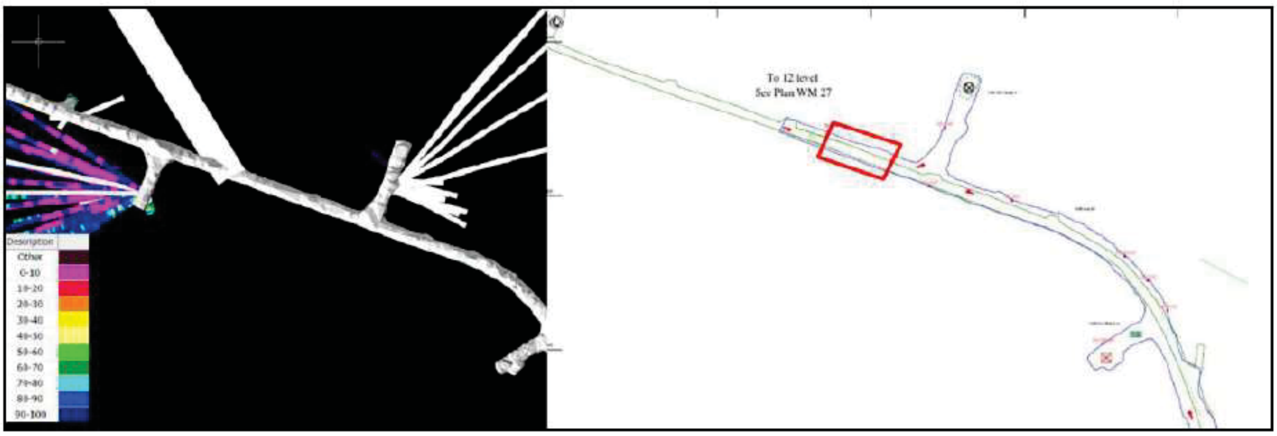

Figure 13: Location of 1480 ft Access Drive Mine Plug (extract from inrush report)

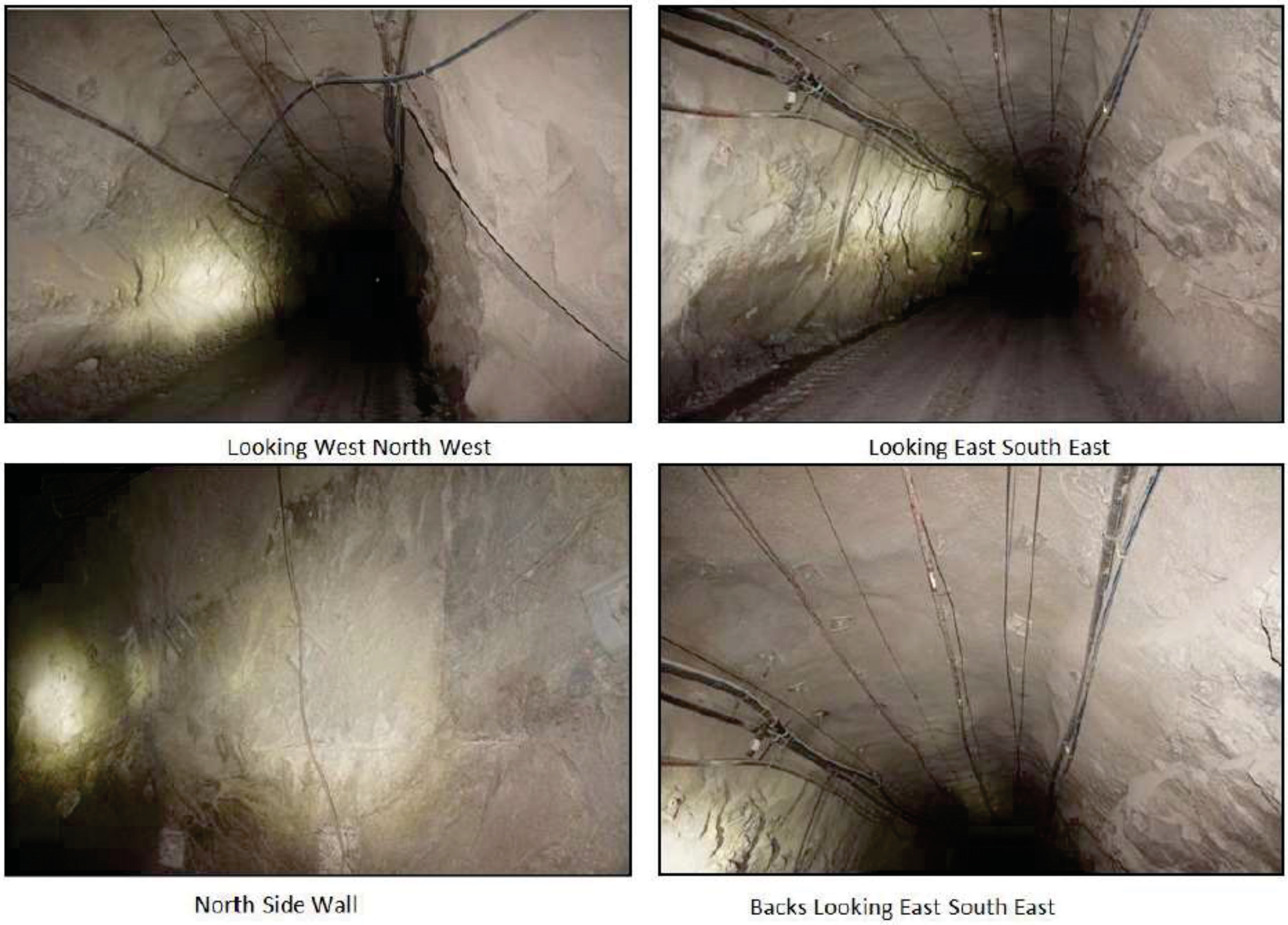

Figure 14: Photos of 1480 ft Drive Mine Plug Location (extract from inrush report)

4.2 Tailing Properties

Golder tested two tailings samples provided by BHOP (Ref 9). The first sample was labelled Cyclone Feed and is representative of the total tailings produced by the plant. The second sample was labelled Cyclone U/F, which we understand to be the fine tailings from cyclone classification of the Feed tailings and which we will refer to as Cyclone O/F. The test results are presented in a Golder report (Ref 9) and show the Cyclone Feed tailings to be a silty fine sand with a fines content (particle size smaller than 75 µm) of 45% and the Cyclone O/F tailings to be a silt of moderate plasticity with a fines content of about 91%. Results of compaction tests on the samples are presented in Table 2.

Table 2: Compaction Test Results

Sample ID	Optimum Water Content * (%)	Standard Maximum Dry Density (SMDD) (t/m^3)
Tails Cyclone Feed	10.0	1.98
Tails Thickener O/F	15.0	1.76

* water content = mass of water/mass of solids.

In a flowable condition the tailings density is conservatively estimated to have a density of 1.5 t/m^3.

4.3 Rock Mass Properties

Rock mass condition for the various plug location were adopted from the inrush report prepared by BHOP. A summary of rock mass properties at proposed plug locations is presented in Table 3.

Table 3: Summary of rock mass properties in Mine Plug locations

Plug Location	Rock Quality Designation RQD (%)	Description	Rock Type
Portal Plug	60	3 joint sets (Jn 9), Planar Rough (Jr 1.5), Surface Stain Only (Ja 1), Dry (Jw 1), Near surface (SRF 2.5)	Fair to good bedded rock mass
Western Min Decline near MLD Intersection	50-60	joint sets (Jn 9), Planar Rough (Jr 1.5), Surface Stain Only (Ja 1), Dry (Jw 1), Near surface (SRF 2)	Fair to good bedded rock mass
Dickenson's Shaft Western Min Decline below SP3	50-60	joint sets (Jn 9), Planar Rough (Jr 1.5), Surface Stain Only (Ja 1), Dry (Jw 1), Near Surface (SRF 2)	Fair to good bedded rock mass
1000 ft Level East of Parkbay	60-70	joint sets (Jn 9), Planar Smooth (Jr 1), Surface Stain Only (Ja 1), Dry (Jw 1), Medium confining stress (SRF 0.5).	Good bedded rock mass
Block 11 Access Incline east of ladderway intersection	50-60	3 joint sets (Jn 9), Planar Smooth (Jr 1), Surface Stain Only (Ja 1), Dry (Jw 1), Medium confining stress (SRF 0.5).	Fair to good bedded rock mass
1480 Access Drive West of intersection with airway	70-80	joint sets (Jn 9), Planar Rough (Jr 1.5), Surface Stain Only (Ja 1), Dry (Jw 1), Medium confining stress (SRF 0.5).	Good bedded rock mass

5.0 OVERVIEW OF PLUG DESIGN CONSIDERATIONS

5.1 Definitions

Tunnel or shaft plugs in mining applications are typically designed where an opening is below the equilibrated water table and with the objective of reducing or controlling the flow of water through the opening. Plugs may also be designed where an opening may potentially be subjected to a mud flow/tailings flow and to prevent loss of solids into downstream areas or mine workings.

Plugs are defined as permanent barriers (usually constructed of concrete) to restrain fluid pressures which often exceed 1 000 kPa (equivalent to a 100 m high column of water). The plugs may be monolithic or hollow and can be parallel-sided (with approximately constant section) or may be hitched (where an enlargement is made into the tunnel or shaft wall to provide increased resistance against shear).

Failure Mechanisms

Plug design criteria

The potential failure mechanisms that must be considered for permanent plugs retaining fluids are described as follows. Adopted factors of safety for each failure mode are summarised in Table 4. The selected length for the plug will be the one which corresponds to the most critical of these conditions.

Table 4: Summary of Plug Design Criteria (after Lang Ref 5)

Failure Mode	Design Criteria
Punching shear failure along rock/concrete contact or through rock mass	FoS ≥3 normal condition FoS ≥1.5 earthquake or dynamic load condition
Deep beam flexure	FoS ≥ 3 normal condition FoS ≥ 1.5 earthquake or dynamic load condition
Hydraulic jacking of rock surrounding plug	FoS ≥ 1.3 normal condition (total stress analysis) FoS ≥ 1.1 earthquake or dynamic load condition (total stress analysis)
Excessive seepage around plug and possible downstream erosion	Maximum hydraulic gradient based on empirical design methods
Long term disintegration of concrete	Concrete to be designed to appropriate standards for resistance to acid attack, sulphate attack and alkali aggregate reactivity

Punching shear failure

This is the mechanism whereby the applied pressure causes the plug to move relative to the rock by shearing either through the rock mass, through the concrete or along the rock-concrete interface. The design concept assumes that the load will be transmitted from the concrete plug to the rock as punching shear around the perimeter of the plug along its full length. In calculating the potential plug lengths both static and dynamic loading conditions are considered.

The allowable shear stress at the rock-concrete interface depends primarily on the rock mass quality and whether the interface has been grouted. In tunnel or adit applications the plug is usually formed by placing mass concrete between bulkheads. Typically this placement does not fill to the crown of the tunnel and secondary grouting is required to fill the remaining void. If the rock mass is fractured pressure grouting (to at least twice the hydrostatic head) may be required to fill the fractures and reduce the hydraulic conductivity of the rock mass.

Deep beam failure

If the design for punching shear results in a plug length that is less than approximately the maximum dimension of the tunnel, the design should be checked for resistance to deep beam flexure. According to the American Concrete Institute (ACI) 318-95 (Ref 6) a plug fits in the category of a deep beam when the ratio of plug width/plug length > 1.25.

Hydraulic jacking

Hydraulic jacking is caused when pressure on the plug from a sustained supply of water or mud (for example from a tailings storage facility) exceeds the minimum *in situ* rock stresses and results in opening of existing fractures that transmit the fluid to the downstream side of the plug. In adverse rock conditions this sustained pressure could lead to hydrofracturing developing along any unrestrained pathways through the rock mass and loosening of blocks around or near the plug.

Hydraulic gradients

This mechanism may be described as failure due to excessive leakage around the plug. Based on experience it has been established that the magnitude of leakage depends on the hydraulic gradient across the plug, the hydraulic conductivity of the rock mass and the competence and erodibility of joint infill materials in the rock mass surrounding the plug.

Potential leakage can be controlled by selecting a plug length to give an acceptable value of hydraulic gradient and pressure gradient or, if required, by improving the rock condition by grouting the rock around the plug annulus to reduce the permeability (hydraulic conductivity) and increase the integrity of the rock mass by rock bolting.

Chemical attack

Chemical attack by groundwater or tailings water may reduce the integrity of concrete and grout over time. The main chemical constituents of concern include the acidity (pH) and the concentration of sulphates and chlorides in the water.

6.0 PRELIMINARY DESIGN OF PLUGS

6.1 Design Assumptions

This preliminary plug design has used the geotechnical and rock mass data at the proposed plug locations presented in the inrush report and the Golder test data on the tailings samples.

The following design assumptions have been made:

i) Possible faults and geological structures within the rock mass between the Kintore Pit and the mine workings or in the near vicinity of the plug will not transmit tailings slurry around or downstream of the plug. As a guide it is assumed the rock mass conditions are consistent to those reported at the plug locations for least 10 m from either end of the plug.

ii) The tailings water and seepage water in the rock mass will not chemically degrade concrete in the plug.

iii) The plugs will drain seepage water from the upstream end of the plug and seepage will be managed as part of the ongoing mine water management system. It is noted that this seepage is expected to be minor if the tailings are placed at the design moisture content and compacted, and ponded stormwater on the tailings surface is removed as intended, which minimises rain effects on the seepage rate. Hence seepage by-pass under normal operational conditions is assumed to **not** be a design criteria for the size of the plug.

Of note is that the Portal Plug design comprises two parts; one to provide a plug to manage tailings migration into the underground workings, and two, to reduce the potential for large scale collapse of the existing opening in the pit wall once this areas is loaded by tailings. The design therefore includes the filling of the existing decline with waste rock to limit the collapse and movement of the existing pit slope, if the void was left unfilled. Such collapse or movement (if it was to occur) could result in stress changes in the tailings which could initiate liquefaction, if all the other conditions exist for tailings liquefaction. A concrete plug is proposed to be installed at the specified location in the decline where the existing rock is less affected by fracturing etc from the original pit excavation, and the thickness of intact rock around the proposed plug location prevents potential jacking movement of the plug, if it was subject to liquified tailings pressures.

6.2 Plug Design

Six plugs are proposed to be installed at identified locations shown in Table 4. The plugs are designed based on the rock mass properties from inrush report summarised in Table 3. The Portal plug was designed as non-pressure grouted plug whereas the others were designed as pressure grouted plugs.

6.2.1 Pit Fill

The preparation works in Kintore pit is to develop a stable and uniform base on the pit floor by dozing some of the waste rock from the in-pit stockpile to create a 12 m thick rock layer over the base. The rock layer is designed as a drainage layer and will include drainage pipes surrounded by aggregate to collect possible seepage water from the tailings and pit sidewalls and discharge it into the mine through the proposed plug near the existing Portal for removal as mine water. The rock layer will be nominally compacted by track rolling.

The design intent for the rock layer is to:

i) Depressurise and discharge any seepage water at the base of the tailings.

ii) Form a reasonable size surface area to enable the placement and compaction of tailings for the anticipated rate of tailings production.

iii) Create a firm and shaped substrate for tailings deposition.

iv) Form an engineered rock layer that extends above the crown elevation of the existing Portal.

Compacted tailings will be deposited onto the rockfill layer. The tailings will be spread in layers and compacted to achieve a minimum density of 95% of the SMDD.

The dewatered tailings should have no free water and the tailings surface will be shaped to drain rainwater runoff to a depression where it can be removed by pumping.

The pit slopes will be inspected as the tailings surface rises and any old workings intersecting the pit face will be stabilised and closed with a rockfill buttress or similar approach before tailings is placed against them.

6.2.2 Hydraulic head

The maximum hydraulic pressure that may be exerted on the plugs if the tailings liquefies. The maximum head occurs at the end of pit filling when the maximum elevation of tailings is achieved if the tailings is in a liquefiable state. The tailings is intended to be dewatered before it is placed into the pit and compacted in layers. For the plug design it is conservatively assumed that the tailings will be in a saturated condition and be potentially liquefiable under static or dynamic loading. This is effectively an upset condition where all the tailings are either wet when placed and remain wet, or not compacted as designed and/or the underdrainage system at the bottom of the pit fails. If the tailings in the pit are relatively dry and at a void ratio below the liquefaction state, then the tailings are not expected to liquefy.

The plugs are designed for the total tailings depths presented in Table 5 based on the inrush report plug elevations with the mine surface elevation (RL 10333 m, provided by BHOP in an email from David Matthews on 2 July 2020).

Table 5: Depth of tailing at Mine Plug locations

Plug Location	Final Average Tailing Surface Elevation (m)	Plug Elevation (m)	Tailing Depth (m)
Portal Plug	10 324	10 226	98
Western Min Decline near MLD Intersection	10 324	10 212	112
Dickenson's Shaft Western Min Decline below SP3	10 324	10 145*	179
1000 ft Level East of Park bay	10 324	10 046*	278
Block 11 Access Incline east of ladderway intersection	10 324	9 944	380
1480 Access Drive West of intersection with airway	10 324	9 900	424

*provided via an email from David Matthews (BHOP) on 2 July 2020.

The loading on the plugs is assumed to be equivalent to that of a liquid tailings with a density of 1500 kg/m^3 filled to the pit crest, i.e: the entire tailings mass liquified. This density of tailing was adopted based on the consideration that the tailings will have a high porosity when acting as moving fluid.

During an earthquake, shock loading (water hammer) may also propagate through the tailing to the plug.

The anticipated maximum hydraulic heads on the plug, including the increased head due to water hammer, are summarised in Table 6.

Table 6: Anticipated Maximum Hydraulic Heads

Mine Plug Location	Potential Hydrostatic Head (kPa)	With Water Hammer (kPa)
Portal Plug	1440	1680
Western Min Decline near MLD Intersection	1650	1890
Dickenson's Shaft Western Min Decline below SP3	2630	2870
1000 ft Level East of Park bay	4090	4330
Block 11 Access Incline east of ladderway intersection	5590	5830
1480 Access Drive West of intersection with airway	6240	6480

6.2.3 Rock Mass Classification

Table 7 presents the adopted allowable shear stresses within and along the interface with rock masses, and incorporates a Factor of Safety of 3.0. For example, an allowable shear strength value of 250 kPa was adopted for fair to good bedded rock condition in a plug location.

Table 7: Allowable Shear Stress for Rock (Benson 1989)

General Rock Condition RMR – Rock Mass Rating[1]	Allowable Shear Stress (kPa)
Very Good Rock, Massive, hard, widely jointed, 81< RMR< 100	500
Good Rock, Hard to mod. Hard, moderately jointed, 61<RMR<80	300
Fair Rock, Moderate to weak, moderately jointed, 41<RMR<60	200
Poor Rock, Weak, closely jointed or sheared, 21<RMR<40	100
Very Poor Rock, Very weak, possibly erodible, RMR<20	50

1: Bieniawski (1976)

6.2.4 Water hammer from earthquake loading

Water hammer is the shock wave caused by an earthquake that could propagate through liquified tailings on the upstream side of the plug and considerably increase the applied pressures on the plug. An earthquake acceleration of 0.2 g was adopted to calculate the water hammer pressure. The water hammer pressure was added to the static fluid pressure to calculate the minimum plug length for punching shear failure considering a factor of safety of 1.5. Adopted plug lengths considering water hammer pressure were smaller than the length obtained considering only static pressure with factor of safety of 3.

6.2.5 Punching shear

The punching shear assessment considers the maximum load applied to the upstream face of the plug by liquefied tailings. The applied pressure is based on fully liquified tailings in the pit, with earthquake loading on the plugs. Analyses were carried out to evaluate the shear mobilised in the concrete, at the rock/concrete interface and through the rock mass. A factor of safety greater than 3 is to be provided for static loading and 1.5 is to be provided for static loading plus dynamic loading.

A preliminary review indicated that the concrete compressive strength of the plug should be at least 25 MPa from a durability point of view. Based on the concrete shear strength of 25 MPa concrete, an assessment indicated that the critical interface for the plug length for punching shear is the rock shear strength. The rock mass shear stress with a factor of safety of 3.0 results in the minimum length of plug for punching shear and presented in Table 8.

Table 8: Summary of plug length for punching shear criteria

Mine Plug Location	Design length (m)	Controlled Failure criteria
Portal Plug	7.6	Shear failure in rock
Western Min Decline near MLD Intersection	8.6	Shear failure in rock
Dickenson's Shaft Western Min Decline below SP3	13.8	Shear failure in rock
1000 ft Level East of Park bay	17.9	Shear failure in rock
Block 11 Access Incline east of ladderway intersection	29.3	Shear failure in rock
1480 Access Drive West of intersection with airway	27.2	Shear failure in rock

6.2.6 Deep beam failure

The six plugs designed for the proposed location will have a length to lateral dimension of more than 1.25 so unreinforced concrete may be used.

6.2.7 Failure through Seepage

The pressure gradient is the ratio between the applied hydrostatic and impact pressures and the plug length and has units of kPa/m.

Based on experience gained with underground hydroelectric projects Benson (1989) recommended empirical guidelines for allowable hydraulic gradients for tunnel plugs. Higher values of hydraulic gradient may be used if grouting was carried out during plug construction. The guideline values are presented in Table 9 and incorporate a Factor of Safety of 3.

Table 9: Summary of Recommended Civil Engineering Practice Guidelines for Hydraulic Gradients for Tunnel Plugs (adapted from Benson 1989).

General Rock Condition RMR – Rock Mass Rating[1]	Maximum Allowable Hydraulic Gradient (m/m)
Very good Rock, Massive, hard, widely jointed, 81 < RMR < 100	15 – 30
Good Rock, Hard to mod. Hard, moderately jointed, 61<RMR<80	10 – 14
Fair Rock, Moderate to weak, moderately jointed, 41<RMR<60	7 – 9
Poor Rock, Weak, closely jointed or sheared, 21<RMR<40	5 – 6
Very Poor Rock, Very weak, possibly erodible, RMR<20	3 – 4

A hydrostatic head would only develop on the upstream end of a plug if the rockfill drain under the tailings were to block, and /or water or seepage that may accumulate at the upstream end of the plugs is not released through the plug. Based on the given rock mass condition and maximum allowable hydraulic gradient in Table 9 the required plug lengths are presented in Table 10.

Table 10: Summary of design plug length based on seepage failure

Mine Plug Location	Design Length (m)
Portal Plug	21.4
Western Min Decline below MLD Intersection	11.2
Dickenson's Shaft Western Min Decline below SP3	17.9
1000 ft Level East of Park bay	21.4
Block 11 Access Incline east of ladderway intersection	38.0
1480 Access Drive West of intersection with airway	32.6

The values in Table 10 are provided as an indication only to provide context of the plug dimension of water release through the plugs was not to occur.

6.2.8 Hydraulic jacking around the plug

Hydraulic jacking is not applicable to the Kintore Pit plug since the *in-situ* rock overburden pressure at the plug locations exceeds the pressure applied by the tailings on the plug.

6.2.9 Long term disintegration of concrete

Degradation of the plug to a failure condition by chemical attack on the concrete would only occur over a long period. We consider that this failure mode is not of concern for the RASP decline plug since a dense moderate strength concrete is to be used to construct the plug and the tailings will generate little or no seepage to transmit potentially deleterious leachate to the plug.

6.3 Plug Length considering Rock Bolt Installation

All initial plug lengths were governed by punching shear failure in the rock (excluding seepage failure condition). The cost of the mass concrete plugs may be significant and hence a second option of plug detail was developed that may be considered based on cost. An option of including rock bolts in the surrounding rock was considered to increase the effective shear perimeter of plugs (Figure 15). The rock bolt option was considered for plugs with a length of more than 10m. The revised plug lengths and rock bolt lengths are listed in Table 11.

Note the frequency and spacing of rock bolts would be subject to detailed design based on the joint and rock conditions at the plugs to stitch the rock inside the enlarged perimeter to suit the shear load of the plug. A preliminary estimate of bolts at 1.5 m spacing may be adopted for costing at this stage. Any existing rock bolts in the area of the plugs may potentially contribute to the plug design, depending on the condition of the rock bolts. The plugs could also be modified to include haunches into the side of the tunnels, if that is a more cost effective option depending on the condition of the rock at the plug and the cost of rock bolting related to spacing and length. This detail is to be developed as part of the execution stage of the works, and should be based on the detailed rock conditions at each plug location.

The rock bolts would need to be designed for the design life of the plug.

Table 11: Summary of plug length with and without rock bolts

Plug length	Depth (m)	Length without rock bolts		Length with rock bolts	
		Controlling factor without seepage	Design Length (m) Minimum	Bolt length to achieve effective shear perimeter (m)	Design Length (m)
Portal Plug	107	Punching shear failure in rock	7.6	NR	NR
Western Min Decline near MLD Intersection	121	Punching shear failure in rock	8.6	NR	NR
Dickenson's Shaft Western Min Decline below SP3	188	Punching shear failure in rock	13.8	2.5	7.1
1000 ft Level East of Park bay	287	Punching shear failure in rock	17.9	2.5	9.1
Block 11 Access Incline east of ladderway intersection	389	Punching shear failure in rock	29.3	5.5	9.5
1480 Access Drive West of intersection with airway	433	Punching shear failure in rock	27.2	5	9.4

NR-Not Required

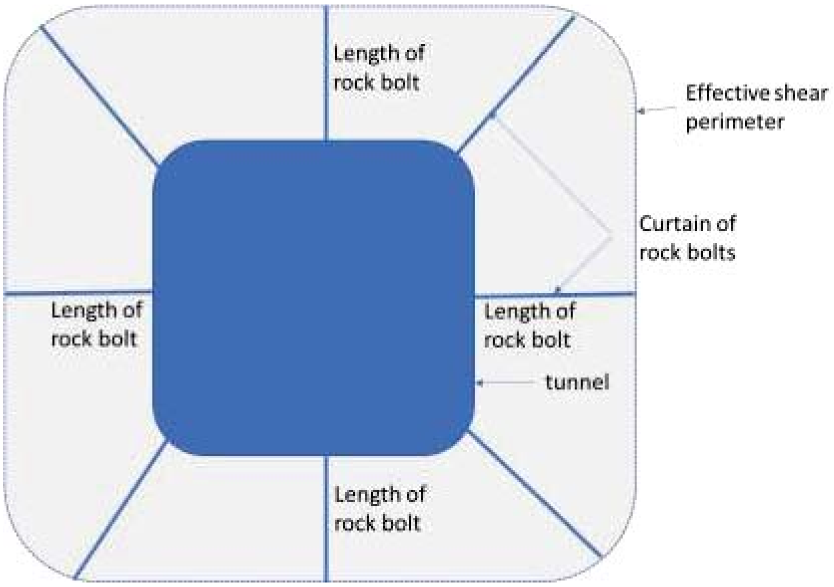

Figure 15: Increased shear perimeter with rock bolt installation

7.0 PLUG CONSTRUCTION

Each plug will be formed using upstream and downstream bulkheads to close off the tunnel section and facilitate placement of the plug concrete. Any existing ducts, pipes, cables etc in the area of the plug will be decommissioned and the service relocated away from the plug area. All the plugs should be pressure grouted except Portal Plug. The Portal Plug will also include low pressure grouting of the tunnel crown interface with the top of the plug to close off any gaps on the interface. Rock bolt installation may be an option for 4 plugs as shown in Table 11.

The required lengths of rock bolts (Table 11) shall be installed in rows along the tunnel and around the perimeter of the tunnel, and extend at least 500 mm into the tunnel concrete plug. The plug may be formed by placing 25 MPa unreinforced concrete into the location of the tunnel. The interface between the rock/existing shotcrete and concrete shall be pressure grouted at a pressure greater than twice the design hydrostatic pressure. In this context grouting pressure at the lowest plug (1480 Access Drive) is 12.5 MPa. Additives to improve concrete workability are recommended or alternatively additives to produce self-consolidating concrete may be considered.

Depending on the condition of any fibrecrete lining in the tunnels it may be necessary to remove some or all of the fibrecrete and to expose the rock bolt heads before the mass concrete is placed. If the fibrecrete is removed any loose or spalled rock should also be removed to leave a competent rock surface.

All plugs should include a permanent drainage outlet through the plug with a high pressure valve on the downstream end that can be closed in an emergency. The valve should remain open under normal operating conditions. The drain should extend at least 10 m upstream of the plug and be covered with rockfill and aggregate to protect the drain and filter seepage water to retain solids in the upstream tunnel.

The drainage outlet through the plug should be high strength steel pipe suitably corrosion protected and designed for the maximum hydraulic pressure, so it remains operational during and after any liquefaction event. Similarly the valve should be specified to the same robustness.

8.0 PLUG REQUIREMENT

The plugs are intended to be the fourth line of defence against tailings inrush into the underground workings. The first line of defence is dewatered and compacted tailings placed in the pit, the second line of defence is a drainage layer in the pit with collection system managed as part of mine water, the third line of defence is placing a rockfill layer over know historical workings in the bottom on the pit and against the pit side walls, and the fourth line of defence is the plugs. The fourth line of defence is only required if the tailings liquefy, and for this to occur three conditions must be satisfied:

- Tailings at or near saturation
- Tailings void ratio is above the critical void ratio
- Change is stress condition, such as breach of the rock surround into mine workings. This change in stress can also be initiated by a rise in water level within the tailings.

The liquefaction risk of the placed tailings in the pit is proposed to be assessed periodically by conducting in-situ testing of the entire depth of placed tailings. This will enable an assessment to be made whether the tailings are wet or dry, any phreatic surface and whether the tailings is above or below the critical void ratio that enables liquefaction. If the tailings assessment shows that the tailings are approaching conditions conducive to liquefaction, then the plugs and associated raise infills should be installed, together with any associated changes to the mine ventilation layouts.

The frequency of in-situ tailings assessment will depend on the results of the previous investigations, with investigations to start once approximately 15 m thickness of tailings is in place, and then for at least every subsequent 10 m thickness. The required frequency of testing is expected to be more frequent as the thickness of tailings increases and the rate of rise reduces, to track the changes in the tailings conditions.

Note the existing portal plug and associated rockfill infill should be installed as part of the pre-deposition works for Kintore pit. The 1480 Access Drive plug is being developed as part of existing underground operations.

9.0 CLOSURE

This preliminary design has been prepared using the provided geological and rock mass data at the plug locations.

10.0 REFERENCES

1) Golder Associates, 2018. “RASP Mine – Kintore Pit Tailing Storage Facilities – Staging of Tailing Deposition Strategy”. Memorandum reference 1896230-010-M-Rev2 dated 11 September 2018

2) Department of Mining and Resources, NSW. (1961). “Mining and Exploration at Broken Hill. A Review”

3) Australian Earthquake Map (2012)

4) Broken Hill Operations Pty Ltd. “Inrush and Inundation Pathways from TSF3-Rasp Mine_final V2”

5) Lang, B. (1999) Permanent Sealing of Tunnels to retain Tailing or Acid Rock Drainage - In: Fernandez Rubio: Mine, Water & Environment II – p 647-655, Sevilla (International Mine Water Association)

6) American Concrete Institute 318-95 (19 “Building Code Requirements for Reinforced Concrete”

7) Benson, R.P. (1989) Design of Unlined and Lined Pressure Tunnels. Tunnelling and Underground Space Technology, Vol 4 No 2, pp 155 -170

8) Garrett, W.S. and Campbell Pitt, L.T. (1958) Tests on an Experimental Underground Bulkhead for High Pressures. J.S. African Inst. Min. and Metal, Apr. v.3, pp 1283-1302

9) Golder Associates, 2018. “Kintore Pit Tailing Storage Facility – Critical State Testing”. Report reference 1896230-004-R-Rev0 dated August 2018.

Signature Page

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https://golderassociates.sharepoint.com/sites/25201g/deliverables/047 kintore pit mine plug design/1896230-047-r-rev1.docx

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APPENDIX F

BHOP Report detailing Drying Trials dated 12 January 2021.

BROKEN HILL OPERATIONS PTY LTD

RASP MINE

Memo

TO: **Carlos Vanegas**

FROM: **Daniel Hitchcock, James McMaster, Clare Gilby**

DATE: **12/01/2021**

RE: **Blackwood TSF Moisture Survey For Use In Engineered Fill**

Key Points

- Natural desiccation of tailing in Blackwoods Pit TSF occurs at a rate fast enough for harvesting of 383ktpa of tailing to be feasible (450ktpa mill feed) based on the test work and parameters outlined in this report.
- The tailing material to a depth of 0.4m reaches the moisture specified for safe use in engineered fill (Standard Optimum Moisture Content (SOMC) of 11%) within 1 week of drying and potentially even within 4 days. This is based on the sampling method considered most representative of natural, in-situ drying. A different sample method showed tailing reached SOMC after 19 days, despite a small rain event.
- Rotating between three cells with an 8/6 production roster leaves 34 days to dry and harvest. With drying taking between 4 to 19 days, at least 15 to 30 days should be available for harvesting operations.
- Using a basis of 383ktpa and 3 hectares per cell, harvesting depth required per cell each round is only 0.31m.
- Drying rates generally decrease with increasing depth; however, the top layers are not always the first to dry as they are more susceptible to external events.
- Faster drying rates may be possible if the surface is 'shaved' multiple times rather than waiting for the full depth to dry.

Background

Rasp is investigating the possibility of harvesting naturally dried tailing from Blackwoods Pit for use as engineered fill in Kintore Pit. Golder have advised that to safely avoid liquefaction, a Standard Optimum Moisture Content (SOMC) of 11% is required (Gassner, 2020).

In April through June 2020, moisture testing of Blackwoods Pit tailing was conducted over multiple locations in a grid pattern covering the western ('lookout') end of the pit. This was followed up in July 2020 with sampling conducted over a period of 21 days at only 3 locations with the purpose of charting drying times. A further set of testing commenced in September 2020 as the previous testing showed tailing had already reached a steady state moisture content before commencement of measurement. The new round of testing placed slurry in 200mm deep buckets which were able to be moved as necessary to avoid contamination with pooling water. On analysing the data, it was determined that given the drying rate, harvesting would need to be at depths greater than 200mm. This survey, commenced 30/11/2020 sought to address issues encountered in the prior trials.

Objective

The objective was to determine the drying rate of fresh tailing over time at depths up to 0.5 metres. This was to allow assessment by Golder of the feasibility of using natural drying and harvesting of tailing at Rasp.

Test Methods

Two test methods were used in this round of test work and will be discussed separately. The first method filled 0.5m deep pits in the TSF with fresh tailing and measured the time taken to dry. Each pit was approximately 5m by 3m in area. The second method noted an area of fresh tailing naturally deposited and measured the time taken to dry in-situ. The combination of the two methods provides more representative data of what is expected. The location of each sampling point is shown in Figure 1 below.

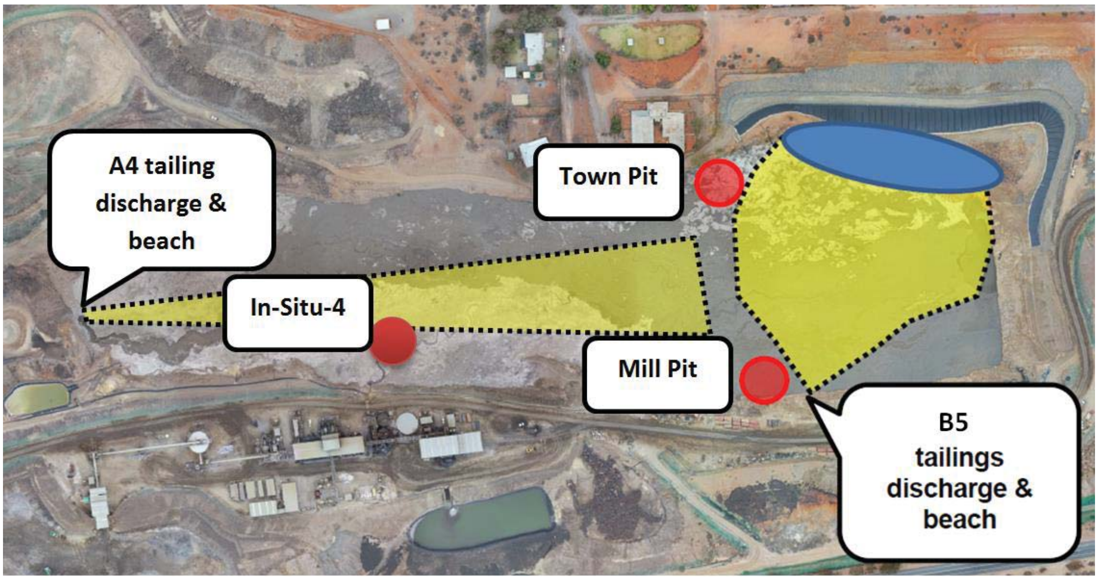

Figure 1 Locations of Test Pits and In-Situ Sample Point

Assumptions

Throughout this report, 'moisture' refers to gravimetric moisture – the mass of water divided by the mass of solid.

The deposition of tailing is taken to be into three separate cells, each of 3 hectares area. It is assumed deposition will rotate between the three cells on an 8/6 production roster, leaving 34 days between ceasing and recommencing deposition in each cell.

At 450ktpa mill feed, the tailing produced is calculated to be 383ktpa or, if low head grades and recoveries experienced, a worst case of approximately 419ktpa of tailing. If using three cells, each 3 hectares in size, the average depth of deposition/harvesting required to maintain TSF level at steady state is then 0.31 to 0.33m. In the event tailing is distributed unevenly across the cell, it is assumed that previously dried tailing can be harvested and mixed with any deep/wet tailing. If rotating between cells with each 8/6 milling campaign, the time available to dry and harvest is 34 days.

Sampling Equipment

In both methods (test pit and in-situ), collection of samples for moisture testing was achieved using a 'yabby pump' sampling device, consisting of a tube with sealing plunger. See Figure 2.

Samples were divided into 100mm increments and the moisture of each section measured separately by drying them for a minimum of 14 hours (overnight) in an oven set to 80C.

The holes remaining after sampling were not capped or otherwise modified.

Figure 2 'Yabby Pump' sampling device with remaining hole

Figure 3 Sample Ready to Divide Into 100mm Increments

Weather Conditions

The relevant parts of the tests were conducted in December 2020. While summer months are generally hotter temperature and drier, promoting drying, December 2020 was an exception to the rule. Bureau of Meteorology indicate that La Nina conditions are prevalent for the summer of 2020/21 (BOM, 2021). The December 2020 average maximum daily temperature was 30.3C compared to the typical 32.2C. Rainfall for December 2020 was 21.8mm, higher than the average December rainfall of 18.3mm and higher than the average for all months in the year of 18.9mm. The month average of daily maximum temperatures for Broken Hill airport BOM weather station from 2000 to December 2020 are presented in Figure 4 while rainfall is presented in Figure 5.

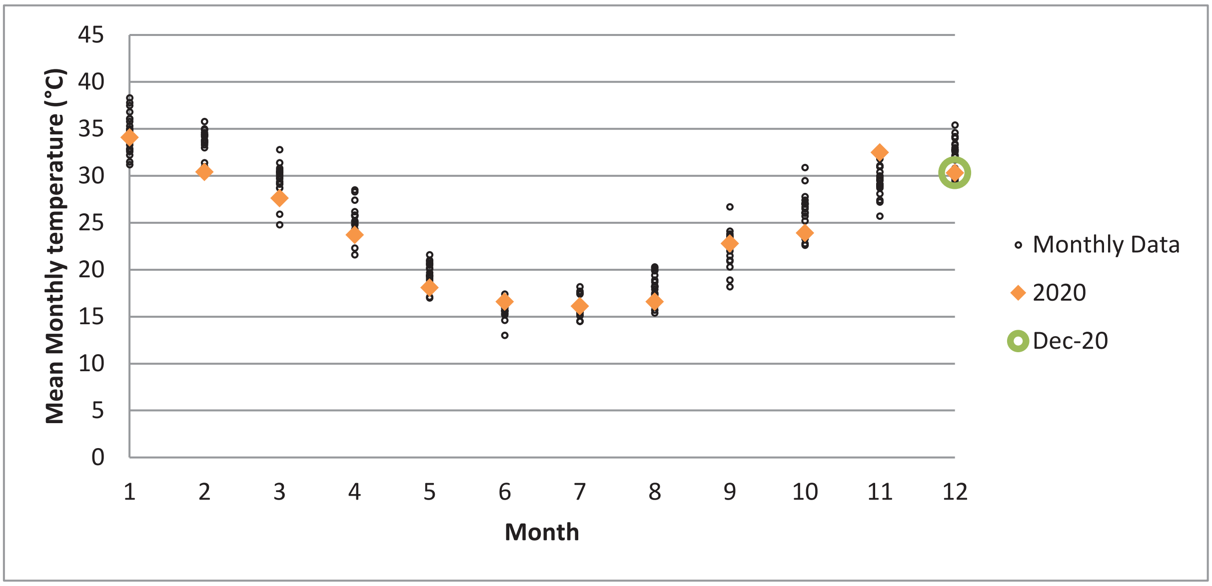

Figure 4 Maximum Daily Temperature - Broken Hill Airport, Year 2000 to 2020

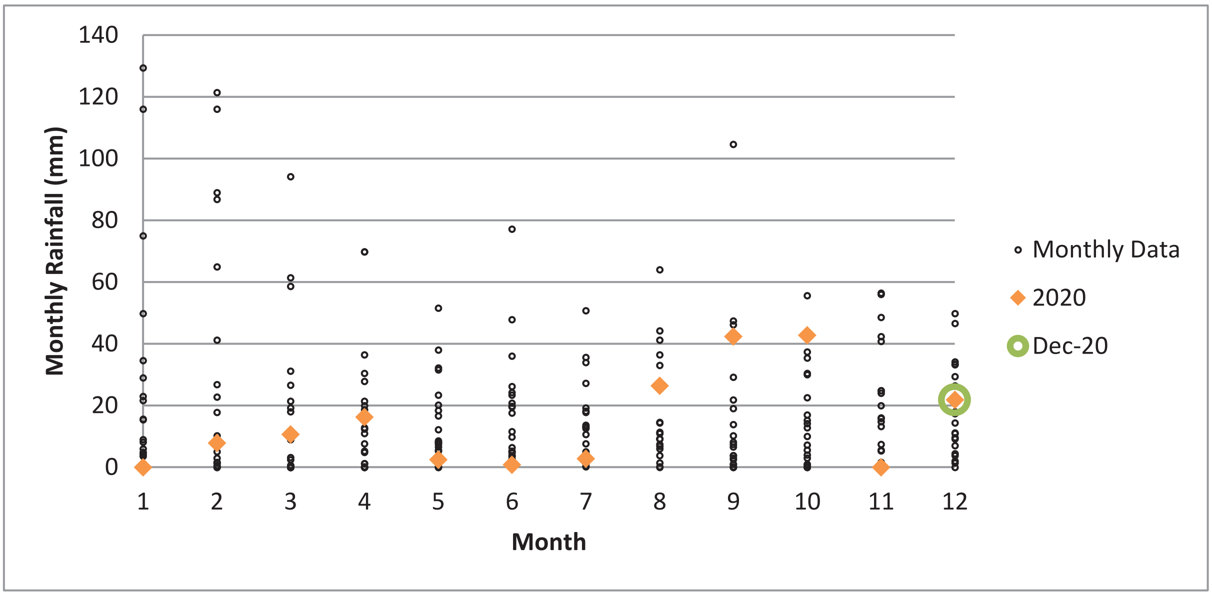

Figure 5 Monthly Rainfall - Broken Hill Airport, Year 2000 to 2020

In-Situ Sampling Location Preparation

A 1.65m star picket was placed 0.25m deep into dry tailing slightly south of the centre of the TSF on 8th December (Figure 6). The milling campaign commenced on the same day and finished on the 16th December. The height of star picket exposed was measured to indicate the depth of tailing as fresh tailing deposited around it. When the depth rose above 0.5m and after the tailing stream had shifted away from the area, moisture sampling commenced at the star picket with samples denoted as 'In-Situ-4' or abbreviated to 'IS-4'. This sample point is considered the most representative of natural drying in the TSF because the tailing was deposited in the same manner as normal - over several days (affording time for partial drying of each layer by the sun), with runoff allowed to escape the area and not confined by already dry tailing or other impermeable barriers.

Figure 6 In-Situ-4 Location Circled in Red – 15th December

In-Situ Data

All data is included in the attached spreadsheet.

In-Situ Results

Sampling of the tailing at the In-Situ-4 location was not possible for the first few days after deposition due to access across the wet tailing surface being impractical. The exact date on which deposition around the location ceased is known to within 3 days (10th – 13th December). As charted in Figure 7, the tailing is estimated to have stopped depositing in the area on day 0 (13th December). The milling campaign commenced on day -5 (8th December). Slurry was still flowing around the location on day -4 (9th December) and the end of the milling campaign was on day +3 (16th December). The tailing was deposited over only one campaign. A subsequent campaign commenced on day 9 (22nd December) did not re-cover the sample location; however, evidence of minor wetting of the area around the In-Situ-4 location was observed occasionally. This suggests the tailing stream may have re-approached the area overnight, delaying drying marginally.

By estimated day 4 (17th December, which is at most actually day 7 from ceasing deposition), the average moisture to a depth of 400mm had already reached SOMC. This leaves an estimated 30 days for harvesting (or at minimum 27 days).

The 200mm and 300mm layers were much drier than the top layer (Figure 9). In both theory and practice, feasibility of harvesting should therefore not be decided on moisture of the top layer alone. Deeper layers should also be checked before determining whether a cell is ready for harvest.

The lowest layer dried much more slowly, reaching at 16% moisture after three weeks (refer Figure 9) and holding the average moisture for the full 0-500mm just above SOMC at 11.5 to 14% (refer Figure 8). However, the failure of the lower layer to dry is believed to be due the tailing continuing to run and pond nearby on subsequent campaigns. It is not representative of the 3 proposed 3 cell arrangement where no tailing deposition will occur in the same cell while the cell is drying. (The test pit method which did not have fresh tailing nearby did not show the same characteristic.) When designing cells, it may therefore be important to ensure any water runoff is not ponded at an elevation below which harvesting is planned to occur. Otherwise the phreatic pressure may rewet lower layers that had previously dried. Furthermore, by progressively shaving the top layers, the bottom layers could be exposed, allowing them to dry more quickly.

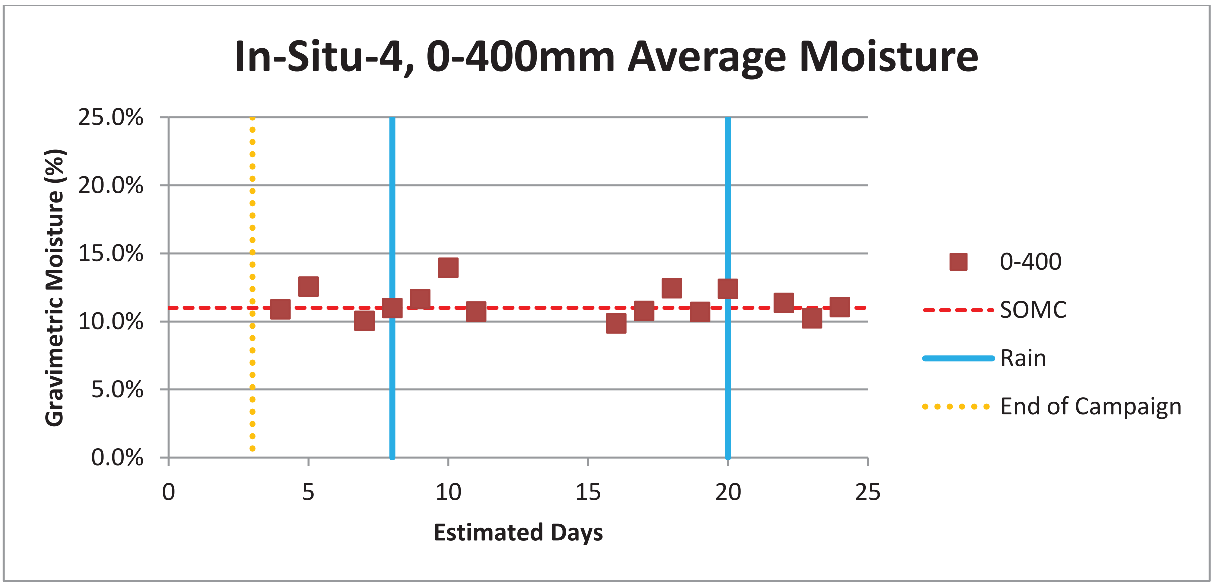

Figure 7 In-Situ-4, 0-400mm Average Moisture

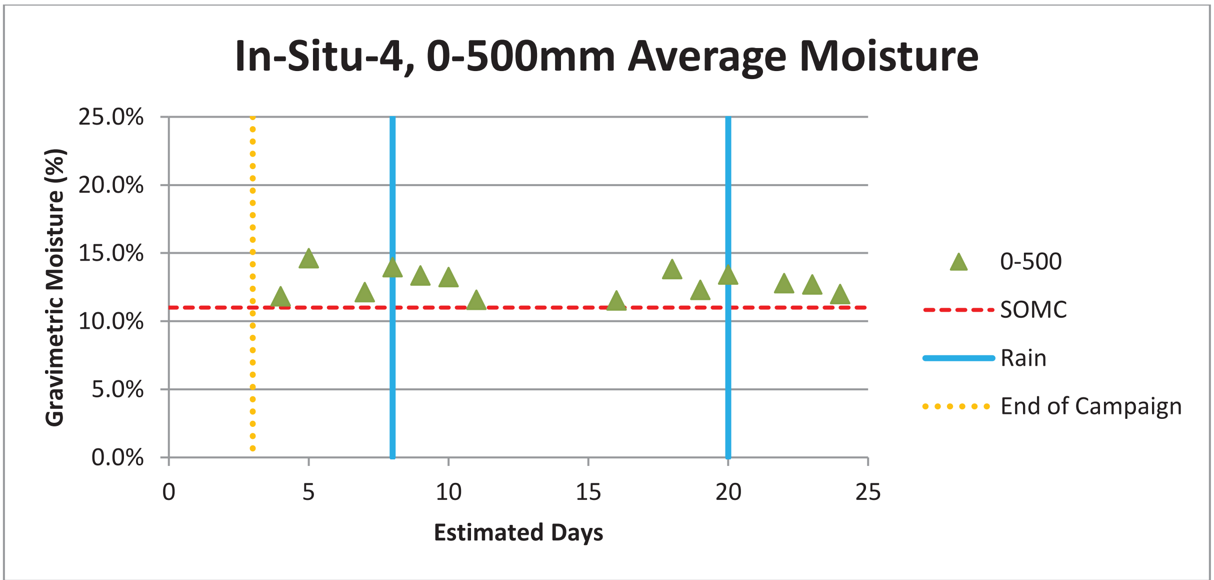

Figure 8 In-Situ-4, 0-500mm Average Moisture

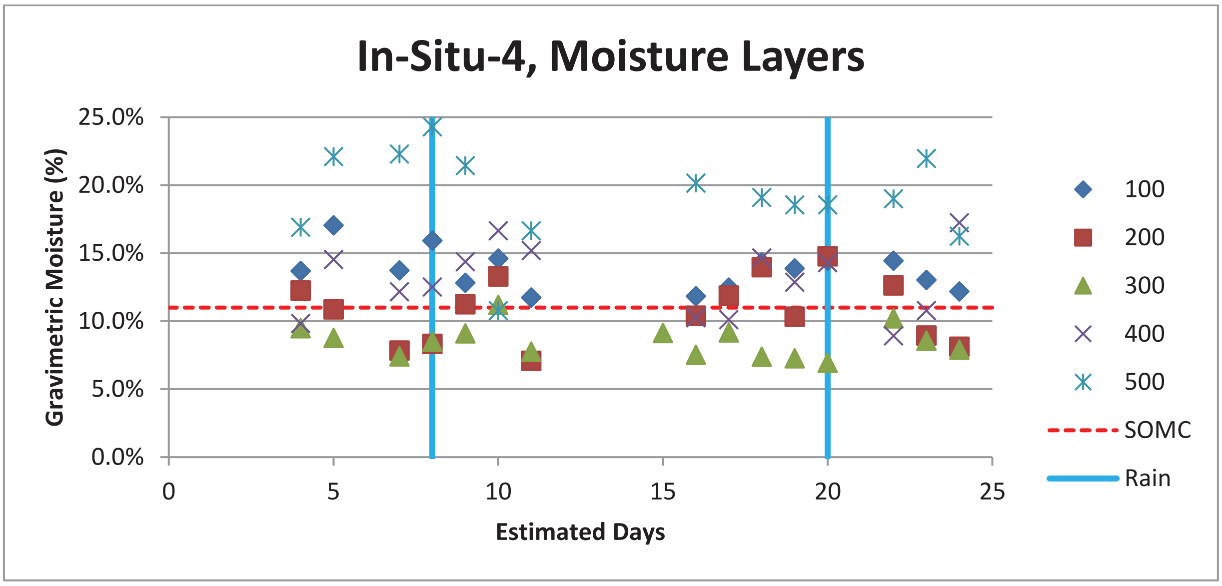

Figure 9 In-Situ-4 Moisture Layers

Test Pit Preparation

Two test pits were excavated in the existing TSF. Each pit was approximately 5m x 3m x 0.5m deep. The pits were at two locations: one adjacent to the B5 spigot where tailing was being discharged (denoted as 'mill test pit') and the other close to the southern end of Embankment 2 (denoted as 'town test pit'). Refer to Figure 1. These areas were to provide information on the coarse and fine particle fractions of the tailing beach. The mill pit was filled with fresh tailing via a channel dug from the current tailing discharge to the pit. A suitable channel to the town pit was unable to be dug due the risk of machinery working close to the active tailings beach. The town pit filled with run-off water before the tailing stream naturally diverted away again.

The tailing discharge point was shifted from spigot B5 to spigot A4 (see Figure 1), leaving the mill pit to dry. The town pit eventually filled with slurry; however, it was only able to be sampled briefly between milling campaigns due to fresh tailing covering it at the beginning of the following campaign. Data for this pit is not discussed in the report as it did not receive sufficient chance to dry before being inundated with fresh tailing and water run-off.

Samples were taken prior to filling the pits, immediately after filling and then every 1 to 3 days following. Samples were collected over a period of 5 weeks.

Each set of samples from the town pit consisted of one sample from each end of the pit and one from the centre – 'North', 'Middle' and 'South'. Approximately 300mm was left between each of the sample holes at each point.

Figure 10 Mill Test Pit Excavated & About to Fill

Figure 11 Mill Test Pit After Filling

The mill pit was accidentally covered with Zn circuit slurry on the 3rd December, shortly after the survey had started. After consulting with Golder, it was attempted to remove this with a screed and this failing, a shovel.

Figure 12 Removing the Zn slurry from the surface of Mill Pit

Test Pit Data

All data is included in the attached spreadsheet.

Test Pit Results

The average moisture content of the Mill Pit samples between 0 and 400mm deep are presented in Figure 13. The SOMC of 11% was reached after 19 days drying despite a small rain event on day 10. This leaves 15 days in which to harvest. Note that subsequent rain events, indicated by the blue, vertical lines, briefly raised the moisture above SOMC again. This test pit is considered less representative than the in-situ stake and overstates the time required to achieve SOMC for several reasons:

- Each time it rained, the majority of run-off water from the nearby TSF access ramp travelled over the test pit, rewetting it.
- Whereas in practice, the water would be able to drain away to the end of the cell, the test pit did not truly allow run off water. Furthermore, it is suspected that on being thoroughly dried, tailing becomes less permeable, preventing drainage of fresh water. In the dry-walled test pit, evaporation would therefore be the sole means of water egress.
- The test pit was not afforded the slow deposition and partial drying of each layer over several days during deposition – the full 0.5m was instead filled in the space of a few hours.

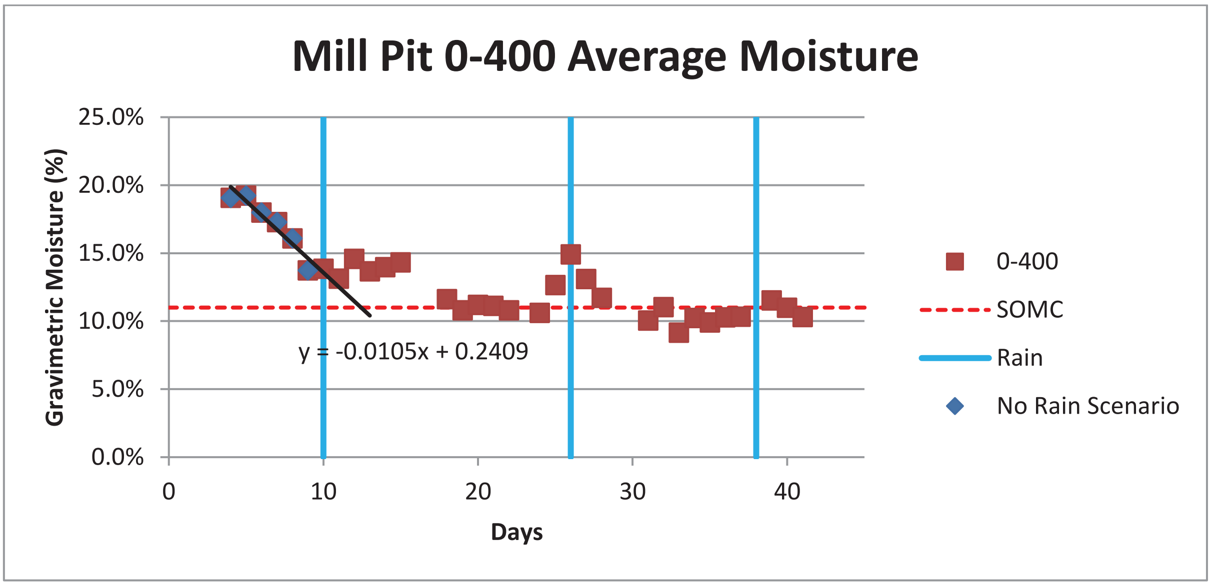

Figure 13 Mill Pit 0-400mm Average Moisture

The full 500mm depth reached SOMC on day 24. If it were not for the rain event, the full 500mm is extrapolated to have been available to harvest after only 14 days as shown in Figure 14.

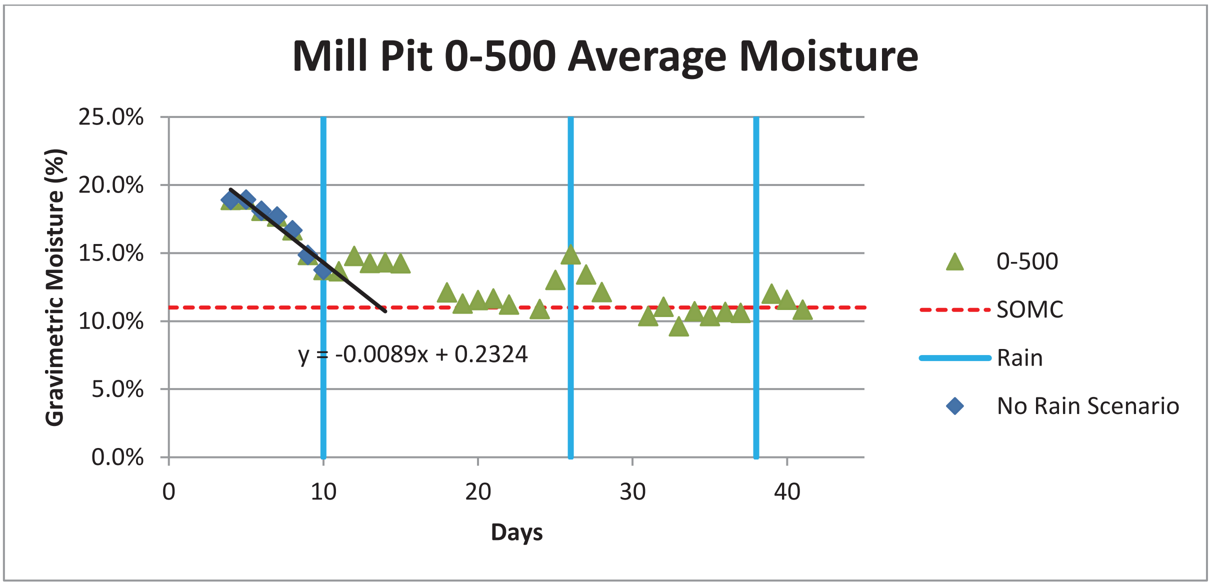

Figure 14 Mill Pit 0-500mm Average Moisture

Charts of moisture for individual 100mm depths with the individual sampling points divided into separate series are included in Figure 15 through Figure 19 for reference.

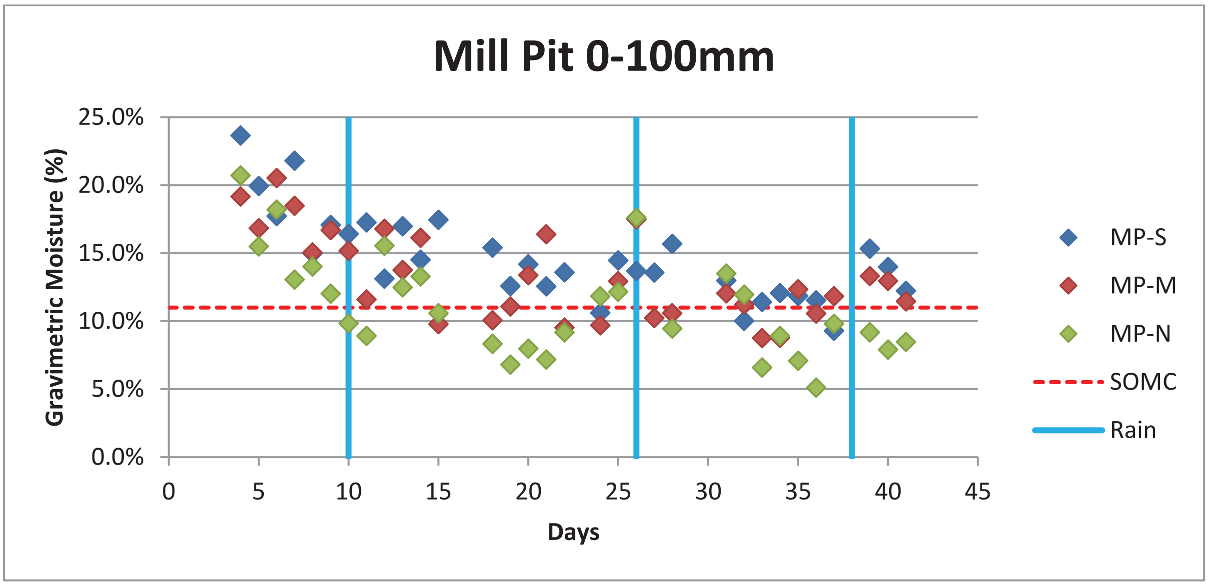

Figure 15 Mill Pit 0 - 100mm

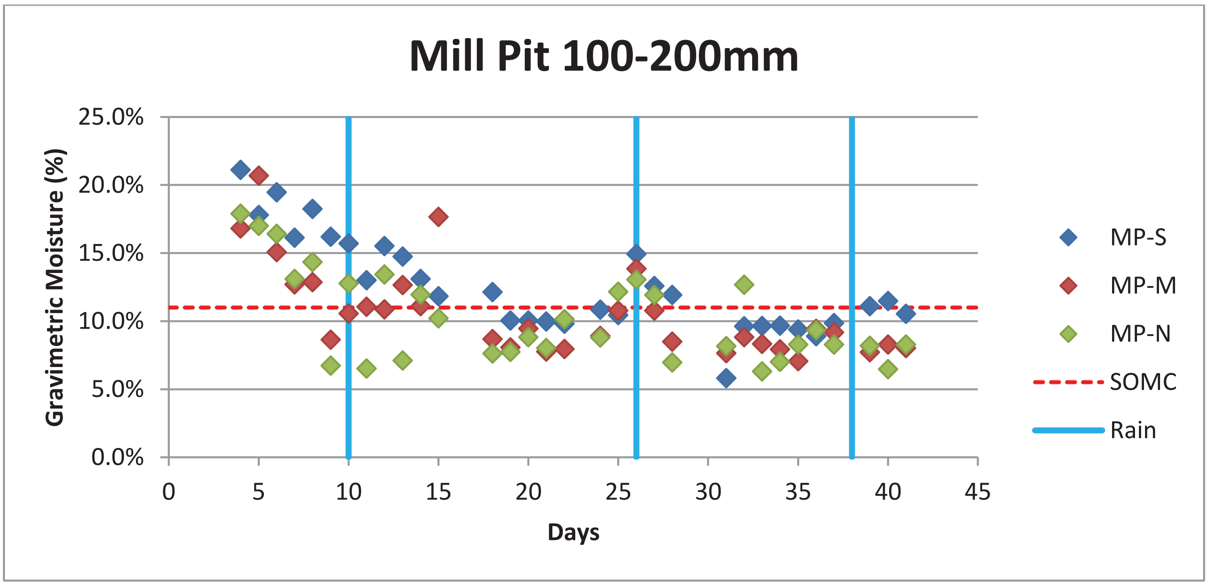

Figure 16 Mill Pit 100 - 200mm

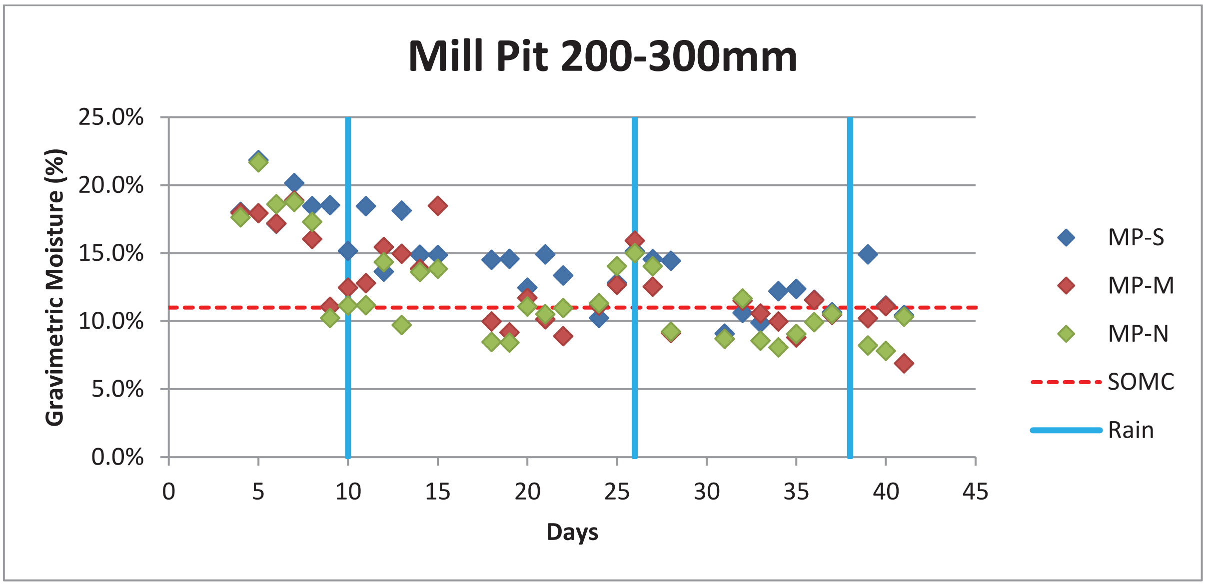

Figure 17 Mill Pit 200 - 300mm

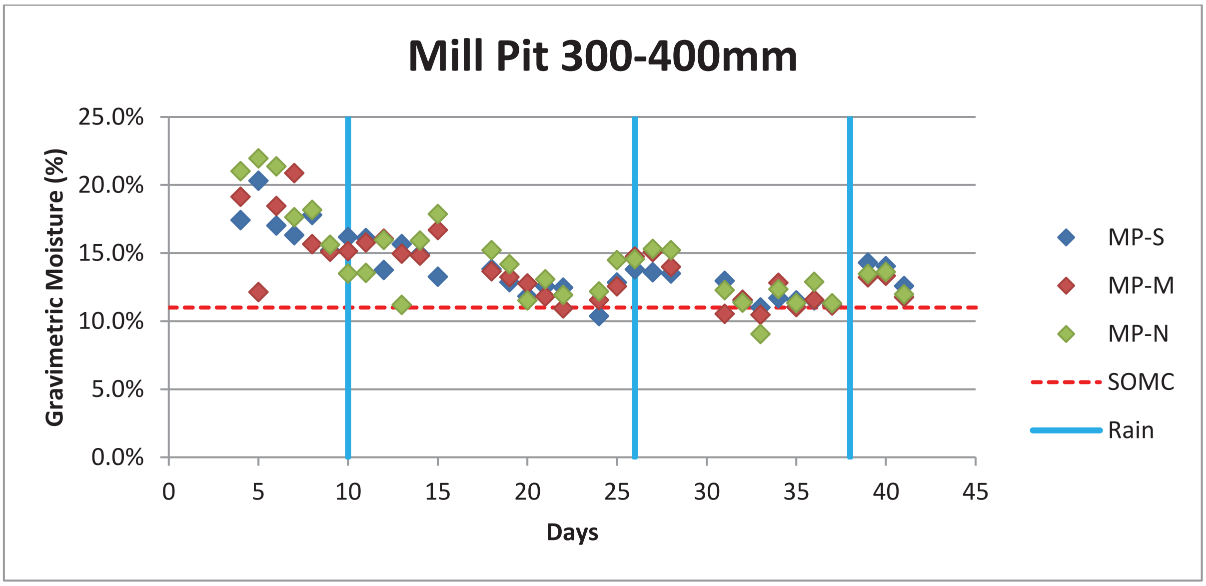

Figure 18 Mill Pit 300 - 400mm

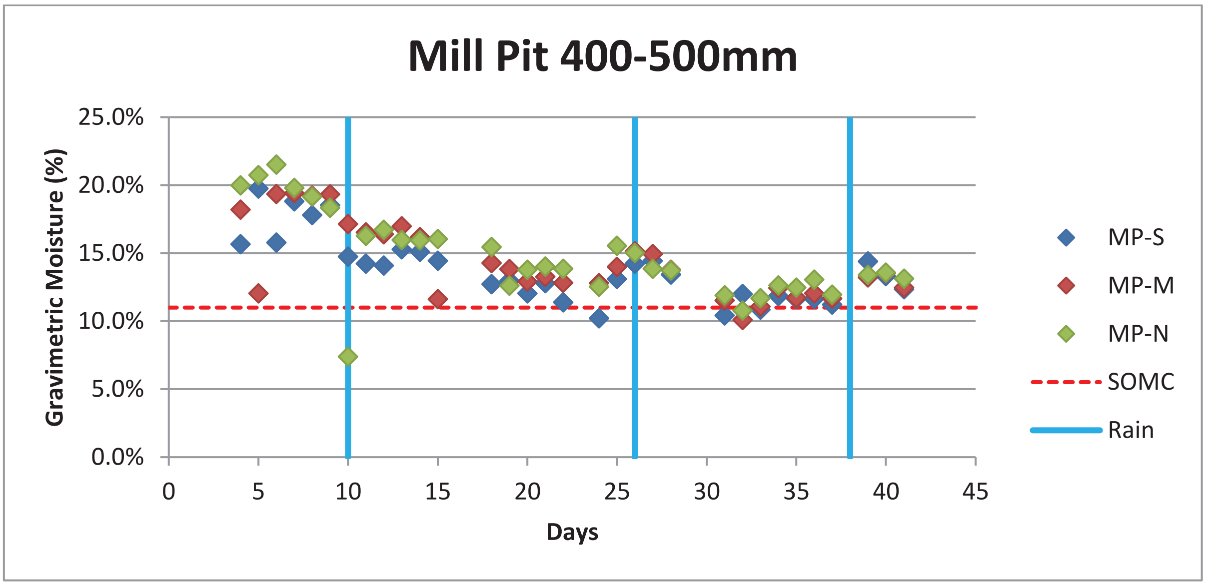

Figure 19 Mill Pit 400 - 500mm

The initial drying rate of each level was determined by taking a linear line of best fit for the initial 10 days of data (up to the first rain event). The exception was level 400-500mm where data up to day 19 was used because the first 10 days did not establish a trend. These are summarised in Table 1 and Figure 20. Note that this drying rate cannot be applied from day zero or using the moisture as discharged because the initial days following deposition see a massive drop in moisture content with water runoff from the fresh tailing.

Table 1 Initial Drying Rate of the Mill Test Pit

	Mill Pit Drying Rate (% moisture/day)			
Depth (mm)	Average	South	Middle	North
100	1.1%	1.1%	0.6%	1.6%
200	1.2%	0.7%	1.6%	1.4%
300	1.1%	0.5%	1.1%	1.6%
400	0.7%	0.5%	0.3%	1.4%
500	0.4%	0.4%	0.5%	0.3%

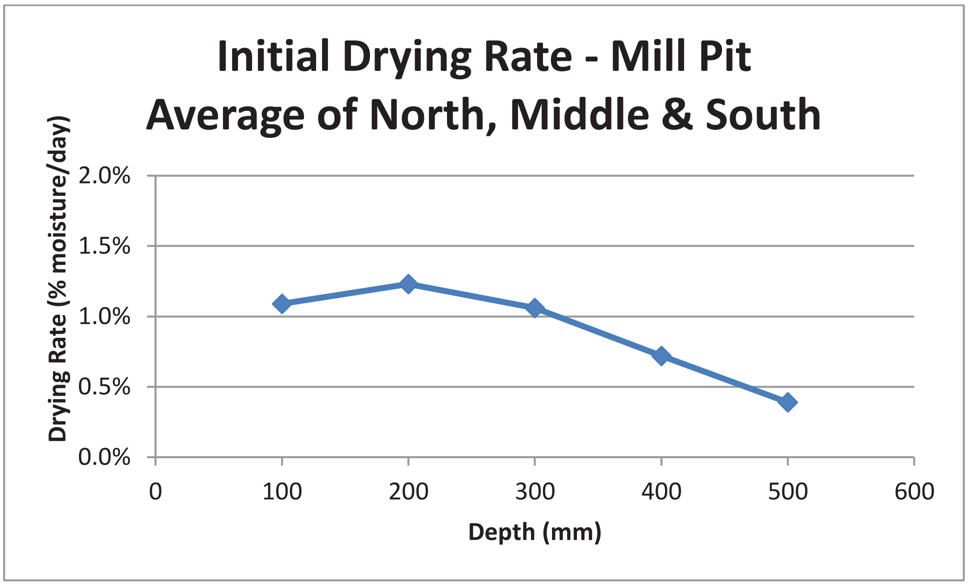

Figure 20 Initial Drying Rate of the Mill Test Pit With Depth

As expected, the tailing was found in general to dry less quickly at deeper levels with the exception of the top layer which was slightly slower to dry than the 100-200mm layer. It is hypothesised the top layer may be slower to dry because it is more susceptible to external events; however, the full mechanics are unknown. (The in-situ sample showed the same characteristic with the top layer retaining moisture while the middle layers dried.) The largest rain event did not have as significant an impact on moisture as the earlier, smaller rain events. Again, it is hypothesised this may be due tailing becoming less permeable after it has dropped below a certain moisture level.

Conclusions and Recommendations

Multiple surveys have been conducted to determine the drying rate of tailing over time. The latest two surveys both demonstrate that natural desiccation of tailing in Blackwoods Pit TSF occurs at a rate fast enough for harvesting of 383ktpa of tailing to be feasible (450ktpa mill feed).

The tailing material to a depth of 0.4m reached the moisture specified for safe use in engineered fill within 1 week of drying and potentially within 4 days. This is based on the sampling method considered most representative of natural, in-situ drying. Although the alternative, test pit method showed the tailing required 19 days to reach SOMC, the test pit is considered to have overstated the time required to dry due to reasons outlined.

While these tests were conducted in summer months, which would generally be expected to have hotter temperatures and drier weather, promoting drying, December 2020 was cooler than usual and wetter than the yearly month average, likely reducing the impact on the survey.

Rotating between three cells with an 8/6 production roster leaves 34 days to dry and harvest. With drying taking between 4 to 19 days, at least 15 to 30 days will be available for harvesting operations.

Drying rates generally decrease with increasing depth; however, the top layers are not always the first to dry. The middle layers (200-300mm and 300-400mm) can be drier than the surface, meaning that decisions on whether a cell is ready to harvest must take into account the moisture content of deeper layers, not just the top. Faster drying rates may be possible if the surface is 'shaved' multiple times rather than waiting for the full depth to dry.

The channelling, storage and removal of runoff water needs to be considered to ensure that rain events do not funnel water onto previously dried tailing, pooling water does not re-wet previously dried tailing and phreatic levels of pooled water do not encroach on harvesting areas.

References:

Gassner F., 10/11/2020, Preliminary Assessment of Proposed Approach for Tailings Harvesting At Blackwood Pit Reference No. 1896230 052 M Rev 0

Bureau of Meteorology, 05/01/2021, ENSO Outlook, http://www.bom.gov.au/climate/enso/outlook/, Accessed 13/01/2021

APPENDIX G

‘Liquefaction Assessment of Tailings – Rasp Mine Blackwood Pit Tailings Storage Facility’ ref: 1896230-044-R-Rev0, dated 31 March 2020.

31 March 2020 Reference No. 1896230-044-L-Rev0

Andrew McCallum
CBH Resources
Broken Hill Operations
Eire Street
Broken Hill
NSW

LIQUEFACTION ASSESSMENT OF TAILINGS – RASP MINE BLACKWOOD PIT TAILINGS STORAGE FACILITY

Dear Sir

1.0 INTRODUCTION

Broken Hill Operations Pty Ltd (BHOP) has commissioned Golder Associates Pty Ltd (Golder) to assess the risk of liquefaction of tailings in the Blackwood pit storage facility at the Rasp Mine in Broken Hill, New South Wales. This document outlines the screening level assessment on data received from a cone penetration test (CPTu) programme completed on the existing tailings in Blackwood Pit on 7 and 8 February 2020. The investigation was carried out in three locations on the tailings surface. Two of the locations are near where future embankments (Embankments 1 and 3) of the TSF design are to be constructed. The location of the third CPTu test was selected to be near the "low" spot of the tailings beach where the tailings drying and desiccation conditions are expected to have been least favourable in the past. The locations of the CPTu tests are presented in Figure 1 attached, which shows the tailings beach contours near the time of the investigation.

This report presents the results of the CPTu analyses and the associated slope stability assessment relative to the proposed embankments along the sides of the pit and the final rockfill rehabilitation profile over the top of the tailings storage facility.

2.0 CPT ANALYSIS

2.1 Method

Golder has conducted a screening level assessment on the data from three CPTu probes using methods proposed by Been & Jefferies (1992) [1] and Robertson (2009[2] and 2015)[3].

The following process has been adopted in the screening level assessment:

- Estimation of the depth to saturation or near saturation.

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[1] Been, K. and Jefferies, M. G. 1992. "Towards systematic CPT interpretation". Proceedings of the Wroth Memorial Symposium, pp.121-134. Thomas Telford, London.

[2] Robertson, P.K., 2009. "Interpretation of Cone Penetration Tests – a unified approach". Canadian Geotechnical Journal, 46 pp 1337-1355.

[3] Robertson, P.K. 2015. Comparing CPT and Vs liquefaction triggering methods. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 141(9): pp. 842–853.

- Assessment of the state parameter to identify the likely in situ state parameter and therefore susceptibility to static liquefaction.
- Estimate the factor of safety against cyclic liquefaction.

2.2 Depth to saturation

A key factor in the potential for soil/tailings to liquefy is the moisture condition. Excess pore pressures may be generated when soil/tailings is subject to shear when it is saturated or in a near saturated condition. The in situ pore pressure profiles were estimated based on the occurrence pf positive pore pressures during penetration and the results of dissipation testing.

An assessment on whether the tailings is close to saturation was made by considering the air entry value. Sustained negative pressures greater than 20 kPa are reported to indicate unsaturated material. Tailings material similar to the Blackwood tailings are shown to have an air entry value between 20 and 100 kPa.

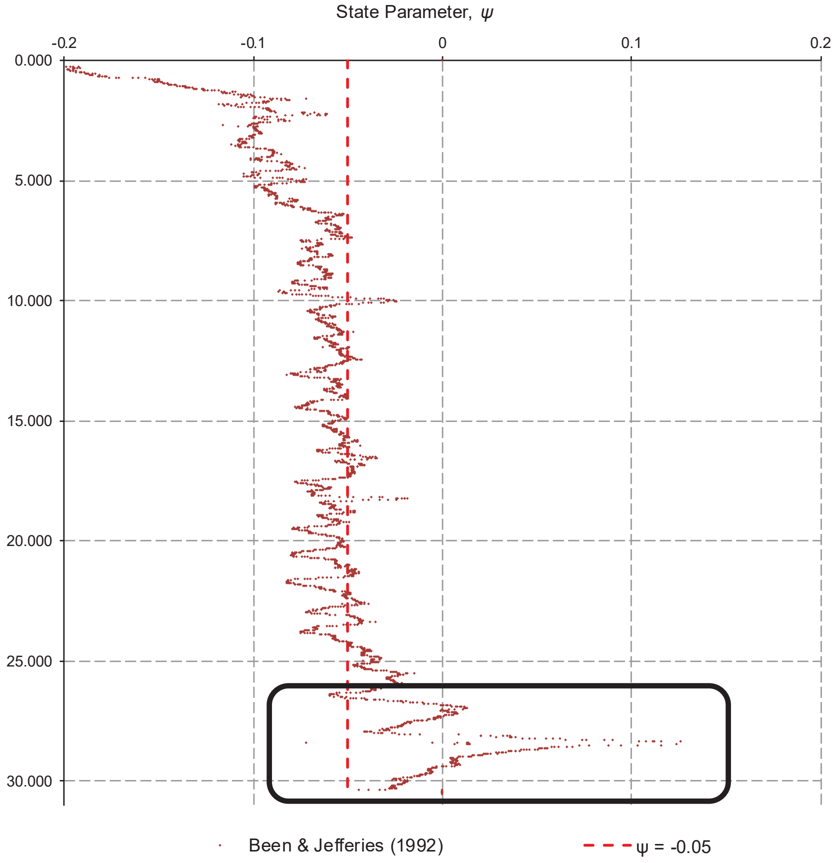
Review of the CPTu data suggest the tailings are saturated or near saturated over most of the depth of measurement since positive dynamic pore pressure measurements were recorded over most of the depth.

2.3 State Parameter

The state parameter (Ψ) of the tailings has been estimated using methods proposed by Been & Jefferies. The state parameter provides a framework for identification of soil/tailings that may be prone to rapid strength loss i.e. static liquefaction. Generally, soil/tailings with Ψ < - 0.05 is dilative (dense) and are immune to brittle strength loss during rapid or cyclic shearing. When Ψ > - 0.05, there is a risk of strength loss resulting from changes in stress, with the likelihood of occurrence and the severity of strength loss increasing with increasing Ψ.

The following can be inferred from the state parameter analysis:

- The top layer (~ 5 m) of tailings is dilative and over consolidated. This is likely due to lower rate of rise, and relatively dry site conditions over the past 2 years;
- CPTu01 has numerous bands of contractive material below 5 m depth;
- CPTu 03 has a layer of strongly contractive tailings from about 24 m to 30 m. This contractive layer has a characteristic (85th percentile) state parameter of 0.012. This is shown in the following excerpt from the CPTu data analysis.



BW CPTu 03 with lower layer of contractive tailings highlighted within the boxed zone.

A summary of the 85th percentile state parameter for each CPTu is provided Table 1.

Table 1: Characteristic State Parameter

CPT ID	Depth Interval (m)	Characteristic State Parameter (85th percentile)
BW CPTu 01	0 – 5	-0.055
	5 - 12	-0.029
BW CPTu 02	0 – 5	-0.077
	5 – 24	-0.046
	24 – 26.5	-0.031
BW CPTu 03	0 – 5	-0.085
	5 – 24	-0.050
	24 – 30	0.009

Based on the above results the tailings in Blackwood pit at the time of CPTu testing are not likely to result in static liquefaction for the shallower depth over tailings. The lower portion of tailings at the three locations are likely to be marginally at risk for static liquefaction.

2.4 Cyclic Liquefaction

2.4.1 Peak Ground Acceleration Estimate

The TSF has been assessed against a maximum credible earthquake (MCE) with a return period of 10 000 years to meet the consequence category and closure requirements outlined in ANCOLD (2019). Geoscience Australia (Allen et al 2018) publishes seismic hazard maps and peak ground accelerations (PGA) for Australia for various return periods up to 5 000 years. In the absence of site specific hazard information we have extrapolated from this data to estimate the PGA for a return period of 10 000 years – Chart 1. The PGA for this return period is estimated at 0.147 m/s^2.

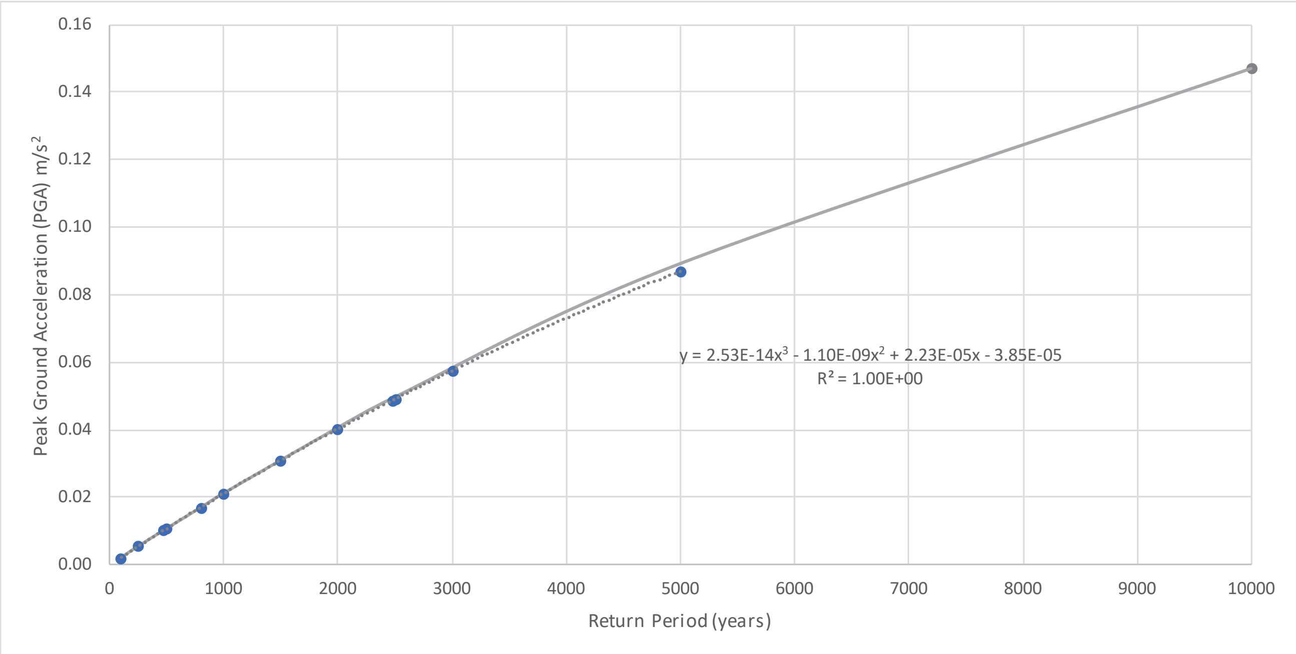


Chart 1: Return periods and peak ground acceleration relationship

2.4.2 Cyclic Resistance

Cyclic liquefaction occurs where seismic loading results in increased pore pressures resulting from cyclically induced strain. The increase in pore pressures results in a decrease in vertical effective stress and corresponding reduction in strength. The cyclic resistance ratio (CRR) is based on the method proposed by Robertson (2009) with the undrained shear strength capped to the critical state friction ratio of 1.2 (i.e. 30°) based on the a database of critical state properties for various soils presented by Been and Jefferies (1992).

The factor of safety (FoS) against liquefaction is defined as CRR/CSR for a magnitude 7.5 earthquake. Data for all the CPTu's results in FoS close to unity for the majority of the tailings for a PGA resulting from a return period of 10 000 years. This indicates that the tailings may liquefy under this event. Further investigation through laboratory testing would be required to more accurately estimate the cyclic resistance of the tailings.

A summary of the FoS for all CPTu's are presented in Appendix A. The results for BW CPTu 1 are shown in Chart 2.

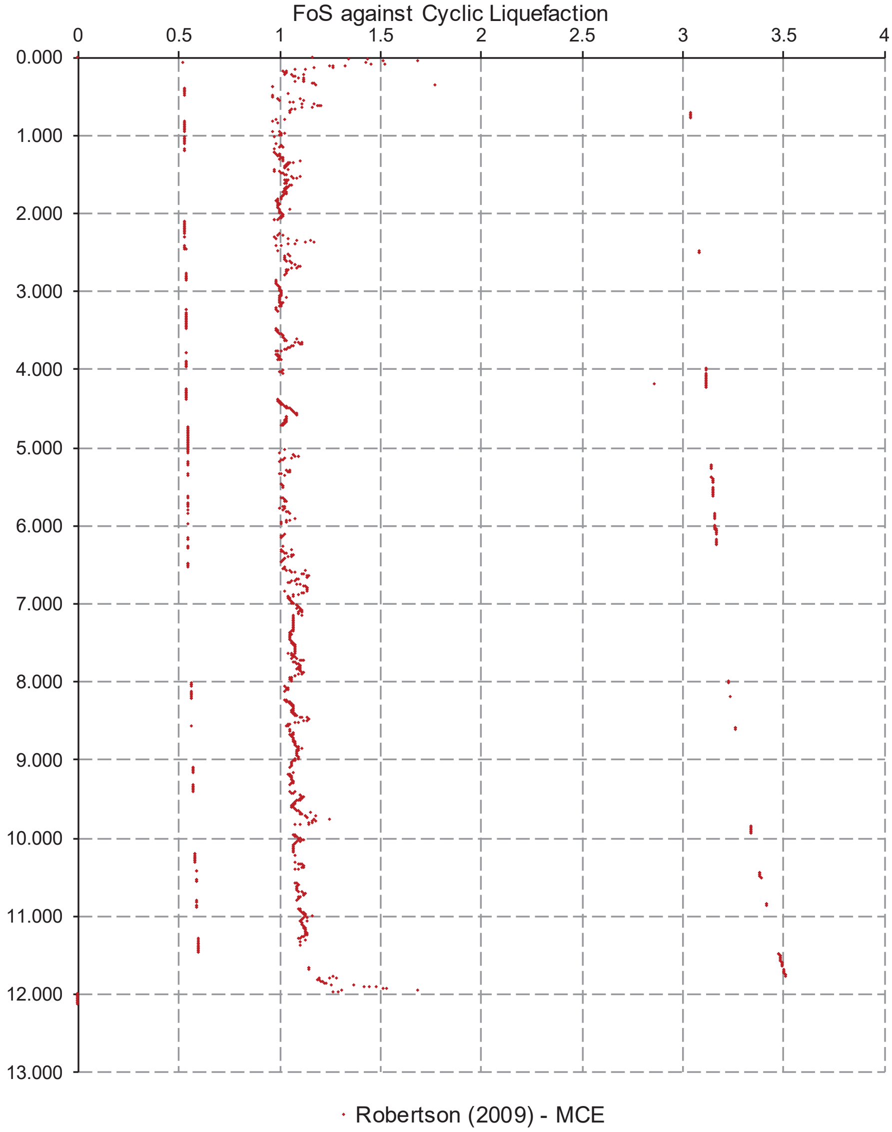


Chart 2: Factor of safety against cyclic liquefaction for BW CPTu 01.

The factor of safety against liquefaction is close to or below unity for a significant portion of the tailings in the MCE event.

3.0 SLOPE STABILITY

Blackwood pit TSF includes three embankments over parts of the pit perimeter. Embankment 2 has been constructed and was constructed either on weathered rock or engineered rockfill foundations. Embankments 1 and 3 are designed to be constructed partly over the tailings beach.

The mine has developed a rehabilitation strategy for the TSF which includes placing a layer of waste rockover the surface of the tailings, with an increased thickness of waste rock towards the south, and the waste rock placed to the crest level of the proposed embankments around the pit. The proposed shape of the final waste rock surface and the results of the liquefaction assessment of the tailings beach have been considered in the slope stability assessment of the perimeter embankments.

Figure 2 includes the selected locations of the cross sections assessed for slope stability. These sections have been adopted based on experience considering the maximum depth of tailings below/near the embankments, steepest and highest embankment slopes and adopting the results of the CPTu testing. The proposed steepest slope of the waste rock rehabilitation profile for the tailings has also been included in the slope stability assessment.

The tailings strength adopted for the slope stability assessment has considered the following:

- For static load case, foundation tailings under Embankment 1 and 3 over top 5 m depth, undrained strength ratio of 0.21. Material below 5 m depth is assessed to be marginal with regards to risk of static liquefaction, so adopt an undrained strength ratio of 0.12.
- Embankment 2 static load case undrained strength ratio of 0.21, and earthquake loading undrained strength ratio of 0.12.
- Waste rock slope over tailings beach, upper 5 m thick layer of tailings with undrained strength ratio of 0.21, and rest of tailings deeper than 5 m adopt undrained strength ratio of 0.12. Tailings beach profile of 2.5 % downwards towards rock slope toe.

The undrained strength ratio was selected from critical state laboratory testing conducted on the tailings being deposited in the pit, ref Golder report 1896230-004-R-Rev0, dated August 2018.

The upper 5 m thick layer of tailings is dilative and over-consolidated. The foundation pressure under the proposed embankments is estimated to be less than the over-consolidation pressure of the upper layer of the tailings, so it is assessed that the tailings will remain dilative when loaded by the proposed embankment. Hence the 5 m layer of tailings below Embankments 1 and 3 are assessed to retain a peak strength ratio of 0.21 under static loading conditions.

The slope stability analysis for Embankment 2 also considers a worst case scenario of the embankment liners and drainage not functioning as intended. With this scenario a phreatic surface develops in the embankment and saturates the entire depth of tailings behind and below the embankment creating a hydrostatic water pressure profile with depth. This is a feasible scenario for Embankment 2 only. Embankments 1 and 3 have a laterally draining (towards the north) tailings beach against the embankments, so water would not pond for any significant time against or near the embankments.

The results of the slope stability assessment are presented in Table 2.

Table 2: Slope Stability Results

Location	Factor of Safety
Embankment 1	1.9
	3.4 extending into liquefied tailings
Embankment 2	2.1
	1.8 with phreatic surface
Embankment 3	< 1.5 without modification
	2.1 with buttress
Waste Rock Slope	2.0

The minimum target factors of safety values as per the ANCOLD guidelines for the consequence category of this TSF are:

Static conditions (drained and undrained conditions) = 1.5

Post liquefied conditions = 1.1

For all of the above slope stability analyses, the post liquefied strength analysis is the critical case and the reported factors of safety relate to the post liquefied condition. All of the static condition cases, except for Embankment 2, the analyses result in higher factors of safety. For Embankment 2 the same factor of safety is obtained for both cases as the embankment is not founded on tailings. Note the factor of safety for shallow sloughing of the embankments outer slope is 1.5.

4.0 CONCLUSIONS

This letter summarised the screening level liquefaction assessment for the tailings in Blackwood Pit at the time of the investigation. The assessment indicates the following:

- The tailings are generally close to saturation but do not support a phreatic surface under static conditions.
- The in situ characteristic state parameter is dilative for the upper 5 m of the deposit. Bands of contractive tailings were recorded below 5 m at two of the three probe locations.

Based on the results the potential exists for the tailings in Blackwood Pit TSF 2 to liquefy in a maximum credible earthquake with a return period of 1 in 10 000.

The results of this liquefaction assessment have been adopted to assess the design slope stability of the tailings beach once the TSF is filled to design capacity. This assessment is based on similar deposition strategy being adopted going forward as has been used in the past 2 years, resulting in the similar strength conditions of the tailings. The assessment has shown that some changes are required to the design of a portion of Embankment 3 where the entire embankment is proposed to be formed over tailings.

The assessment shows that the tailings storage facility is expected to meet contemporary slope stability targets, both for static and post-liquified conditions of the tailings, on the basis that the tailing beach is operated to continue promoting desiccated tailings, supernatant water and stormwater is removed in a timely manner and a limit on the rate of rise of the tailings surface to less than 4 m per year.

Golder Associates Pty Ltd

Fred Gassner
Senior Principal

JE,FWG,BC/ BPW/fwg

Attachments: Appendix A – CPT results
Appendix B – Slope Stability outputs
Limitations

https://golderassociates.sharepoint.com/sites/25201g/deliverables/044 blackwood pit tsf liquefaction/1896230-044-r-rev0.docx

Figures

LEGEND

EXISTING TAILINGS CONTOURS AT 1 m INTERVALS

EMBANKMENT AND SPILLWAY EXTENTS

CPT1 APPROXIMATE CPT LOCATIONS

NOTE(S)

1. ALL LEVELS ARE REFERENCED IN METRES TO AUSTRALIAN HEIGHT DATUM (m AHD).
2. CPT LOCATIONS COMPLETED ON SITE 7-8 FEBRUARY 2020.
3. REFER TO ATTACHMENT B FOR SLOPE STABILITY SECTIONS.

REFERENCE(S)

EXISTING TAILINGS CONTOURS GENERATED FROM INFORMATION PROVIDED BY CBH RESOURCES ON 13 JANUARY 2020 IN FILE: bw_contours_mga1.dxf

AS CONSTRUCTED INFORMATION GENERATED FROM INFORMATION PROVIDED BY CBH ON 15 JANUARY 2020 IN DIXON SURVEY FILE(S):

- WAE Embankment 2 Capping 191003.dwg
- WAE Embankment 2 HDPE Liner, Anchor Trench and Ballast Tubes 191213.dwg
- WAE Embankment 2 Outside Solid Pipe 191203.dwg
- WAE Embankment 2 Piezometer Locations 191206.dwg
- WAE Embankment 2 Stormwater Channel and Basin 191213.dwg
- WAE Embankment 2 Subgrade Final 190903.dwg
- WAE Embankment 2 Subgrade Final with Extended Toe 190930.dwg
- WAE Embankment 2 Type 2 Pipe 1907126.dwg
- WAE Spillway Final Excavation 191127.dwg
- WAE Spillway Final Rip Rap Area 191203.dwg
- WAE Spillway Rip Rap Area and Seepage Pipes 191002.dwg

AS CONSTRUCTED INFORMATION GENERATED FROM INFORMATION PROVIDED BY CBH ON 17 FEBRUARY 2020 IN DIXON SURVEY FILE(S):

- WAE Embankment 2 Final Contours 200216.dwg
- WAE Embankment 2 Final Surface 200216.dwg

NOT FOR CONSTRUCTION

0 50 100

1:2,500 METRES

CLIENT
BROKEN HILL OPERATIONS PTY LTD

PROJECT
BLACKWOOD PIT TAILINGS STORAGE FACILITY
RASP MINE, BROKEN HILL

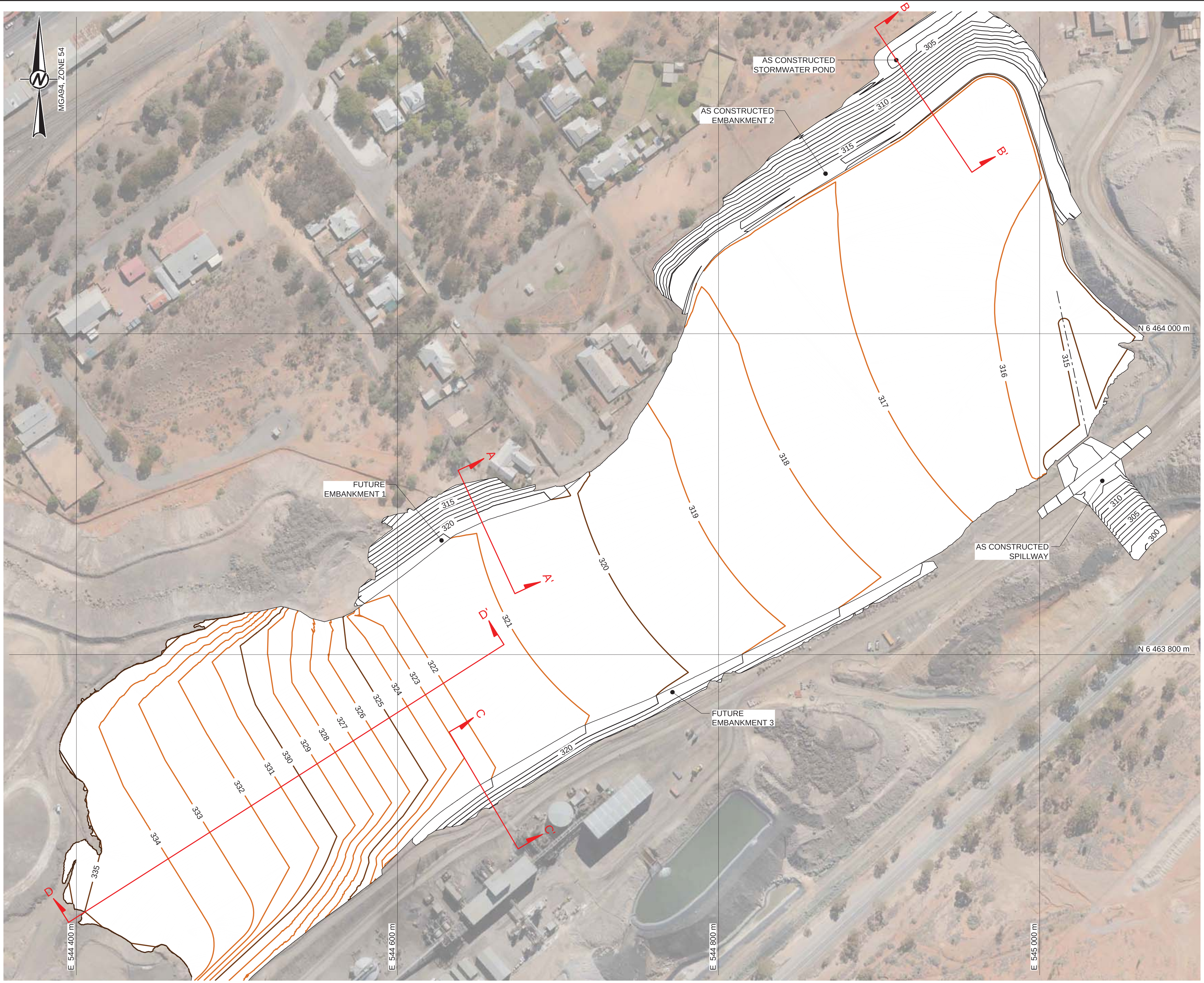
CONSULTANT

GOLDER

YYYY-MM-DD	2020-03-27
DESIGNED	EEW
PREPARED	PDM
REVIEWED	FWG
APPROVED	FWG

TITLE
TAILINGS SURFACE (JANUARY 2020) - APPROXIMATE CPT LOCATIONS

PROJECT NO.	CONTROL	REV.	FIGURE
1896230	044-L	0	1



LEGEND

ROCK CLOSURE CONTOURS AT 1 m INTERVALS

EMBANKMENT CONTOURS AT 1 m INTERVALS

NOTE(S)

1. ALL LEVELS ARE REFERENCED IN METRES TO AUSTRLIAN HEIGHT DATUM (m AHD).
2. REFER TO ATTACHEMNT FOR SLOPE STABILITY SECTIONS.
3. AERIAL IMAGE IS APPROXIMATE ONLY AND UTILISED FOR INDICATIVE PURPOSES ONLY.

REFERENCE(S)

AERIAL IMAGE PROVIDED ON 11 MAY 2016 BY CBH RESOURCES IN FILE:
160425 Rasp Mine MGA54 10cm.ecw

AS CONSTRUCTED INFORMATION GENERATED FROM INFORMATION PROVIDED BY CBH ON 15 JANUARY 2020 IN DIXON SURVEY FILE(S):

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- WAE Embankment 2 HDPE Liner, Anchor Trench and Ballast Tubes 191213.dwg
- WAE Embankment 2 Outside Solid Pipe 191203.dwg
- WAE Embankment 2 Piezometer Locations 191206.dwg
- WAE Embankment 2 Stormwater Channel and Basin 191213.dwg
- WAE Embankment 2 Subgrade Final 190903.dwg
- WAE Embankment 2 Subgrade Final with Extended Toe 190930.dwg
- WAE Embankment 2 Type 2 Pipe 1907126.dwg
- WAE Spillway Final Excavation 191127.dwg
- WAE Spillway Final Rip Rap Area 191203.dwg
- WAE Spillway Rip Rap Area and Seepage Pipes 191002.dwg

AS CONSTRUCTED INFORMATION GENERATED FROM INFORMATION PROVIDED BY CBH ON 17 FEBRUARY 2020 IN DIXON SURVEY FILE(S):

- WAE Embankment 2 Final Contours 200216.dwg
- WAE Embankment 2 Final Surface 200216.dwg

NOT FOR CONSTRUCTION

0 50 100

1:2,000 METRES

CLIENT
BROKEN HILL OPERATIONS PTY LTD

PROJECT
BLACKWOOD PIT TAILINGS STORAGE FACILITY
RASP MINE, BROKEN HILL

CONSULTANT

GOLDER

YYYY-MM-DD	2020-03-27
DESIGNED	EEW
PREPARED	PDM
REVIEWED	FWG
APPROVED	FWG

TITLE
INDICATIVE CLOSURE PLAN - SLOPE STABILITY CROSS SECTION LOCATIONS

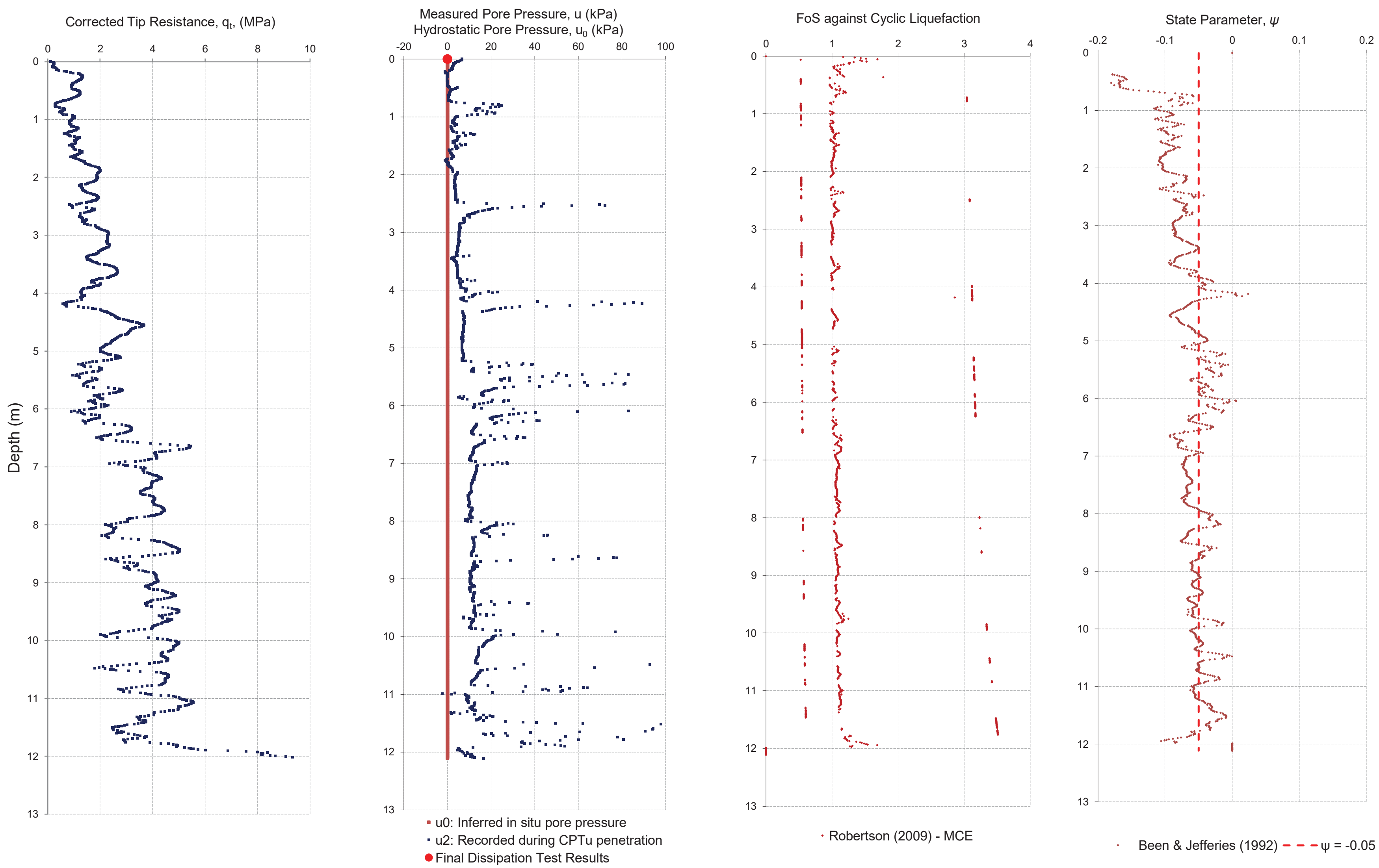
PROJECT NO.	CONTROL	REV.	FIGURE
1896230	044-L	0	2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3

25 mm

APPENDIX A

CPT Results



MCE: 1:10 000 years

PGA: 0.1471 m/s²

GOLDER	CLIENT CBH Resources		PROJECT Rasp Mine TSF Design	
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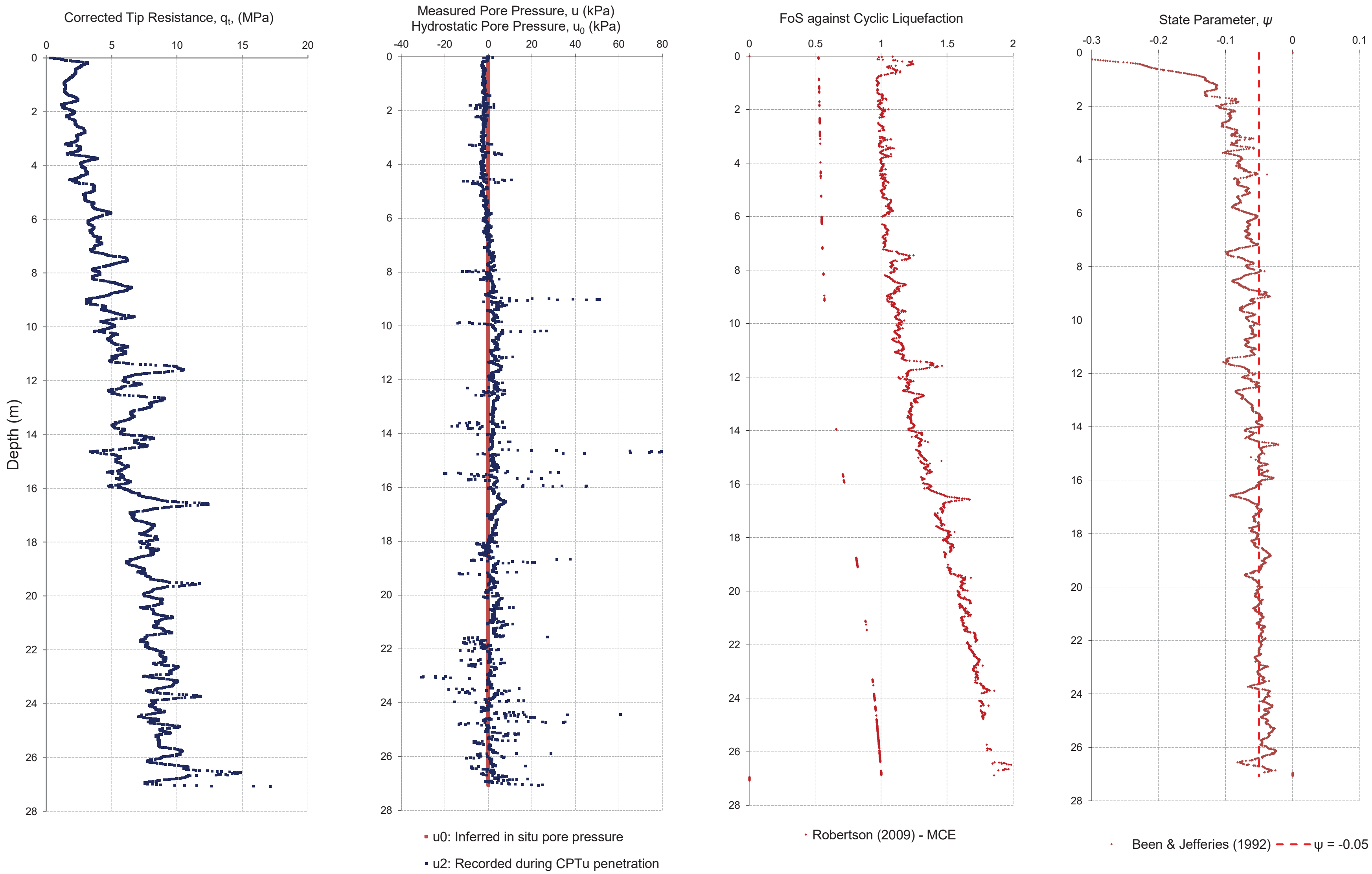
	CHECK 0	DATE 00-Jan-00		
	SCALE NTS	A4	PROJECT No.	1896230



MCE: 1:10 000 years PGA: 0.1471 m/s²

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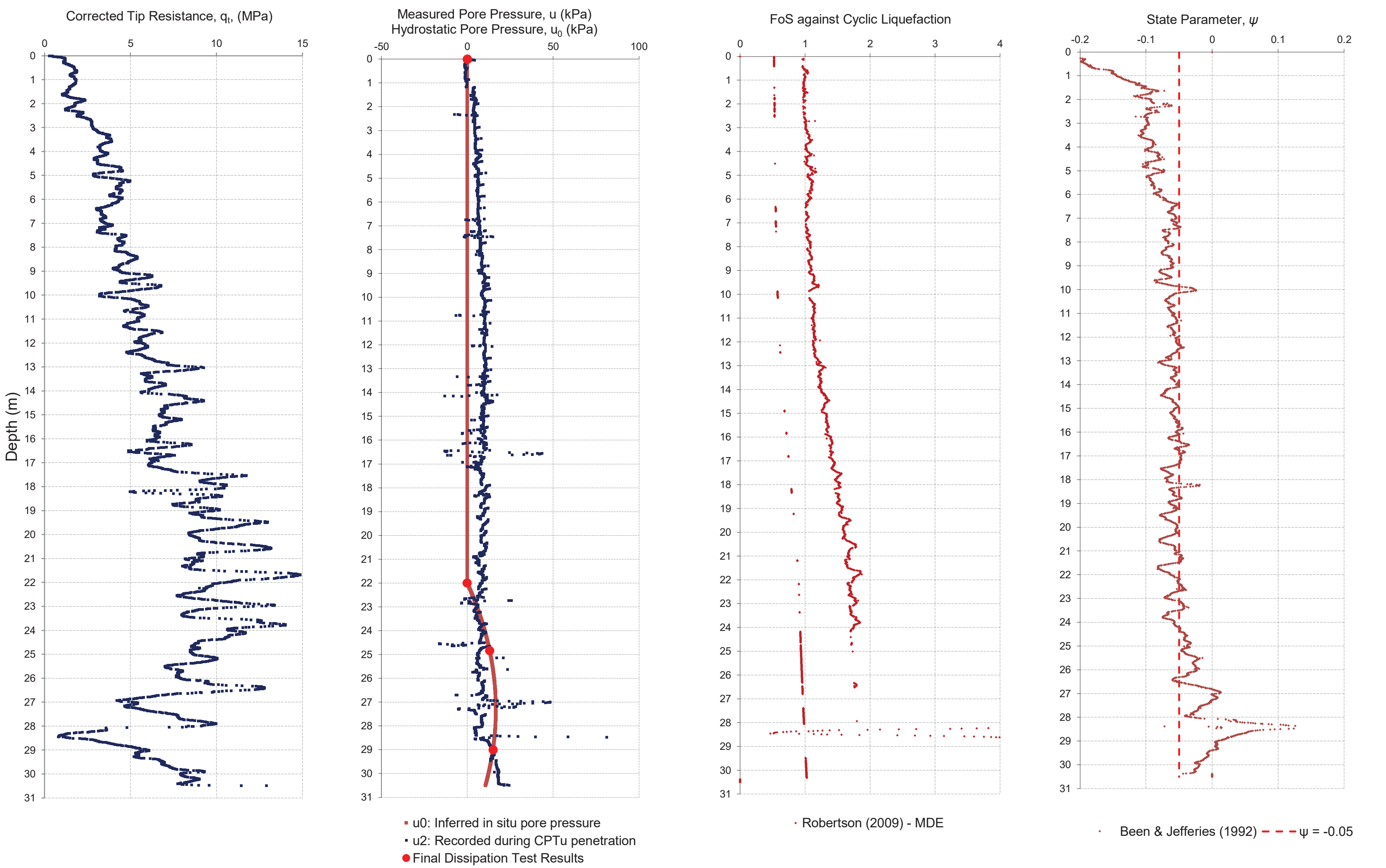

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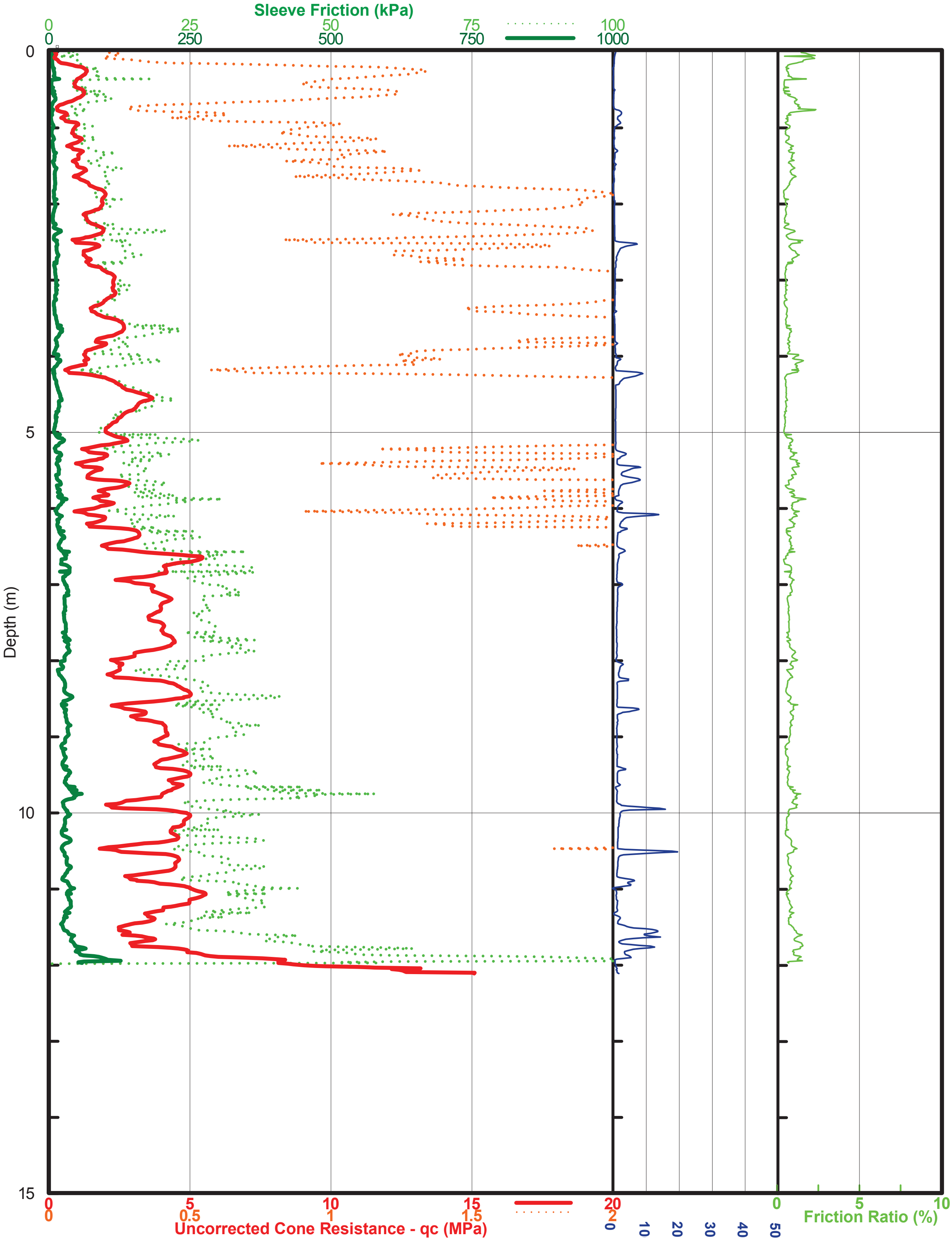
CONE PENETROMETER TEST RESULT

CBH Resources
RASP Mine TSF
Broken Hill NSW

CPT1



Job Number : G19-09-07
Test Date : 07/02/2020
GPS Position : 31*57'33.0"S, 141*28'34.1"E
Rig : Mad Mack
Cone Number : S15CFIIP.S19219
Predrill Depth : 0.00m
Dissipation Tests @ : N/A
Terminated Due To : Equipment at Risk

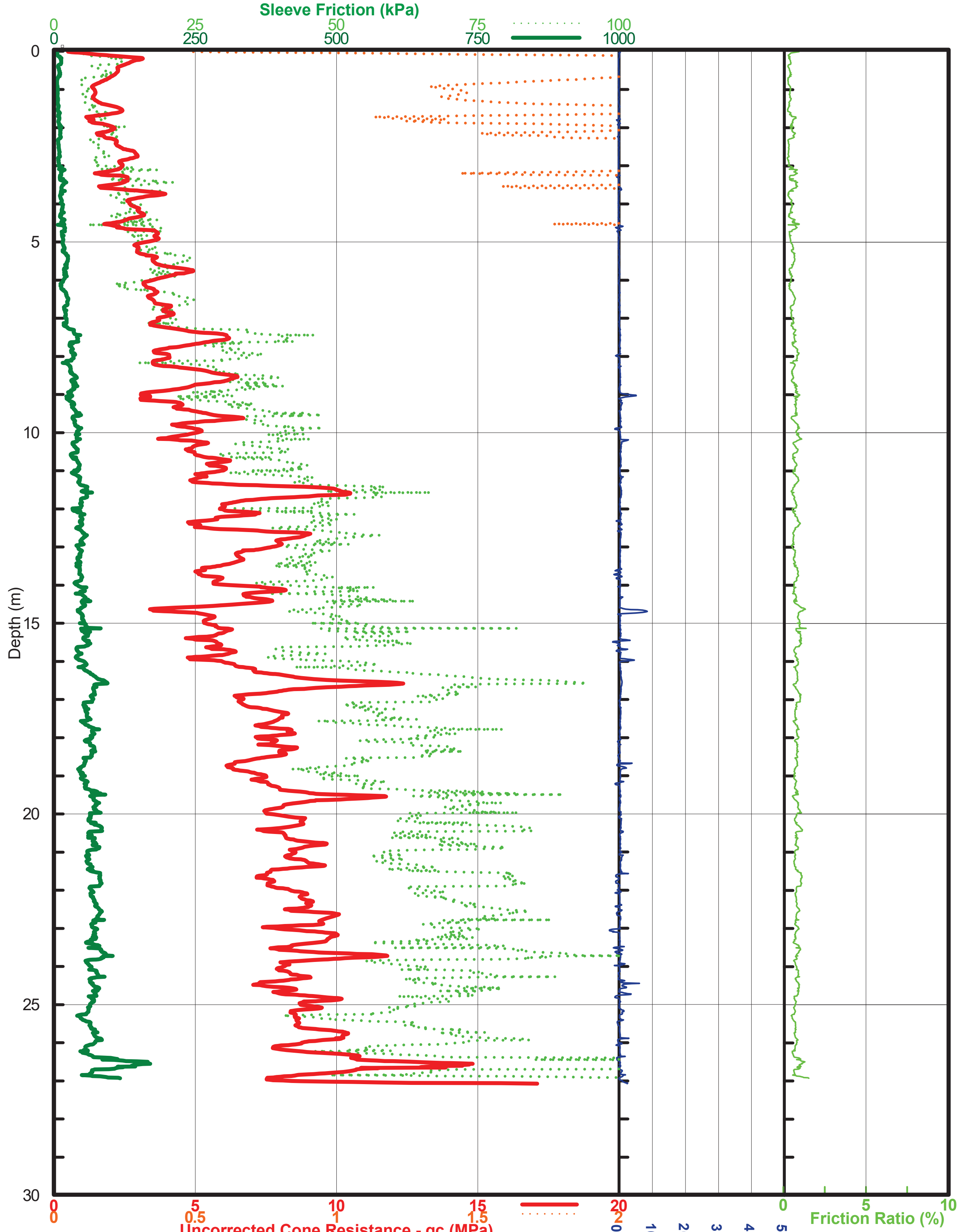
Tested By : Sergey Skrobotov
Test Category : IGS-1S
Checked By : Tony Hitchcock

Insitu Geotech Services Pty Ltd IGS

CONE PENETROMETER TEST RESULT

CBH Resources
RASP Mine TSF
Broken Hill NSW

CPT2



Job Number : G19-09-07
Test Date : 08/02/2020
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Rig : Mad Mack
Cone Number : S15CFIIP.S19219
Predrill Depth : 0.00m
Dissipation Tests @ : N/A
Terminated Due To : Lifted Rig

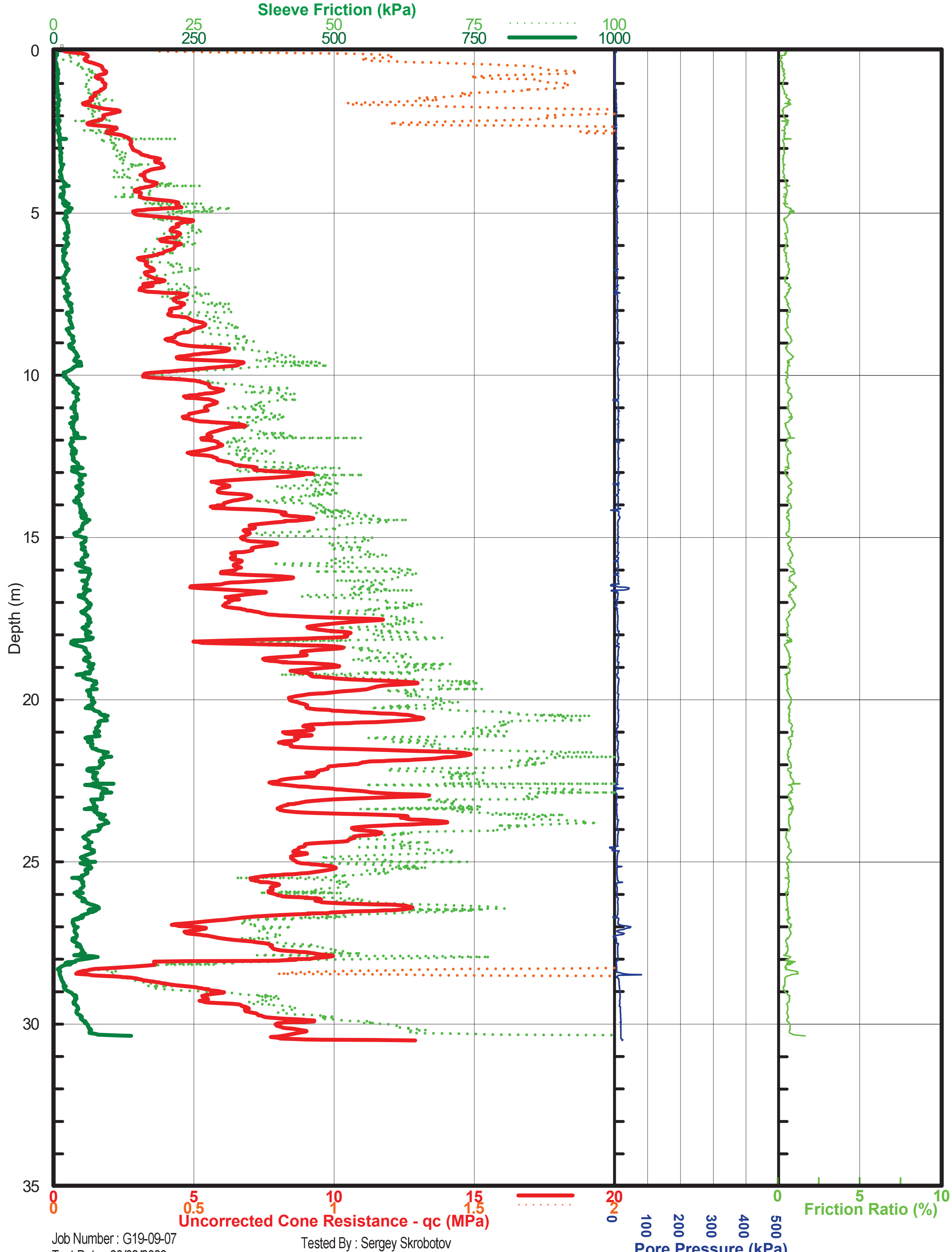
Tested By : Sergey Skrobotov
Test Category : IGS-1S
Checked By : Tony Hitchcock

Insitu Geotech Services Pty Ltd IGS

CONE PENETROMETER TEST RESULT

CBH Resources
RASP Mine TSF
Broken Hill NSW

CPT3



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Test Date : 08/02/2020
GPS Position : 31*57'41.3"S, 141*28'19.6"E
Rig : Mad Mack
Cone Number : S15CFIIP.S19219
Predrill Depth : 0.00m
Dissipation Tests @ : 28.48m
Terminated Due To : Lifted Rig

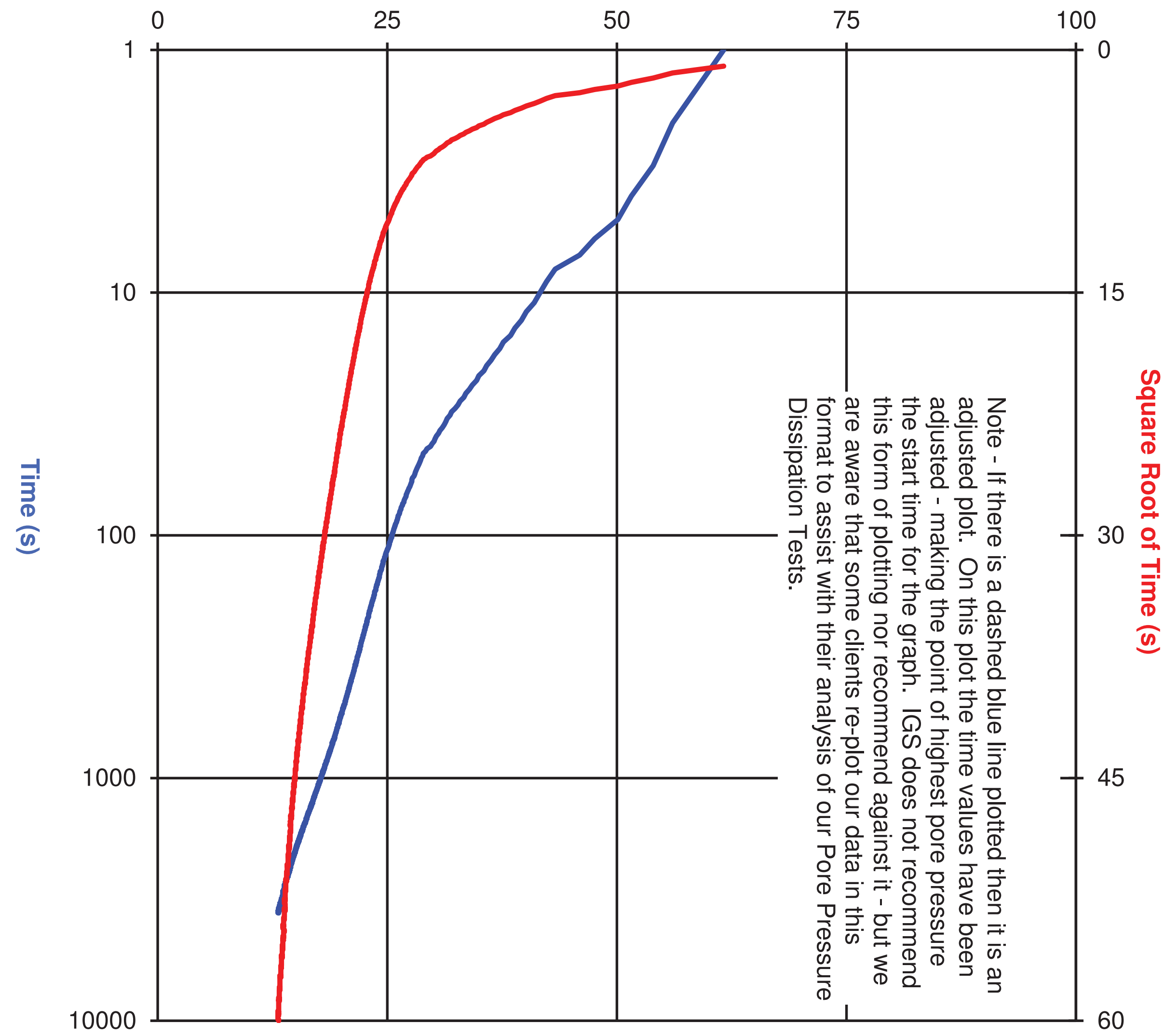
Tested By : Sergey Skrobotov
Test Category : IGS-1S
Checked By : Tony Hitchcock

Insitu Geotech Services Pty Ltd **IGS**

PORE PRESSURE DISSIPATION TEST RESULT

CBH Resources
RASP Mine TSF
Broken Hill NSW

CPT3
Depth: 28.48m



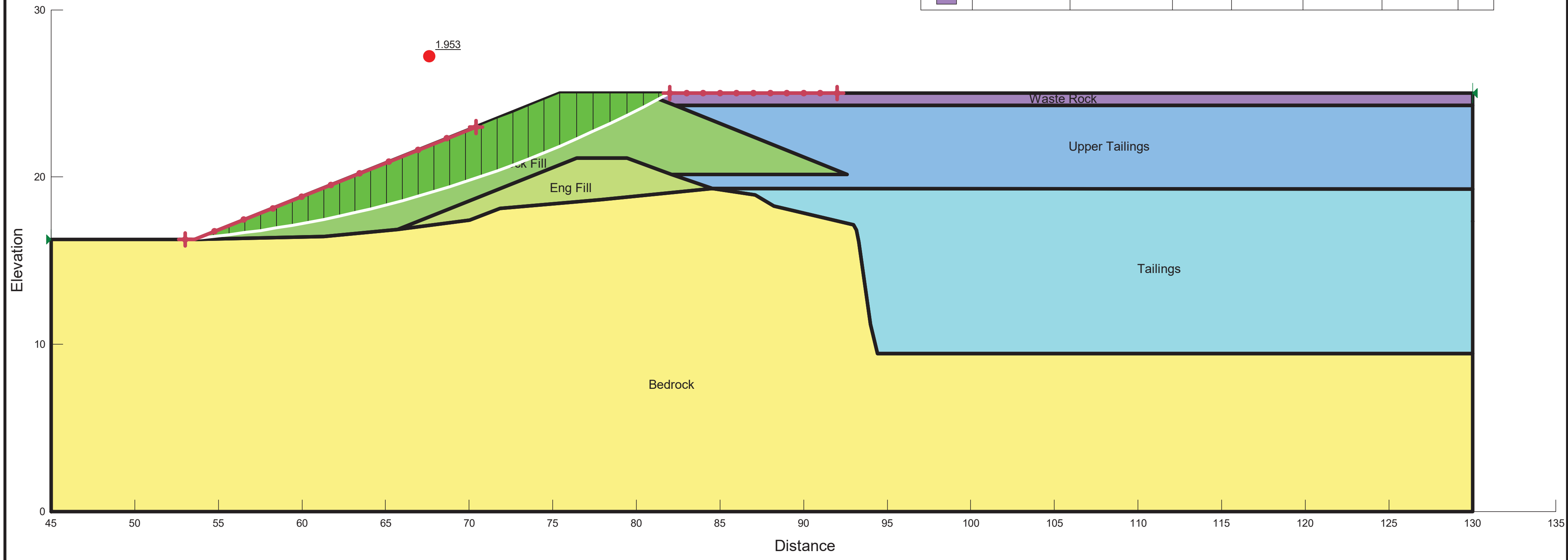
Tested By: Sergey Skrobotov
Test Duration: 1 Hours, 0 Minutes
Test Date: 08/02/2020
Job No: G19-09-07
Cone: S15CFIIP.S19219

Insitu Geotech Services Pty Ltd IGS

APPENDIX B

Slope Stability Outputs

Color	Name	Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Cohesion' (kPa)	Phi' (°)
	Bedrock	Bedrock (Impenetrable)					
	Eng Fill	Mohr-Coulomb	18			0	30
	Rock Fill	Mohr-Coulomb	20			0	32
	Tailings	SHANSEP	16.7	0	0.12		
	Upper Tailings	SHANSEP	16.7	0	0.21		
	Waste Rock	Mohr-Coulomb	20			0	32

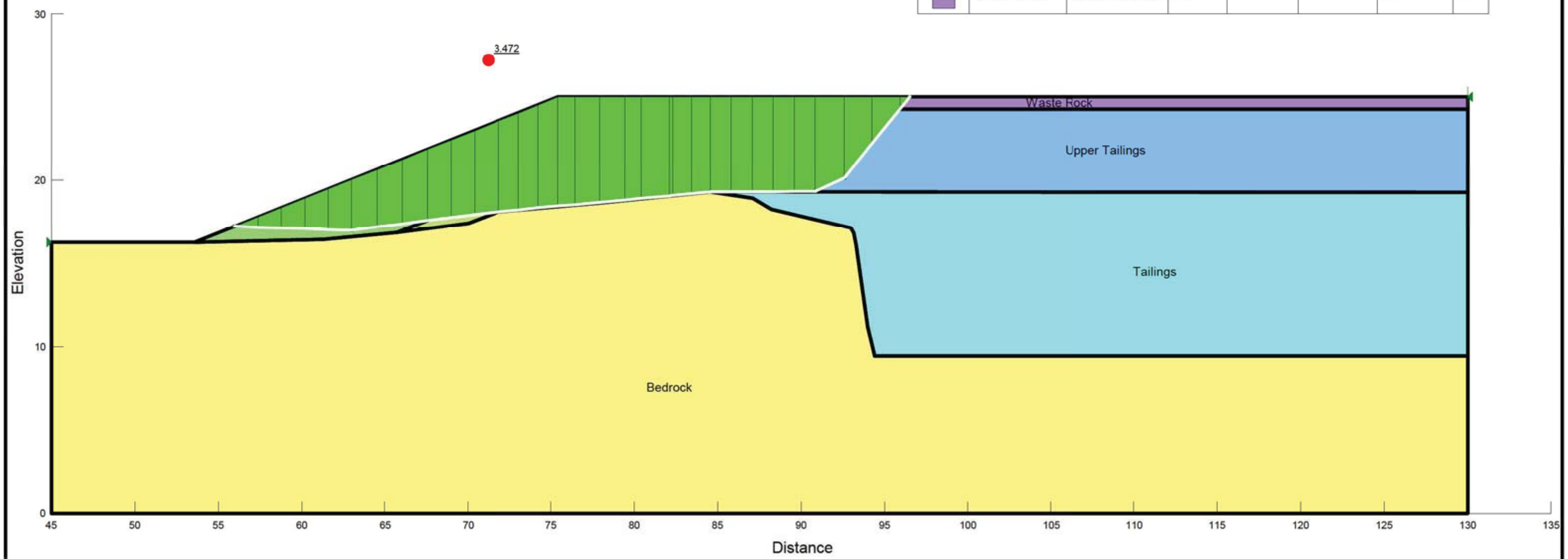


Embankment 1 As-constructed

Embankment 1 with rock stockpile (breach failure).gsz

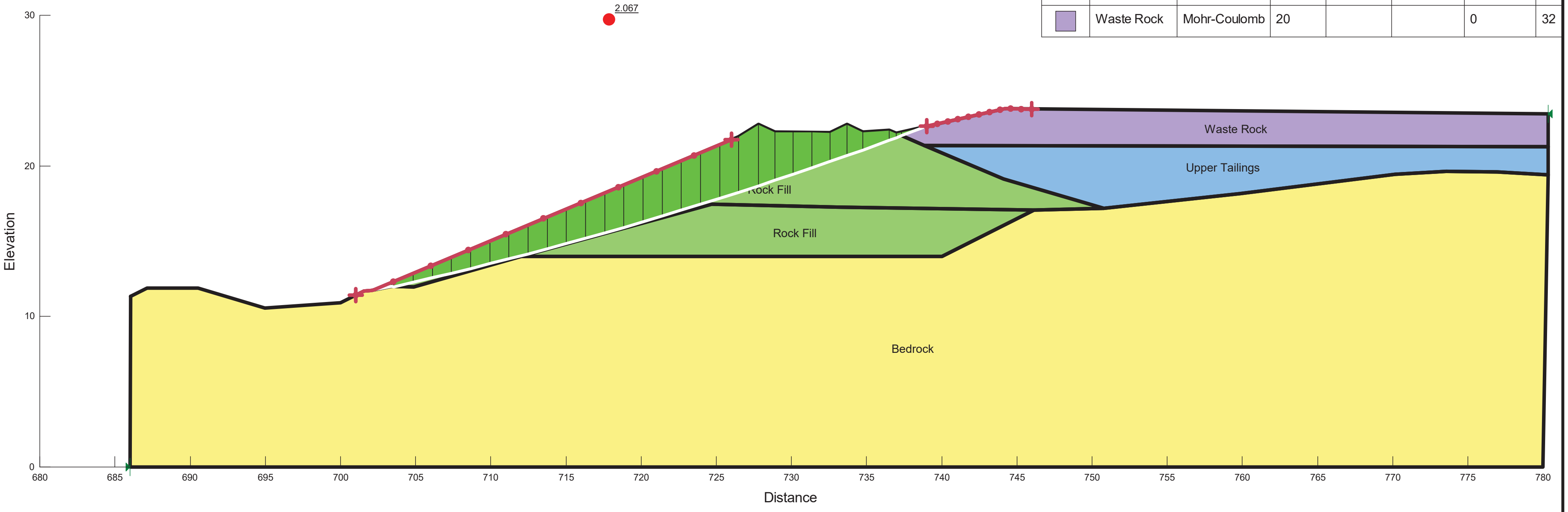
19/03/2020 1:350

Color	Name	Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Cohesion' (kPa)	Phi' (°)
	Bedrock	Bedrock (Impenetrable)					
	Eng Fill	Mohr-Coulomb	18			0	30
	Rock Fill	Mohr-Coulomb	20			0	32
	Tailings	SHANSEP	16.7	0	0.12		
	Upper Tailings	SHANSEP	16.7	0	0.21		
	Waste Rock	Mohr-Coulomb	20			0	32



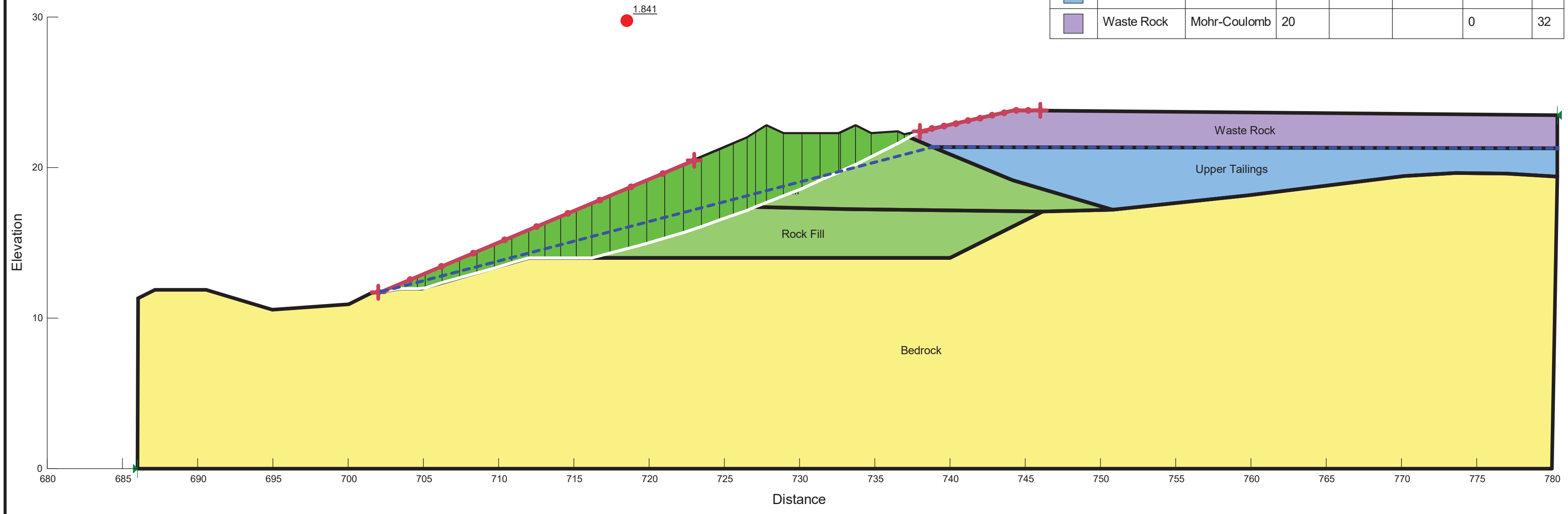
Embankment 1 upper tailings forced failure (3)
Embankment 1 with rock stockpile (upper tailings failure).gsz
23/03/2020 1:350

Color	Name	Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Cohesion' (kPa)	Phi' (°)
	Bedrock	Bedrock (Impenetrable)					
	Rock Fill	Mohr-Coulomb	20			0	32
	Upper Tailings	SHANSEP	16.7	0	0.21		
	Waste Rock	Mohr-Coulomb	20			0	32



Embankment 2	
Embankment 2 with rock stockpile (breach failure).gsz	
19/03/2020	1:390

Color	Name	Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Cohesion' (kPa)	Phi' (°)
	Bedrock	Bedrock (Impenetrable)					
	Rock Fill	Mohr-Coulomb	20			0	32
	Upper Tailings	SHANSEP	16.7	0	0.21		
	Waste Rock	Mohr-Coulomb	20			0	32

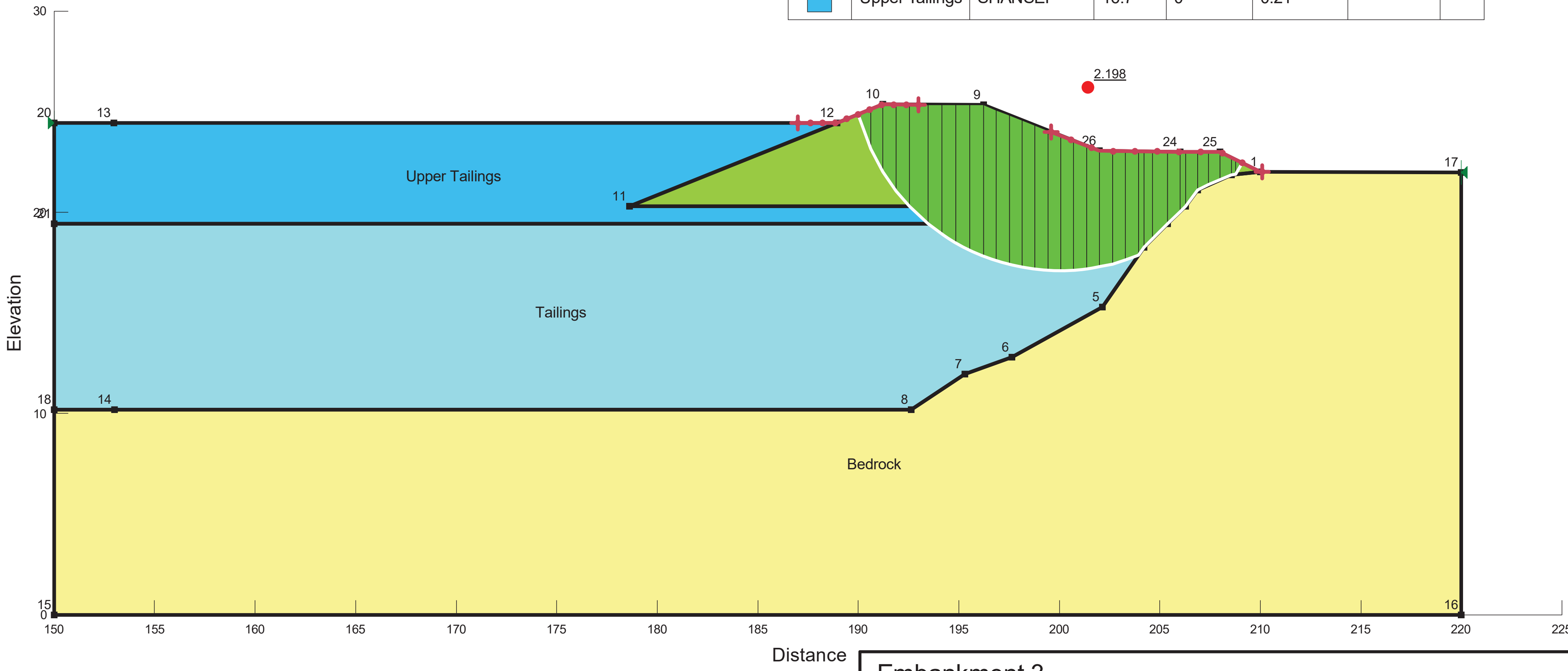


Embankment 2

Embankment 2 with rock stockpile and phreatic surface (breach failure).gsz

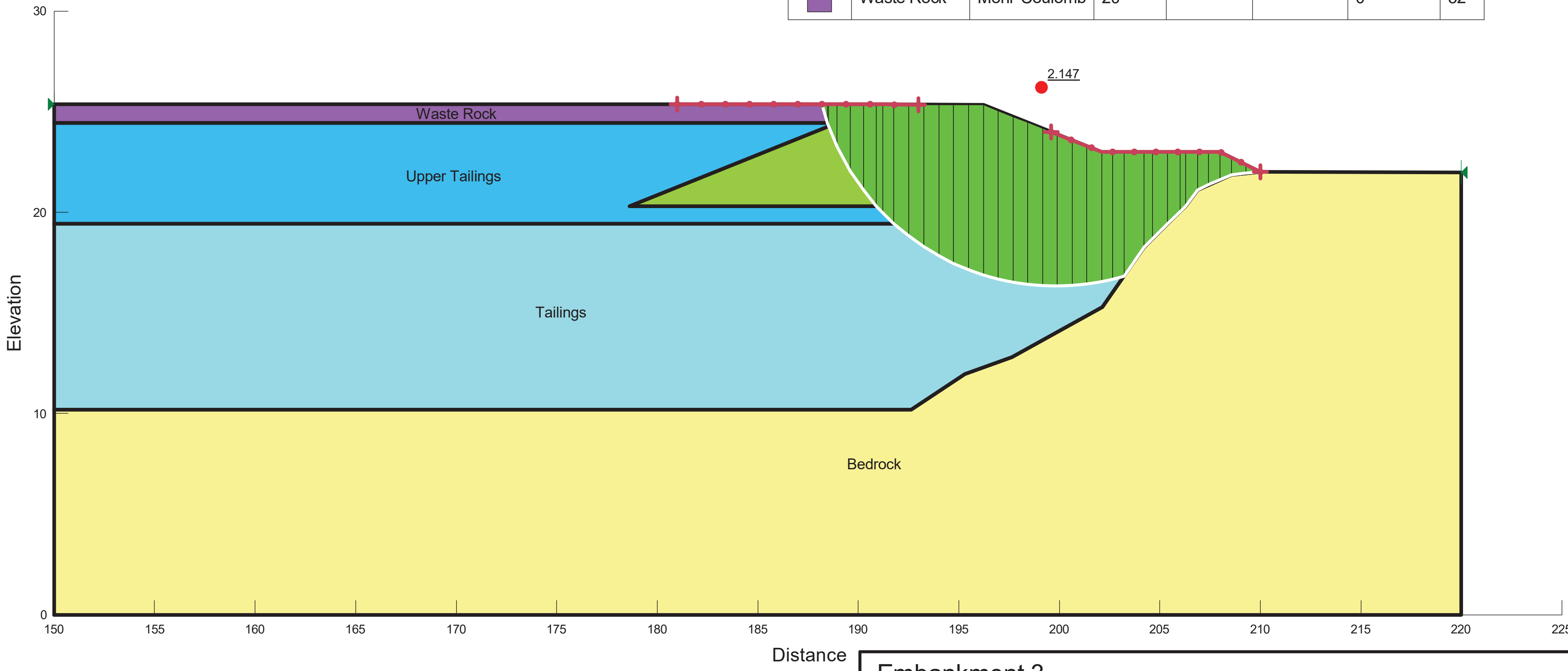
19/03/2020 1:400

Color	Name	Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Cohesion' (kPa)	Phi' (°)
	Bedrock	Bedrock (Impenetrable)					
	Rock Fill	Mohr-Coulomb	20			0	32
	Tailings	SHANSEP	16.7	0	0.12		
	Upper Tailings	SHANSEP	16.7	0	0.21		



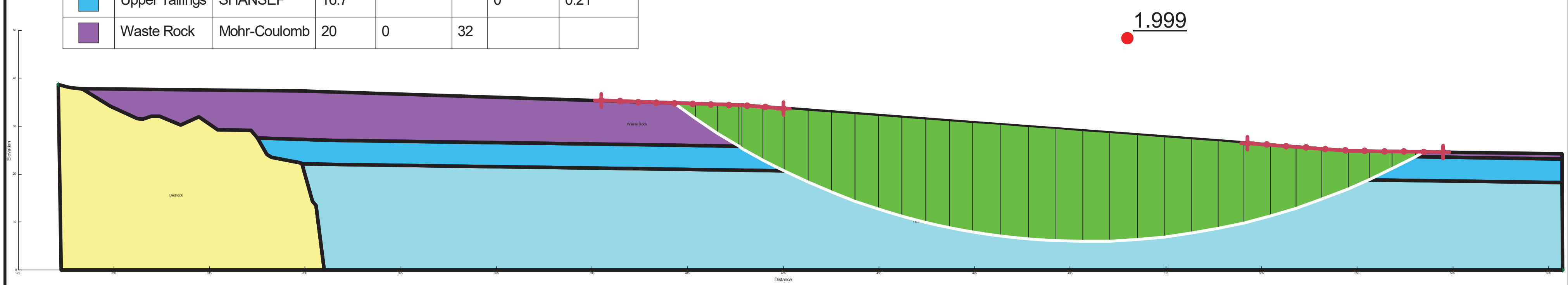
Embankment 3
Embankment 3 with flat mound.gsz
20/03/2020 1:300

Color	Name	Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Cohesion' (kPa)	Phi' (°)
	Bedrock	Bedrock (Impenetrable)					
	Rock Fill	Mohr-Coulomb	20			0	32
	Tailings	SHANSEP	16.7	0	0.12		
	Upper Tailings	SHANSEP	16.7	0	0.21		
	Waste Rock	Mohr-Coulomb	20			0	32



Embankment 3	
Embankment 3 with rock stockpile and flat mound.gsz	
20/03/2020	1:300

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Minimum Strength (kPa)	Tau/Sigma Ratio
	Bedrock	Bedrock (Impenetrable)					
	Tailings	SHANSEP	16.7			0	0.12
	Upper Tailings	SHANSEP	16.7			0	0.21
	Waste Rock	Mohr-Coulomb	20	0	32		



Waste Rock Stockpile	
Waste Rock Stockpile.gsz	
18/03/2020	1:1,225

Limitations

The document ("Report") to which this page is attached and which this page forms a part of, has been issued by Golder Associates Pty Ltd ("Golder") subject to the important limitations and other qualifications set out below.

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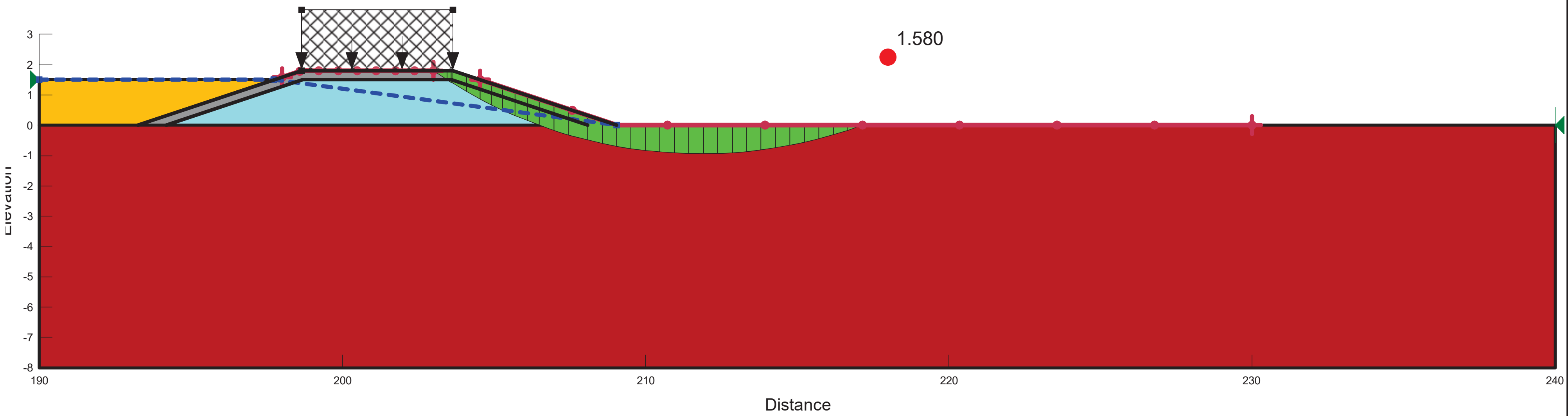
By date, or revision, the Report supersedes any prior report or other document issued by Golder dealing with any matter that is addressed in the Report.

Any uncertainty as to the extent to which this Report can be used or relied upon in any respect should be referred to Golder for clarification

APPENDIX H

Slope/W Outputs for Intermediate Embankment Stability Assessment

Color	Name	Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Maximum Strength (kPa)	Tau/Sigma Ratio	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bund Tailings	Mohr-Coulomb	21.36				0	33
	Existing tailings	SHANSEP	21.36	0		0.12		
	Saturated Tailings	SHANSEP	17.255	0	2	0.12		
	Waste Rock	Mohr-Coulomb	21.5754				0	37



Intermediate Embankment Slope Stability Analysis	
Intermediate Embankment Slope Stability Analysis.gsz	
17/02/2021	1:195

APPENDIX I

Ground Control Engineering Report titled 'Stability Assessment of Pit Slope Comprising Historic Tailings' ref. G0201 Rev 05, dated 20 August 2019.

20th August 2019

Attn: Mr Eamonn Dare
Technical Services Superintendent
Broken Hill Operations Pty Ltd
Rasp Mine
130 Eyre Street
BROKEN HILL NSW 2880

RE: KINTORE OPEN PIT – STABILITY ANALYSIS OF PIT SLOPE COMPRISING HISTORIC TAILINGS

Ground Control Engineering Pty Ltd (GCE) was engaged by Broken Hill Operations Pty Ltd (BHOP) to undertake a preliminary slope stability assessment for the pit slope in the Kintore Pit which is comprised of historic tailings. The slope forms the northern end-wall in the existing Kintore Pit and as such, will form the northern bounding wall during the proposed future placement of 'new' filtered, dry tailings in the Kintore Pit.

GCE conducted two-dimensional limit equilibrium analysis of the pit slope comprised of historic tailings. The aim of the analysis was to assess the stability of the slope with varying fill level of 'new' tailings in the pit and degree of potential water saturation of the slope. This summary report outlines the results of the modelling and key findings of the preliminary slope stability assessment.

Yours sincerely,

GROUND CONTROL ENGINEERING PTY LTD

Ceirin Byrne
Principal Geotechnical Engineer
M 0406 856 380
E cbyrne@groundcontrolengineering.com.au

Cameron Tucker
Principal Geotechnical Engineer
M 0406 856 380
E ctucker@groundcontrolengineering.com.au

1 Introduction and Scope

GCE was requested by Broken Hill Operations Pty Ltd (BHOP) to undertake a geotechnical slope stability assessment of the historic tailings slope which forms the northern end-wall in the existing Kintore Pit. BHOP plans to backfill the Kintore Pit with filtered 'dry' tailings, whereby the historic tailings slope will form the northern bounding wall during placement of the tailings.

The scope of work for this assessment incorporated two-dimensional slope stability analysis of the following:

- Existing north wall pit slope, comprised of historic tailings, and;
- Various slope configurations incorporating the progressive filling of the pit with new tailings and associated potential transient groundwater saturation profiles.

2 Data Provided

BHOP provided GCE with the following data and report:

- Current 'as-built' pit surface as DXF file.
- Kintore Pit: Preliminary Decline Plug Design – Golder report, 17 October 2018 (Ref. 1)

3 Stability Analysis of Historic Tailings Slope

Sections 3.1 to 3.4 of this report describe the method, assumptions and parameters used in the slope stability analyses. The results and conclusions of the analyses are outlined in Sections 3.5, 3.6 and Appendix A.

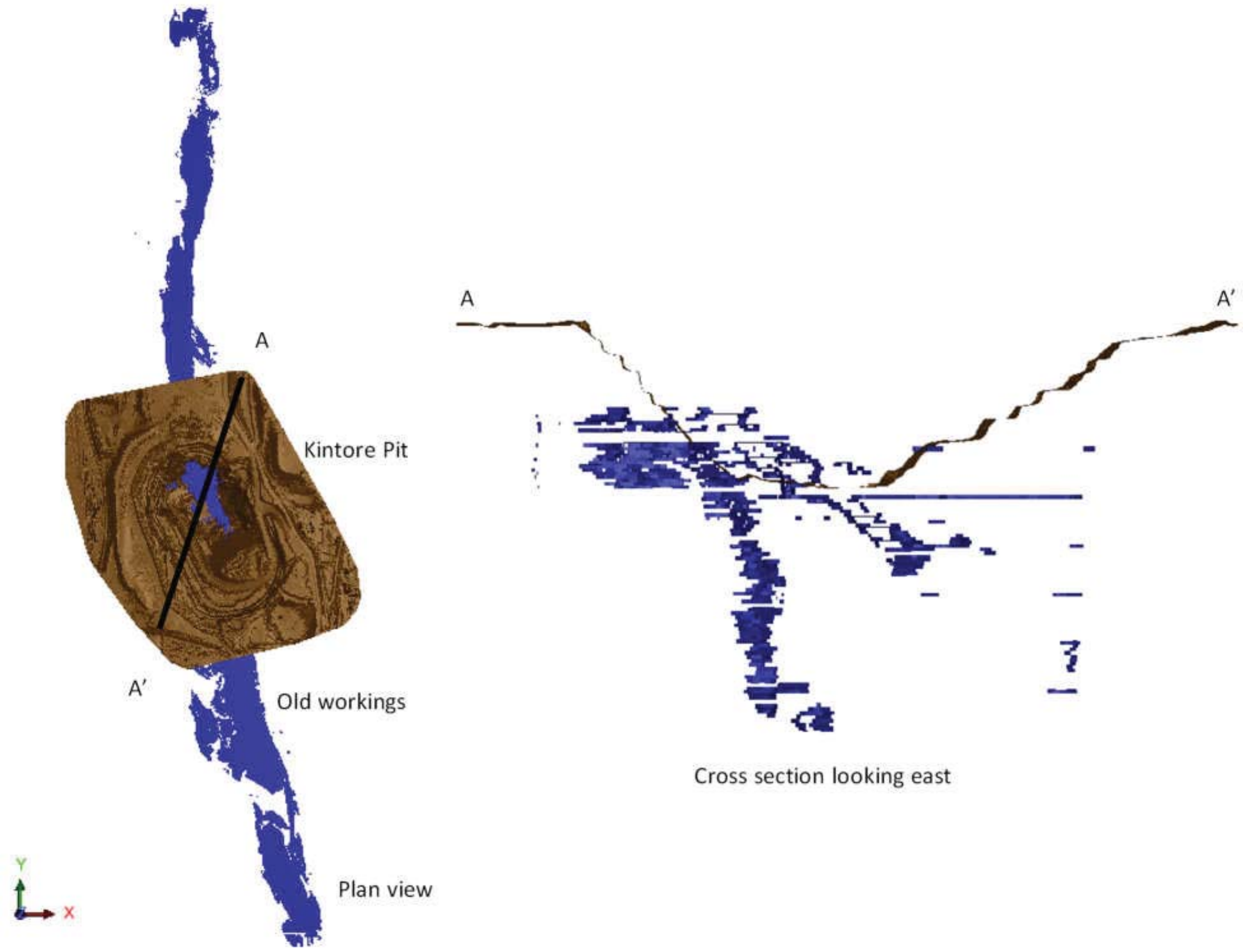
3.1 Modelling method

The industry standard Rocscience Inc. software *Slide* was used to conduct limit equilibrium slope stability analyses of selected two-dimensional cross-sections of the Kintore Pit. Circular failure surfaces were generated using a grid search and analysed using the Bishop method to determine the slope Factor of Safety (FOS). Circular failure through the historic tailings slope is considered the most likely slope failure mechanism given the weak, consistent and structure-less material properties assigned to the remnant tailings. The remnant tailings have been modelled to behave similarly to massive weak rock and/or soil. There is no observed structure within the exposed tailings slope that may induce kinematic style failure mechanisms such as toppling, wedge or planar failure.

The location of the section line where the cross-sections were generated for the analyses is shown in Figure 1. The location was selected by GCE to evaluate the likely 'worst case' slope configurations, approximately perpendicular to the historic tailings slope and with consideration of the most likely failure mechanism.

The 2D modeling does not incorporate or quantify the stabilizing influence of confinement related to the circular pit geometry. The stability of the remnant tailings slope will likely be positively influenced by slope confinement geometry in the pit corner, as shown in Figure 1.

Figure 1 Section line location with respect to existing as-built pit



Mine slope design is essentially governed by two factors:

1. The consequences of failure; and
2. The degree of inherent uncertainty.

To accommodate these two design factors, it is common practice to apply an appropriate Factor of Safety (FOS) and/or Probability of Failure (POF) to the design geometry of mine slopes. An example of FOS and POF design criteria is provided in Table 1. The design criteria have been developed from the Western Australian, Department of Mines, Industry Regulation and Safety (now DMIRS), Geotechnical Considerations in Open Pit Mines.

Table 1: Examples of design criteria for open pit walls

Wall Class	Consequence of Failure	Design FOS	Design POF	Pit Wall Examples
1	Not serious	Not applicable		Walls not carrying major infrastructure) where all potential failures can be contained within containment structures
2	Moderately serious	1.2	10%	Walls not carrying major infrastructure
-3	Serious	1.5	1%	Walls carrying major mine infrastructure (e.g. treatment plant, ROM pad, tailings structures)
4	Serious	2.0	0.30%	Permanent pit walls near public infrastructure and adjoining leases

As the fill slope will be effectively covered and buttressed by future tailings, a FOS of 1.3 was applied to reflect the temporary nature of the slope.

3.2 Slope configurations assessed

Three main slope configurations were assessed for stability, as described below and shown in Figures 2 to 4.

The cross-sections used in the *Slide* modelling incorporate the estimated material boundaries, pit wall geometry and inferred (potential) groundwater profiles.

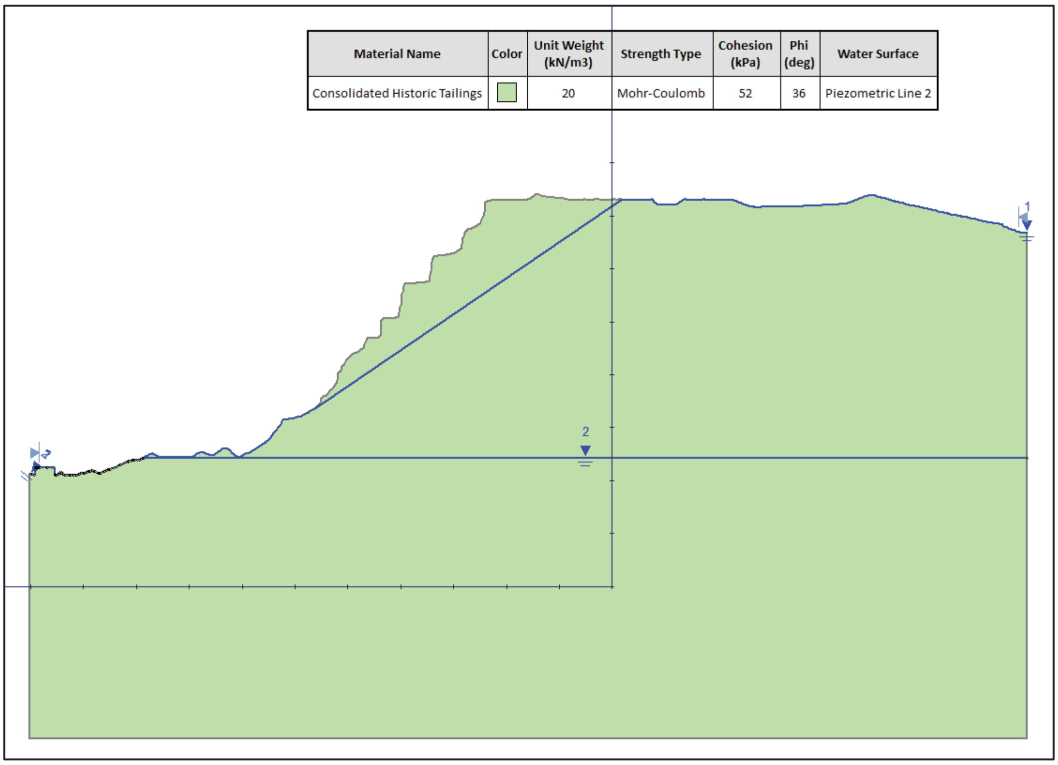
All slope configurations were run with three different groundwater cases, including a "dry" case. The groundwater and material properties applied in the models are described in Sections 3.3 and 3.4 of this report respectively.

NB: Static loading only has been modelled in the current slope stability assessment. The effects of seismic loading and water hammer (resulting from seismic loading) on the 'new' tailings proposed to be placed in the pit were considered in the report by Golder Ref. 1. Golder recommend the final design for the sealing plugs at the base of the Kintore Pit account for complete saturation of the material placed in the pit when full under static and seismic conditions.

<u>Slope configuration #1 – no 'new' tailings</u>:

Existing historic tailings pit wall slope, prior to commencement of backfilling pit with 'new' tailings, as shown in Figure 2.

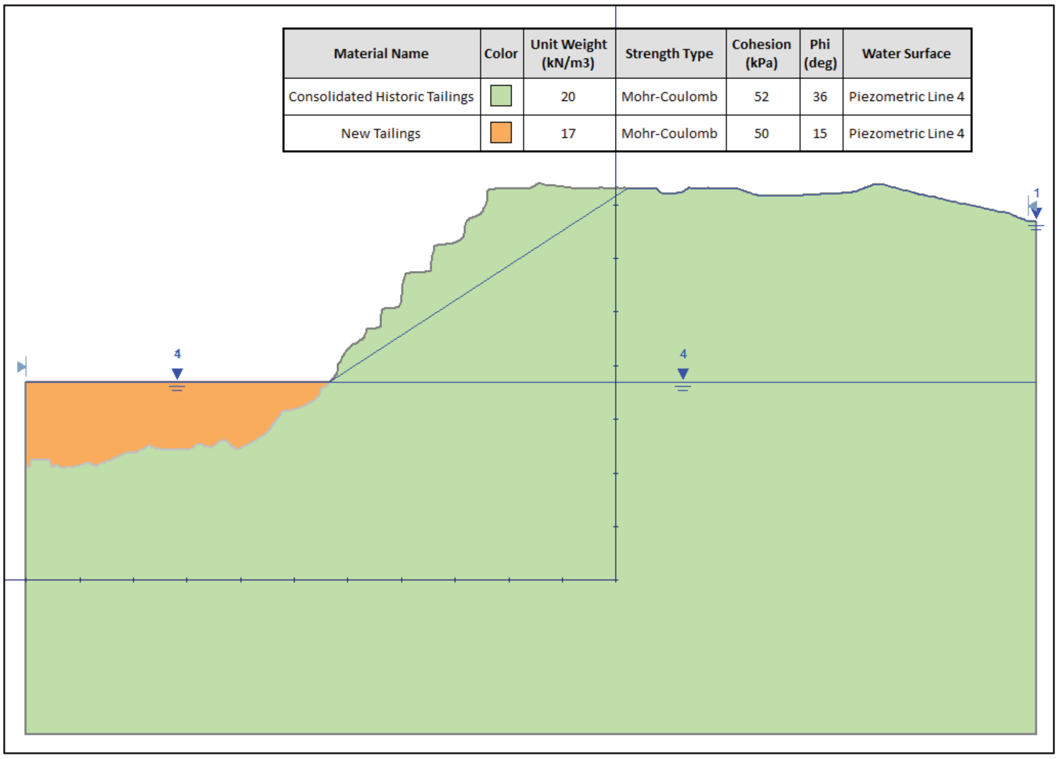
Figure 2 Slope configuration #1 – no 'new' tailings



Slope configuration #2 - 25m of 'new' tailings:

Placement of 25m of 'new' tailings in the pit, adjacent to the existing historic tailings pit wall slope, as shown in Figure 3.

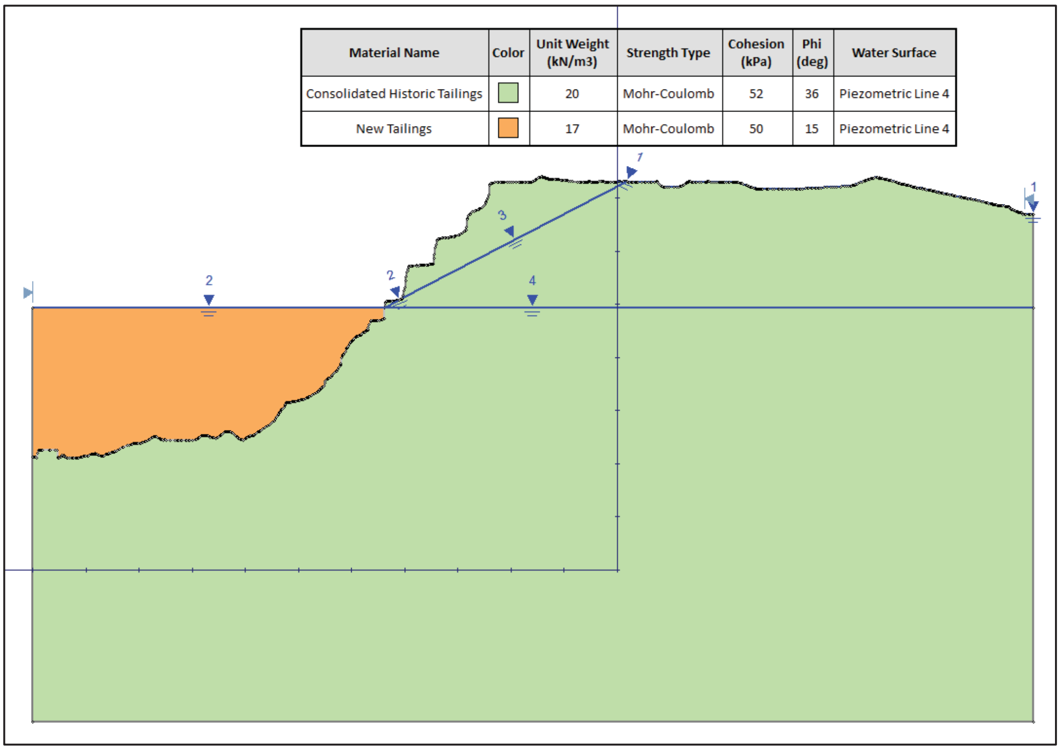
Figure 3 Slope configuration #2 - 25m of 'new' tailings



Slope configuration #3 - 50m of 'new' tailings:

Placement of 50m of ‘new’ tailings in the pit, adjacent to the existing historic tailings pit wall slope, as shown in Figure 3.

Figure 4 Slope configuration #3 - 50m of ‘new’ tailings



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface
Consolidated Historic Tailings		20	Mohr-Coulomb	52	36	Piezometric Line 4
New Tailings		17	Mohr-Coulomb	50	15	Piezometric Line 4

3.3 Material properties

The estimated material properties assigned to each material type used in the modelling are outlined in Table 1. The properties assigned to the historic tailings, comprising the existing north pit wall slope, are based on a combination of laboratory testing and back-analysis of slope performance.

Representative samples of the historic tailings slope material were collected on site for subsequent laboratory testing. The testing included:

- 2 x UCS tests – dry samples
- 3 x UCS tests – saturated samples
- 1 x Direct Shear test

The number and location of samples was limited by slope access constraints.

The material properties outlined in Table 1 were derived from the combination of direct shear testing, saturated and unsaturated UCS testing of intact samples from the existing fill slope and on GCE precedent experience of comparable materials and understanding of the slope performance to date.

Figure 5 shows the UCS samples before and after UCS testing.

Figure 5 Unsaturated UCS test samples

Test 1

Intact sample

Crushed sample

Test 2

Intact sample

Crushed sample

Figure 6 Saturated UCS test results

Intact sample

Crushed sample

The insitu material was successfully tested under dry conditions, however, total disintegration and strength loss was observed under saturated conditions.

Table 1 Material shear strength properties

Material Type	Unit Weight (kN/m³)	UCS (kPa)	Cohesion (kPa)	Friction Angle
Historic tailings slope (unsaturated)	20	222	52	36°
Historic tailings slope (saturated)	20	0	1.3	0°
'New' tailings (estimated)	17		50	36°

3.4 Groundwater

GCE understands that all water inflow will be removed from the pit via an installed drainage system and that groundwater will not be allowed to accumulate at the bottom of the pit or in the pit wall slopes. However, the groundwater profile and potential fluctuation following major rainfall events in the area of the Kintore Pit is currently not well defined as there are no groundwater monitoring bores in the vicinity of the tailings slope and Kintore Pit. There may be periods after heavy rainfall events where part of the historic tailings slope and 'new' tailings will be saturated and a transient piezometric surface may be present within the slope.

To assess the impact that groundwater may have on slope stability, three main groundwater conditions were modelled as follows:

1. "Dry" – No groundwater applied in the model. This scenario is used as a reference to assess the **base case** stability of the slope and the subsequent sensitivity of the modelled failure paths to the introduction of groundwater.
2. "Flat" – a horizontal piezometric surface is applied at the level of the top of the 'new' tailings, applying to both the 'new' tailings and the historic tailings slope.
3. "Sloped from top of new tailings to 50m setback from pit crest" – a sloping piezometric surface is applied from a 50m setback from the pit crest, down to the level of the top of the tailings, applying to both the 'new' tailings and the historic tailings slope.

GCE understands that the historic tailings slope has been observed at Rasp over a number of years to be effectively free draining and it is assumed to be highly permeable. As such, groundwater condition number 3 as described above is considered to be an unlikely, transient, "worst case" scenario.

Material testing conducted has highlighted the potential for disintegration of the historic tailings material when saturated with water. BHOP should consider the potential for slope washout at the toe of the historic tailings slope following significant rainfall events. Water must not be allowed to accumulate and 'pond' at the toe of the historic tailings slope while placing 'new' tailings in the pit.

3.5 Summary of slope stability assessment results

The results of the stability modelling are presented in Appendix A and summarized as follows:

(Factor of Safety is abbreviated as FOS.)

Slope configuration #1 - no 'new' tailings:

- Dry case and horizontal piezometric surface case
    - No failure surfaces are indicated at FOS < 1.
    - Minimum FOS = 1.142, corresponding to a multi-batter slope scale circular failure surface with moderate depth of failure. This indicates that, with the estimated material properties applied, the existing dry slope is relatively close to the threshold of stability.
    - At FOS < 1.3, numerous potential multi-batter slope scale failure surfaces are indicated.
- Sloped piezometric surface case
    - Significant reduction in slope stability from the dry condition. However, as described in Section 3.4, the historic tailings slope is understood by GCE to be highly permeable, effectively free draining, and hence this worst case groundwater scenario is considered to be unlikely.

Slope configuration #2 - 25m of 'new' tailings:

- Dry case and horizontal piezometric surface case
    - No failure surfaces are indicated at FOS < 1.
    - Minimum FOS = 1.164, corresponding to a multi-batter slope scale failure surface from the top of the 'new' tailings to the pit crest. This indicates that, with the estimated material properties applied, the slope is relatively close to the threshold of instability.
    - At FOS < 1.3, numerous potential multi-batter slope scale failure surfaces are indicated. However, slope stability is somewhat increased from slope configuration #1 - no 'new' tailings case.
- Sloped piezometric surface case
    - Significant slope scale instability at FOS = 1.116. In this case, potential for circular failure resulting in significant floor heave through the tailings is indicated at FOS < 1.3.

Slope configuration #3 - 50m of tailings:

- Dry case and horizontal piezometric surface case
    - No failure surfaces are indicated at FOS < 1.
    - Minimum FOS = 1.421, corresponding to a multi-batter slope scale failure surface from the top of the 'new' tailings to the pit crest.
    - At FOS <1.3, no failure surface is indicated. Slope stability is significantly increased from slope configurations #1 and #2.
- Sloped piezometric surface case
    - No material change or reduction in slope stability from the dry condition.

3.6 Conclusions and recommendations

The following comments relate to the slope stability analyses and FOS results outlined in Sections 3.1 to 3.5 and Appendix A.

- The preliminary slope stability analyses conducted by GCE highlights the potential for slope scale instability of the historic tailings slope forming the north wall of the Kintore Pit under certain hydrogeological conditions.
- The placement of 'dry' tailings at the base of existing historic tailings slope is expected to increase the stability of the slope. Particularly when the filled depth in the pit reaches 50m or greater.
- Circular failure or composite failure with a major circular component appears to be the most likely potential failure mechanism.
- Horizontal piezometric groundwater surfaces incorporated at various levels in the modelling, have minimal impact on the stability of the historic tailings slope.
- When a potential "worst case" sloped piezometric groundwater surface is incorporated at various levels in the modelling it has been shown to significantly reduce the stability of the historic tailings slope. Modelling of the current slope configuration #1 where no 'new' tailings have been placed in the pit, indicates a minimum FOS = 0.875 for the sloped groundwater case. However, GCE understands that the historic tailings slope has been observed by Rasp over a number of years to be effectively free draining and the consolidated tailings material is permeable. As such, the sloped groundwater surface incorporated in the modelling is currently considered to be a relatively unlikely, "worst case", transient groundwater scenario.
- Given the reduction in slope stability indicated by the modelling for the sloped groundwater scenarios, GCE recommends that Rasp determine an appropriate stand-off period and procedure following rainfall events or if pooled water is observed at the base of the tailings slope, whereby the tailings slope (crest and toe) will be isolated and access to the pit will be restricted until any accumulated groundwater has drained from the pit walls. These restrictions are required while filtered tailings are being placed in the Kintore Pit and personnel access is required.
- The installation of groundwater monitoring bores in the tailings slope is recommended to ensure that the level of piezometric surface remains below the "worst case" modelling configuration.
- GCE recommends that a large bund (minimum 2m height) is installed along the length of the toe of the historic tailings slope during placement of 'new' tailings to provide a barrier against minor rockfall from the adjacent slopes. The bund will need to be progressively moved and re-established as the level of the tailings backfill rises in the pit.

4 References

1. Golder, (2018) '*Kintore Pit: Preliminary Decline Plug Design*', Ref 1896230-017-R-Rev0, 17 October 2018

DOCUMENT INFORMATION

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Distribution	PDF to client, for review and comment

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DRAFT01	Draft report	C. Byrne, C. Tucker	11/04/19
DRAFT02	Draft report	C. Byrne, C. Tucker	12/05/19
DRAFT03	Draft report	C. Byrne, C. Tucker	
DRAFT04	Draft report	C. Byrne, C. Tucker	06/08/19

DOCUMENT REVIEW AND SIGN OFF

Version	Reviewer	Position	Signature	Date
DRAFT02	C.Tucker	Principal Geotechnical Engineer		12/05/19
DRAFT02	C.Tucker	Principal Geotechnical Engineer		
DRAFT02	C.Tucker	Principal Geotechnical Engineer		06/08/19
V04 FINAL	C.Tucker	Principal Geotechnical Engineer		20/08/19

APPENDIX A

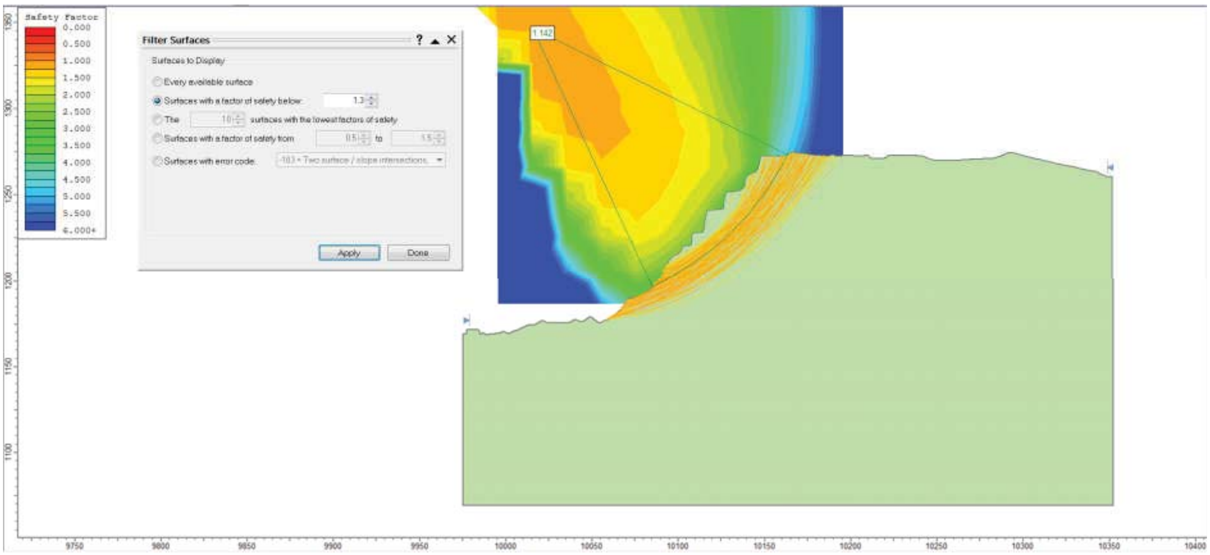
Kintore Pit Historic Tailings Slope Stability Modelling Results Summary

Consolidated tailings: c = 52, phi = 36

<u>Slope configuration #1 - no 'new' tailings</u>:

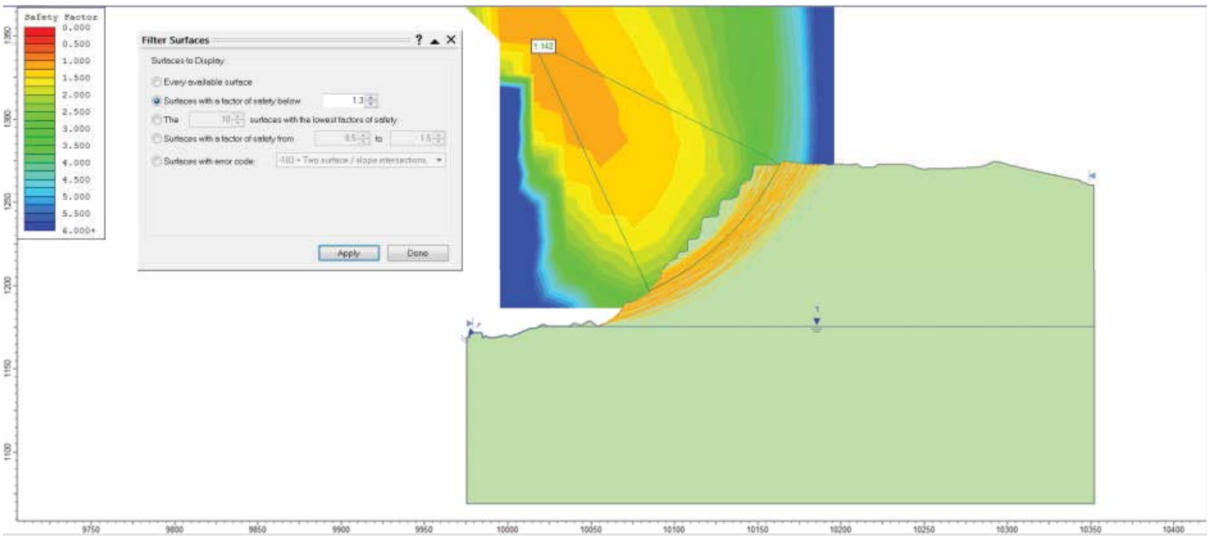
A. No tailings, no water

- FOS min = 1.142, multi-batter slope scale failure.
- FOS < 1.3, numerous failure surfaces indicating significant slope scale failure potential.



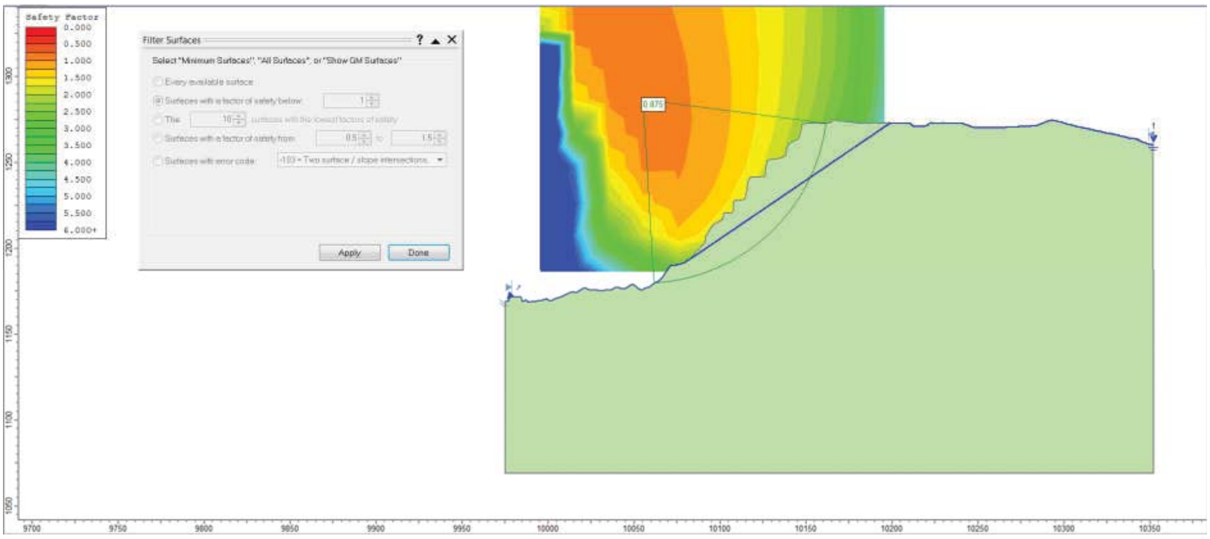
B. No tailings, horizontal water table at base of pit

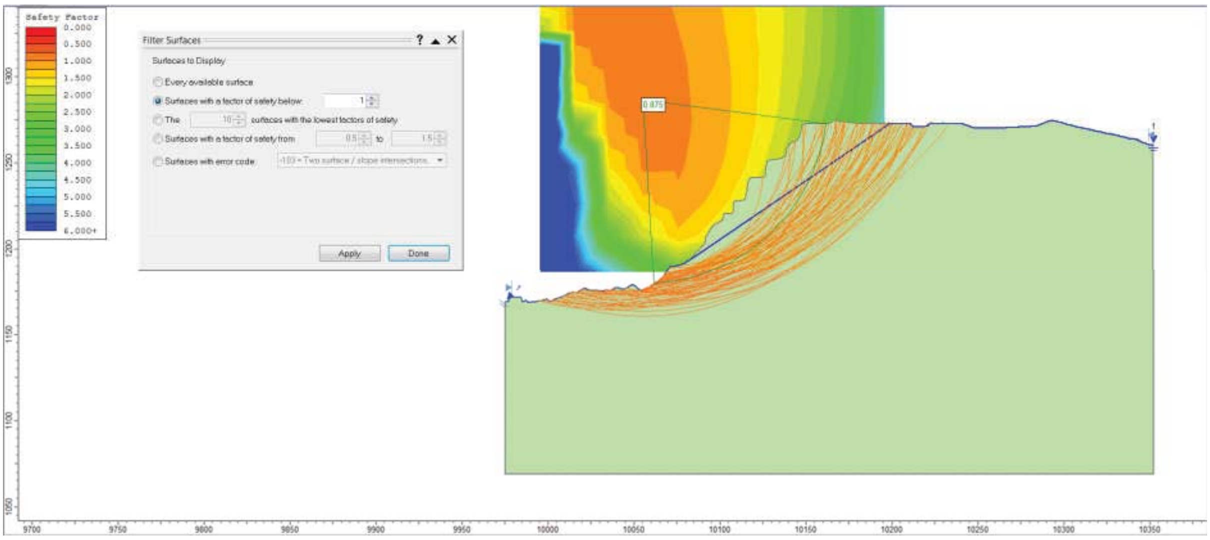
- FOS min = 1.142, multi-batter slope scale failure.
- FOS < 1.3, numerous failure surfaces indicating significant slope scale failure potential.
- No material change from dry condition.



C. No tailings, water sloped from base of pit to 50m setback from pit crest (“worst case”)

- FOS min = 0.875, significant multi-batter slope scale failure indicated.
- FOS < 1.0, significant slope scale failure, including floor heave indicated.
- Significant reduction in stability from dry condition. Low likelihood, transient groundwater condition.

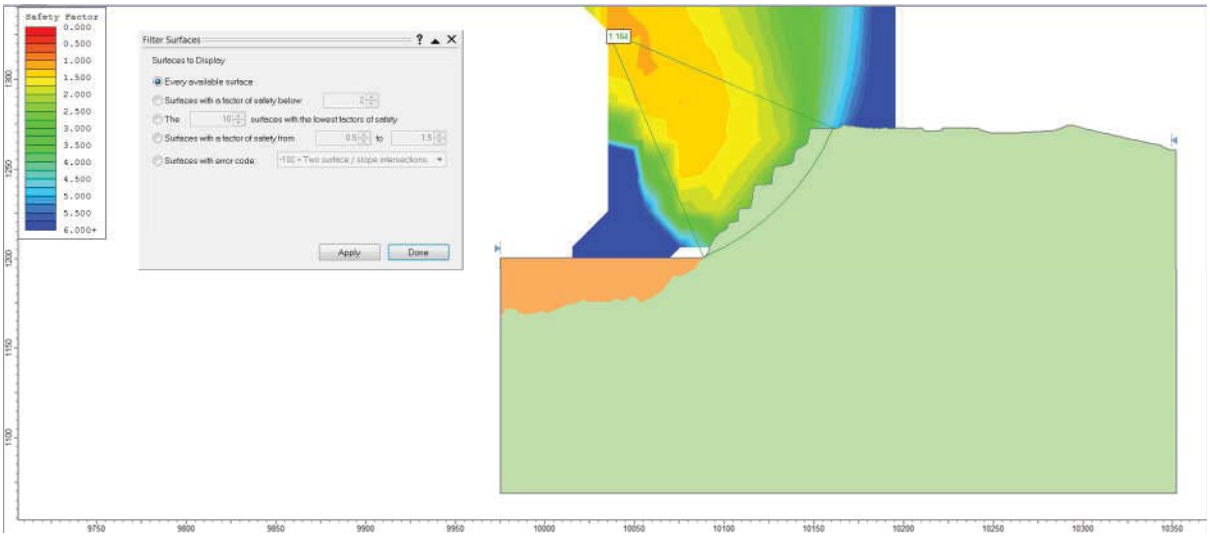


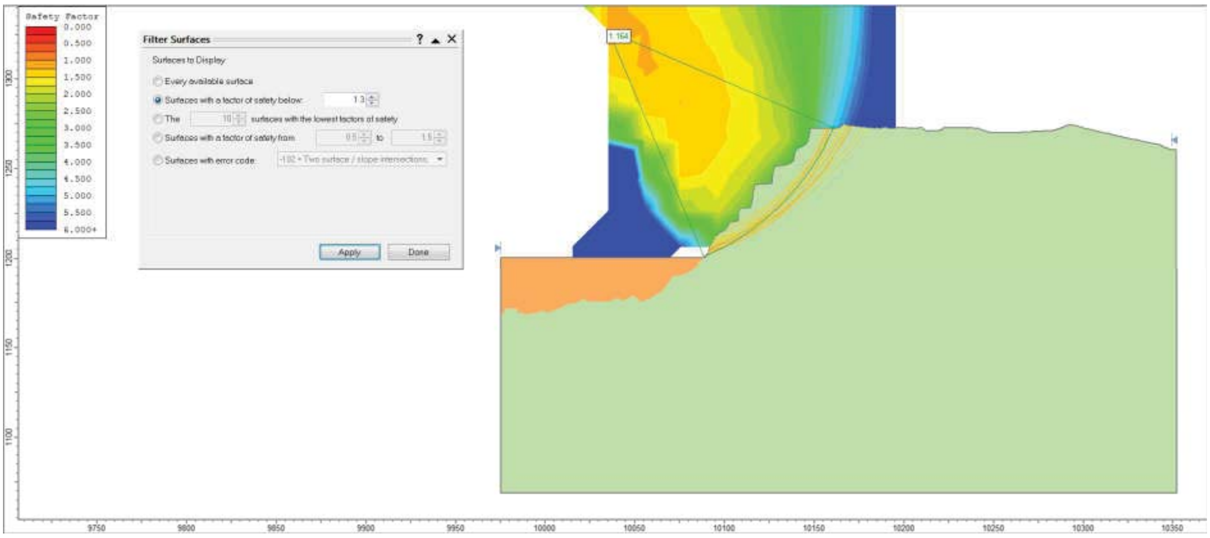


Slope configuration #2 - 25m of ‘new’ tailings:

A. 25m tailings, no water

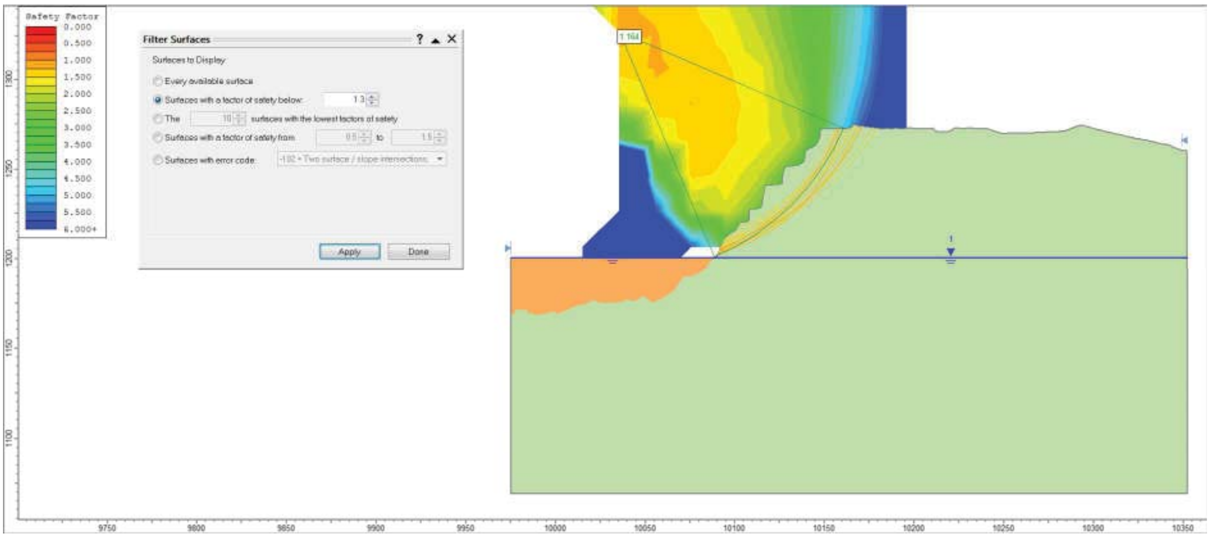
- FOS min = 1.164, slope scale failure
- FOS < 1.3, significant slope scale failure indicated. However, stability slightly increased from ‘no tailings’ case. i.e. current slope configuration.





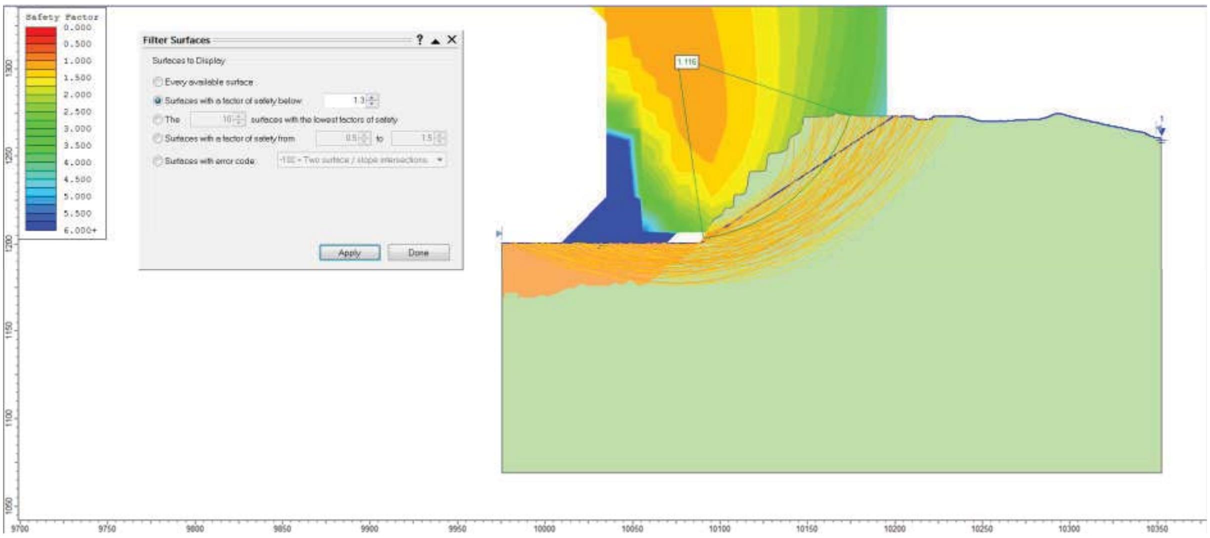
B. 25m tailings, horizontal water table at top of tailings

- FOS min = 1.164, slope scale failure.
- FOS < 1.3, significant slope scale failure indicated.
- No material change from dry condition.



C. 25m tailings, water sloped from top of tailings to 50m setback from pit crest ("worst case")

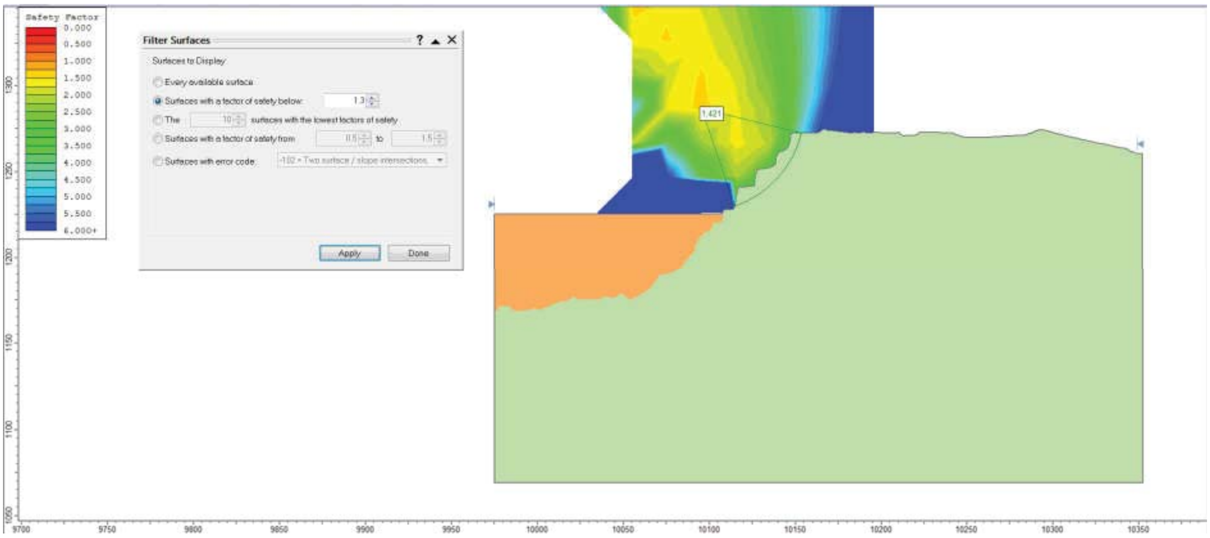
- FOS min = 1.116, slope scale failure.
- FOS < 1.3, significant slope scale failure, including floor heave indicated.
- Significant reduction in stability from dry condition. Low likelihood, transient groundwater condition.



Slope configuration #3 - 50m of 'new' tailings:

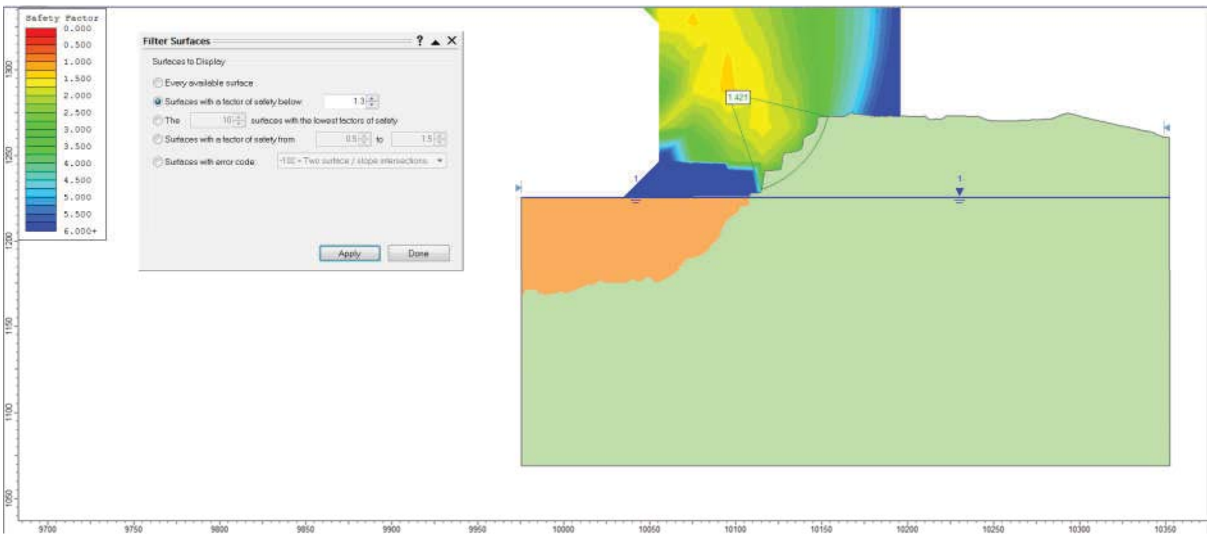
A. 50m tailings, no water

- FOS min = 1.421, slope scale failure to top of tailings.
- FOS < 1.3, no failure surfaces indicated. Stability significantly increased from 'no tailings' case. i.e. current slope configuration.



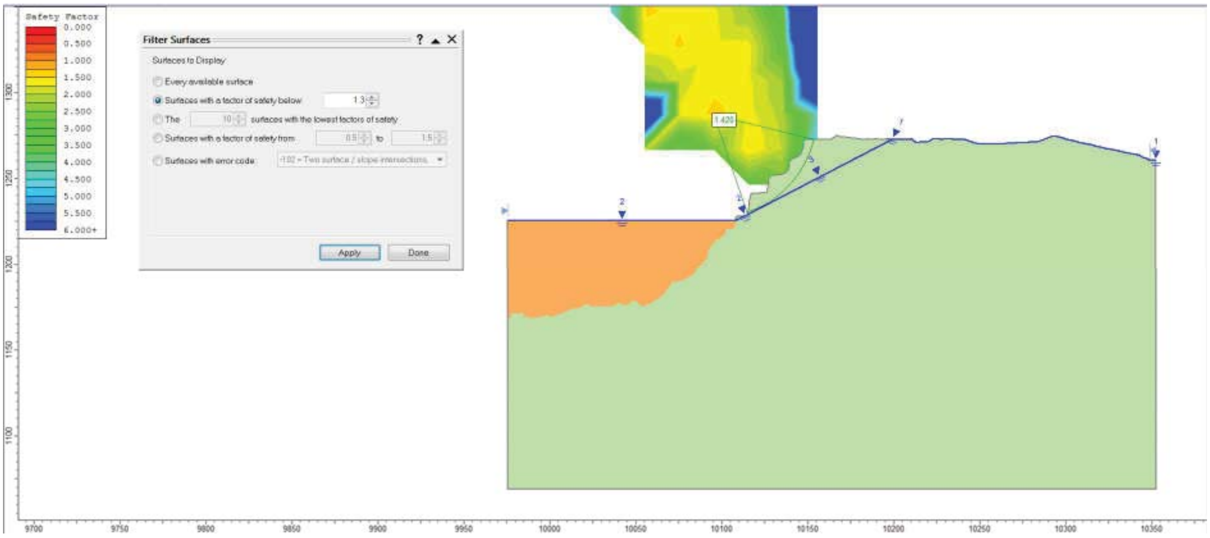
B. 50m tailings, horizontal water table at top of tailings

- FOS min = 1.421, slope scale failure to top of tailings.
- FOS < 1.3, no failure surfaces indicated.
- No change from dry condition.



C. 50m tailings, water sloped from top of tailings to 50m setback from pit crest ("worst case")

- FOS min = 1.420, slope scale failure to top of tailings.
- FOS < 1.3, no failure surfaces indicated.
- No material change from dry condition.



APPENDIX J

Ground Control Engineering Report G0197_RE01_VE01 Kintore Pit Waste Rock Slope Stability Assessment, dated 20 August 2019.

GROUND CONTROL ENGINEERING Pty Ltd
www.groundcontrolengineering.com.au
GEOTECHNICAL AND MINING ENGINEERING SERVICES
PO Box 893 Malanda QLD 4885
ABN 98 124 6688 542

20th August 2019

Attn: Mr Eamonn Dare
Technical Services Superintendent
Broken Hill Operations Pty Ltd
CBH Resources – Rasp Mine
130 Eyre Street
BROKEN HILL NSW 2880

Reference G0197

RE: KINTORE OPEN PIT – SLOPE STABILITY ANALYSIS OF EXISITING IN-PIT WASTE ROCK DUMP, DURING TAILINGS PLACEMENT

Ground Control Engineering Pty Ltd (GCE) was engaged by the Rasp Mine to undertake a slope stability assessment of the existing in-pit waste rock dump in the Kintore Pit. The waste rock dump slope will form the south-east bounding wall during the proposed placement of thickened 'dry' tailings in the Kintore Pit.

GCE conducted two-dimensional limit equilibrium analysis of the waste dump slope. The aim of the analysis was to assess the stability of the waste dump slope with varying tailings fill level and degree of potential water saturation. This summary report outlines the results of the modelling and key findings of the slope stability assessment.

Yours sincerely,

GROUND CONTROL ENGINEERING PTY LTD

Ceirin Byrne
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1 Introduction and Scope

GCE was requested by the Rasp Mine to undertake a geotechnical slope stability assessment of the existing waste rock dump in the Kintore Pit. CBH plans to backfill the Kintore Pit with thickened 'dry' tailings, whereby the waste rock dump slope will form the south-east bounding wall during placement of the tailings.

The scope of work for this assessment incorporated two-dimensional slope stability analysis of the following:

- Existing waste rock slope configuration, and;
- Various waste rock slope configurations incorporating the progressive filling of the pit with tailings and associated potential transient groundwater saturation profiles.

2 Data Provided

CBH provided GCE with the following data and report:

- Current pit surface including existing waste rock backfill area, as DXF file.
- Kintore Pit: Preliminary Decline Plug Design – Golder report, 17 October 2018 (Ref. 1)

3 Stability Analysis of Waste Rock Dump

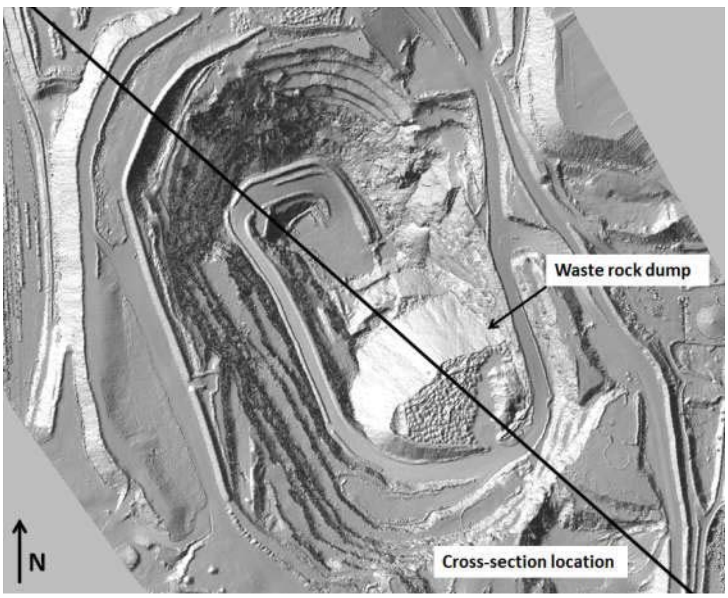
Sections 3.1 to 3.4 of this report describe the method, assumptions and parameters used in the slope stability analyses. The results and conclusions of the analyses are outlined in Sections 3.5, 3.6 and Appendix A.

3.1 Modelling method

The Rocscience Inc. software *Slide* was used to conduct limit equilibrium slope stability analyses of selected two-dimensional cross-sections of the Kintore Pit. Circular failure surfaces were generated using a grid search and analysed using the Bishop method to determine the slope Factor of Safety (FOS). Circular failure through the waste rock slope is considered the most likely slope failure mechanism.

The location of the section line where the cross-sections were generated for the analyses is shown in Figure 1. The location was selected by GCE to evaluate the 'worst case' slope configurations, approximately perpendicular to the waste rock slope and with consideration of the most likely failure mechanism.

Figure 1 Section line location with respect to existing as-built pit and waste rock dump



3.2 Slope configurations assessed

Three main slope configurations where assessed for stability, as described below and shown in Figures 2 to 4.

The cross-sections used in the *Slide* modelling incorporate the material boundaries, pit wall and waste dump geometry and inferred (potential) groundwater profiles.

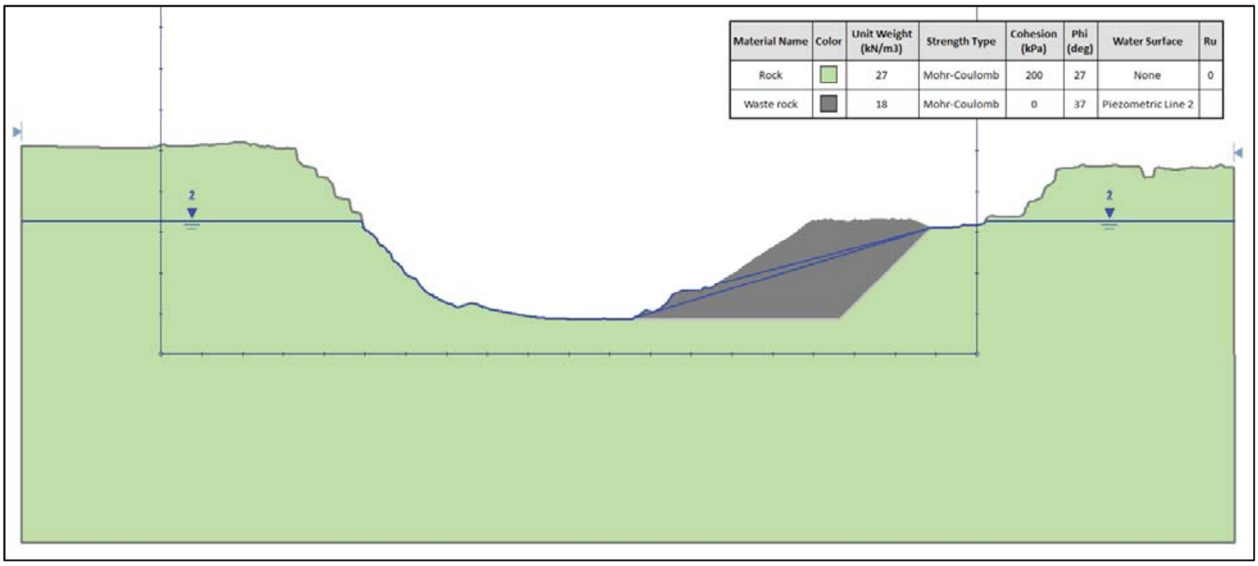
All slope configurations where run with three different groundwater cases, including a “dry” case. The groundwater and material properties applied in the models are described in Sections 3.3 and 3.4 of this report respectively.

NB: Static loading only has been modelled in the current stability assessment. GCE recommends that the impact of seismic loading is considered as part of a more comprehensive stability assessment.

<u>Slope configuration #1 - no tailings</u>:

Existing waste rock dump slope, prior to commencement of backfilling pit with tailings, as shown in Figure 2.

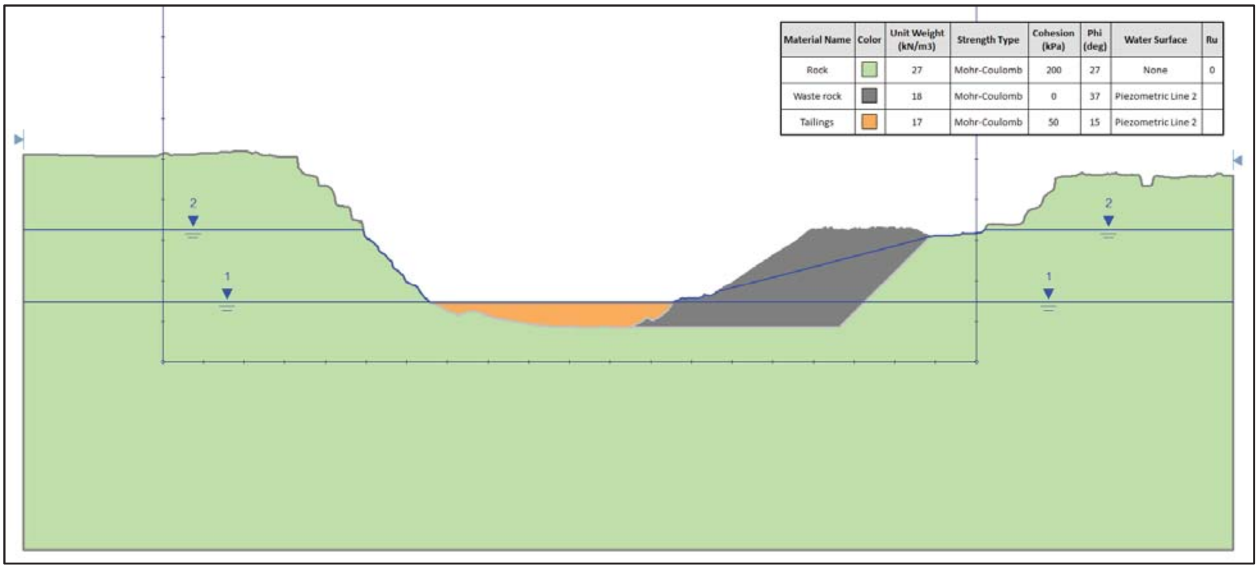
Figure 2 Slope configuration #1 – no tailings



Slope configuration #2 - 15m of tailings:

Placement of 15m of tailings in the pit, adjacent to the existing waste rock dump slope, as shown in Figure 3.

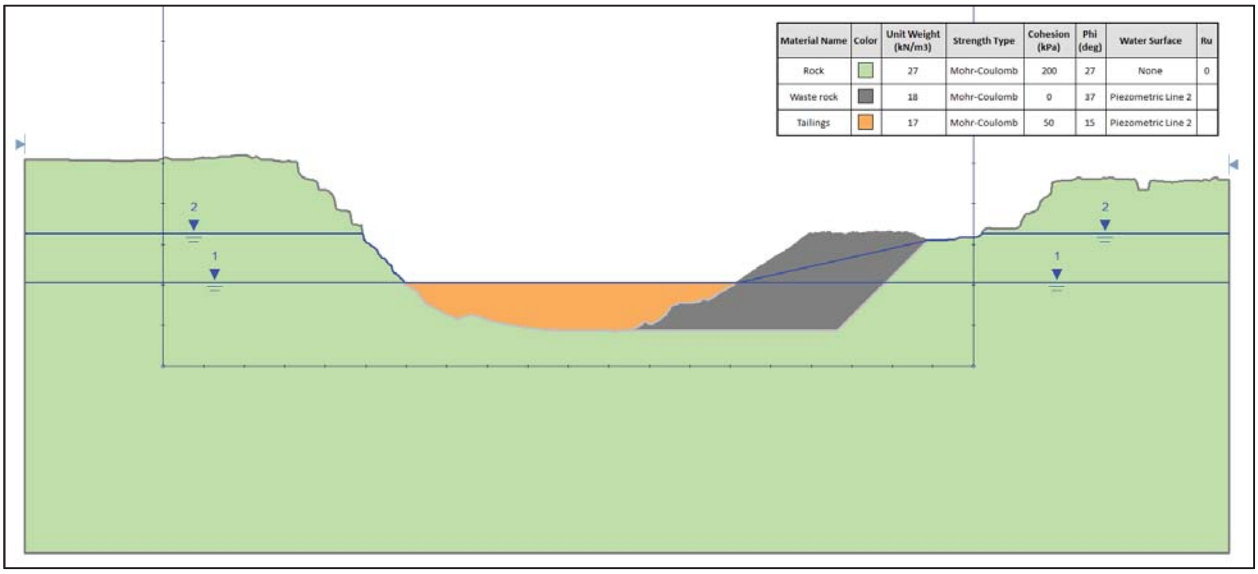
Figure 3 Slope configuration #2 - 15m of tailings



Slope configuration #3 - 30m of tailings:

Placement of 30m of tailings in the pit, adjacent to the existing waste rock dump slope, as shown in Figure 3.

Figure 4 Slope configuration #3 - 30m of tailings



3.3 Material properties

The estimated material properties assigned to each material type used in the modelling are outlined in Table 1.

It must be noted that the properties outlined in Table 1 are estimates only, based on GCE precedent experience of comparable materials and from the Golder report; Kintore Pit: Preliminary Decline Plug Design –17 October 2018.

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Table 1 Material shear strength properties (estimated)

Material Type	Unit Weight (kN/m^3)	Cohesion (kPa)	Friction Angle
Rock (in-situ Gneiss)	27	200	27°
Waste rock	18	0	37°
Tailings	17	50	15°

3.4 Groundwater

GCE understands that all water inflow will be removed from the pit via an effective drainage system and that groundwater will not accumulate at the bottom of the pit or in the tailings and waste rock slope(s). However, the groundwater profile and potential fluctuation following major rainfall events in the area of the Kintore Pit must be considered during the filling of the Kintore pit with classified tailings.. There may be periods after heavy rainfall events where part of the waste rock slope and tailings will be saturated and a transient piezometric surface will be present within the slope.

To assess the impact that groundwater may have on slope stability, three main groundwater conditions were modelled as follows:

1. "Dry" – No groundwater applied in the model. This scenario is used as a reference to assess the base case stability of the slope and the subsequent sensitivity of the modelled failure paths to the introduction of groundwater.
2. "Flat" – a horizontal piezometric surface is applied at the level of the top of the tailings, applying to both the tailings and waste rock materials.
3. "Sloped from top of waste rock" – a sloping piezometric surface is applied from the top of the waste rock, down to the level of the top of the tailings, applying to both the tailings and waste rock materials.

3.5 Summary of waste rock slope stability assessment results

The results of the stability modelling are presented in Appendix A and summarised as follows:

(Factor of Safety is abbreviated as FOS.)

<u>Slope configuration #1 - no tailings</u>:

- Very minor, shallow, sloughing style instability is indicated at FOS < 1. This may manifest as minor riling, which is typical of waste rock slopes.
- At FOS = 1.3, very shallow circular failure (sloughing) is indicated for both the "dry" and "water sloped from top of waste rock to pit floor" scenarios.
- The "worst case" transient groundwater scenario whereby a sloping piezometric surface is applied from the top of the waste rock, down to the mid-level of the slope indicates moderate slope scale instability at FOS < 1. This represents a significant reduction in slope stability from the dry condition.

However, the waste rock slope is understood by GCE to be free draining and hence this worst case groundwater scenario is considered to be very unlikely.

<u>Slope configuration #2 - 15m of tailings:</u>

- At FOS = 1.3, very shallow circular style failure (sloughing) is indicated for both the "dry" and "flat", piezometric surface at the level of the top of the tailings, scenarios.
- The "flat" piezometric surface scenario indicates potential for slope scale instability (relatively shallow) at FOS = 1.36. Potential for circular failure resulting in floor heave through the tailings is indicated at FOS = 1.81.
- The "worst case" transient groundwater scenario whereby a sloping piezometric surface is applied from the top of the waste rock, down to the top of the tailings indicates potential for slope scale failure at FOS = 1.17. In this case, potential for circular failure resulting in floor heave through the tailings is indicated at FOS = 1.39.

<u>Slope configuration #3 - 30m of tailings:</u>

- At FOS = 1.3, very shallow circular style failure (sloughing) is indicated for all groundwater scenarios modelled.
- Potential for slope scale instability (upper exposed slope above tailings only) is indicated at FOS = 1.52. Potential for circular failure resulting in floor heave through the tailings is indicated at FOS = 1.65 in the "worst case" transient groundwater scenario.

3.6 Findings and recommendations

The following comments relate to the analyses and FOS results outlined in Sections 3.1 to 3.5 and Appendix A.

- The slope stability analyses conducted by GCE indicates that current, free draining, waste rock dump slope has a FOS for overall slope scale stability of greater than 1.3.
- Generally speaking, the placement of 'dry' tailings at the base of existing waste rock dump slope is expected to increase the stability of the slope.
- The modelling highlights the potential for shallow, circular style failure (sloughing) in all cases. This may materialise as minor rilling, which is typical of waste rock slopes. GCE recommends that a large bund is installed along the length of the toe of the waste rock dump during placement of tailings to shield against rockfall from the adjacent slope. The bund will need to be progressively moved and re-established as the level of the tailings backfill rises in the pit.
- The slope stability model incorporating 15m of tailings (slope configuration model #2) and the "worst case" transient groundwater scenario, whereby a sloping piezometric surface is applied from the top of the waste rock, down to the top of the tailings, indicates potential for slope scale failure at FOS = 1.17. In this case, potential for circular failure resulting in floor heave through the tailings is indicated at FOS = 1.39.

4 References

1. Golder, (2018) '*Kintore Pit: Preliminary Decline Plug Design*', Ref 1896230-017-R-Rev0, 17 October 2018

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Version	Description of changes/amendments	Author(s)	Date
DRAFT01	Draft report	C. Byrne	19/03/19
FINAL	Final report – no changes requested	C. Byrne / C. Tucker	20/08/19

DOCUMENT REVIEW AND SIGN OFF

Version	Reviewer	Position	Signature	Date
DRAFT01	C.Tucker	Principal Geotechnical Engineer		19/03/19
FINAL	C.Tucker	Principal Geotechnical Engineer		20/08/19

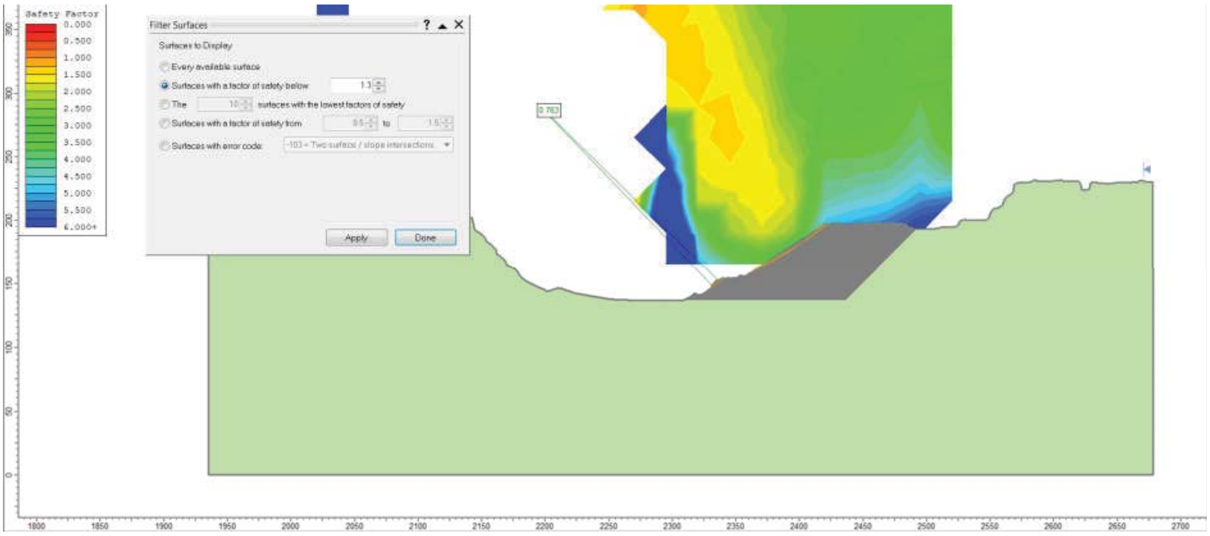
APPENDIX A

Kintore Pit Waste Rock Slope Stability Modelling Results Summary

Slope configuration #1 - no tailings:

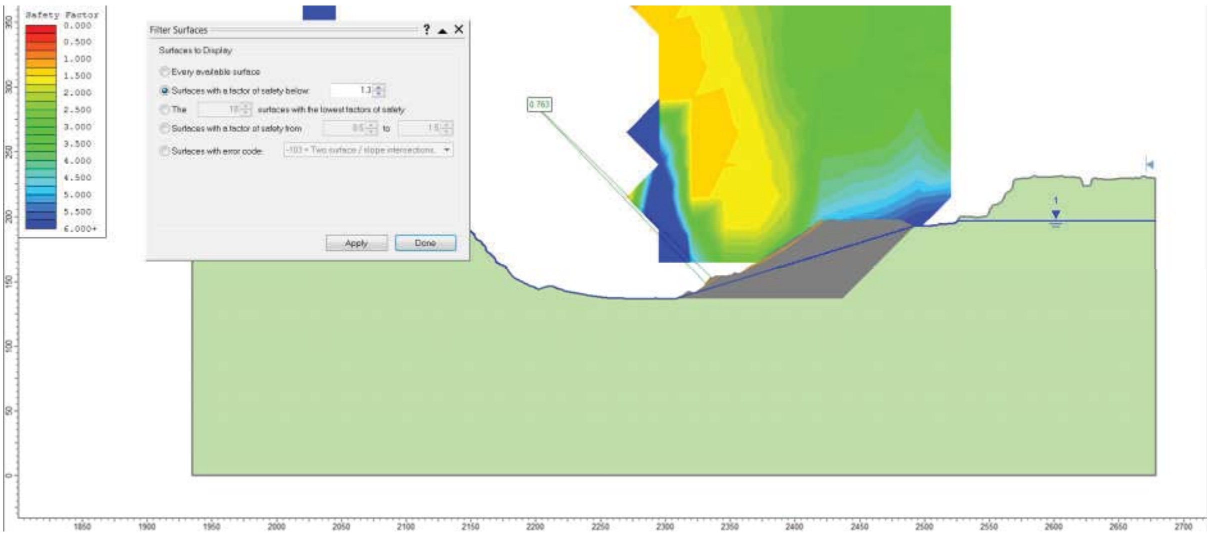
A. No tailings, no water

- FOS min = 0.763, very shallow, minor sloughing failure only
- FOS < 1.3, shallow sloughing only



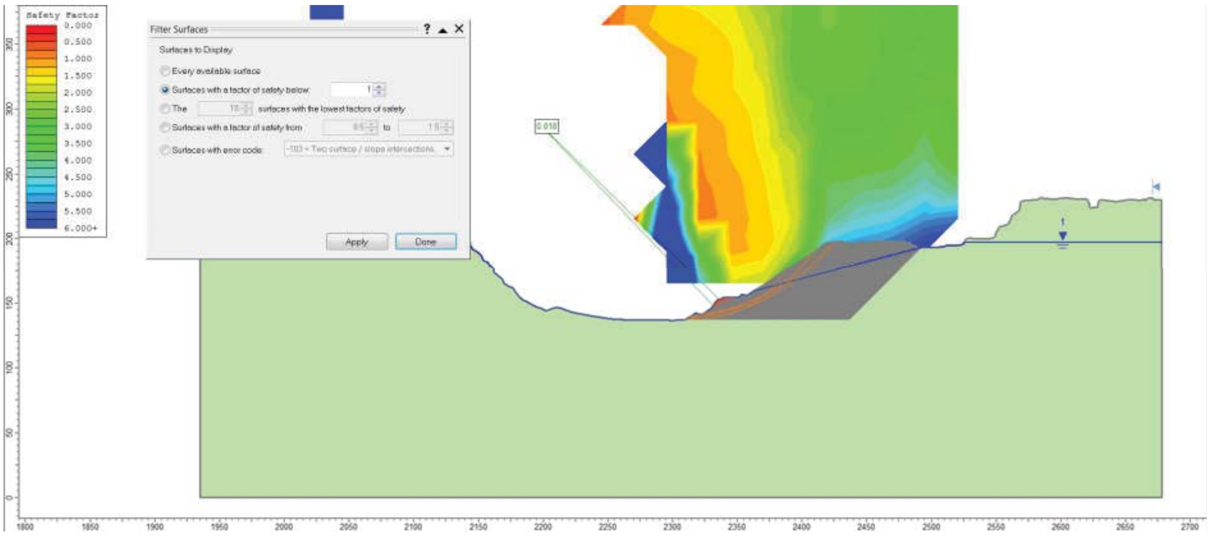
B. No tailings, water sloped from top of waste rock to pit floor

- FOS min = 0.763, very shallow, minor sloughing failure only
- FOS < 1.3, shallow sloughing only
- No change from dry condition



C. No tailings, water sloped from top of waste rock to mid slope ("worst case")

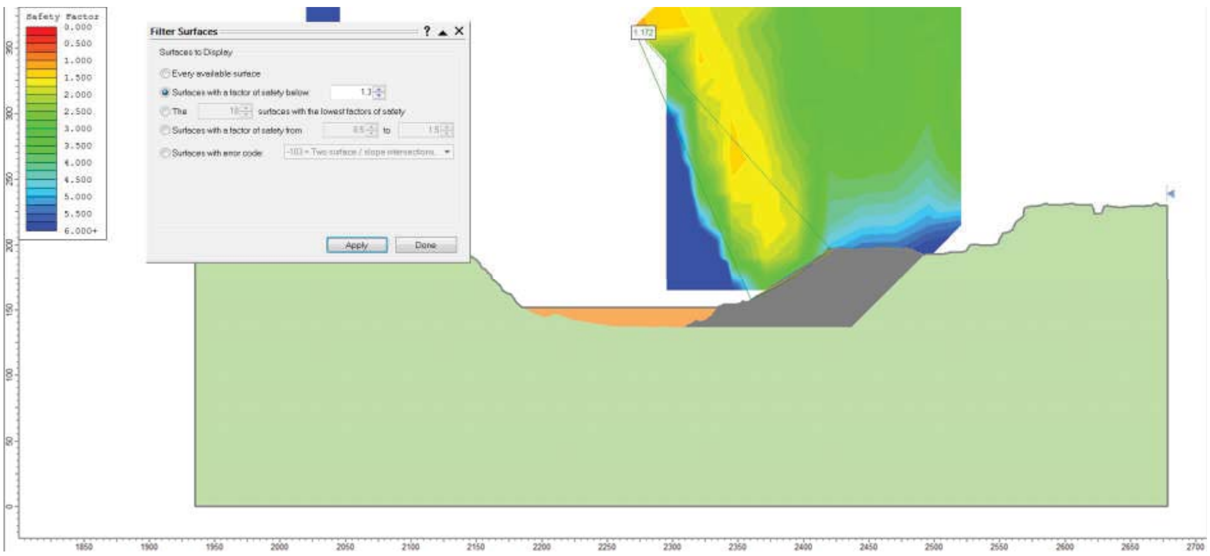
- FOS min = 0.018, very shallow, minor failure only
- FOS < 1.0, moderate slope scale failure indicated
- Significant reduction in stability from dry condition. However, would require large rainfall event.



Slope configuration #2 - 15m of tailings:

A. 15m tailings, no water

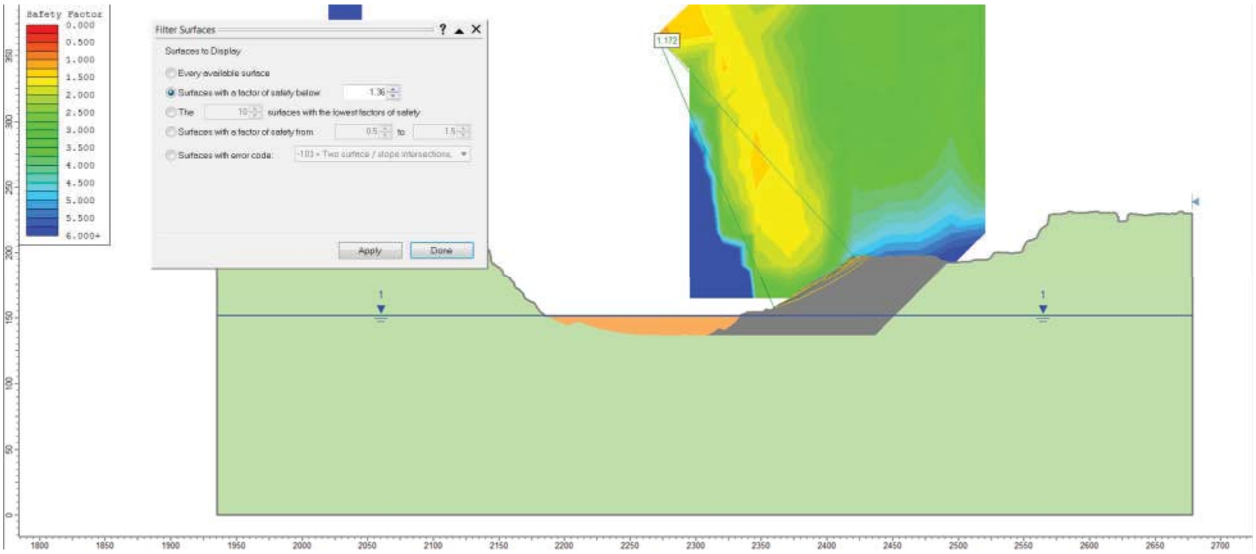
- FOS min = 1.172, shallow, sloughing failure only
- FOS < 1.3, shallow sloughing only
- Tailings increase stability of overall waste slope when dry



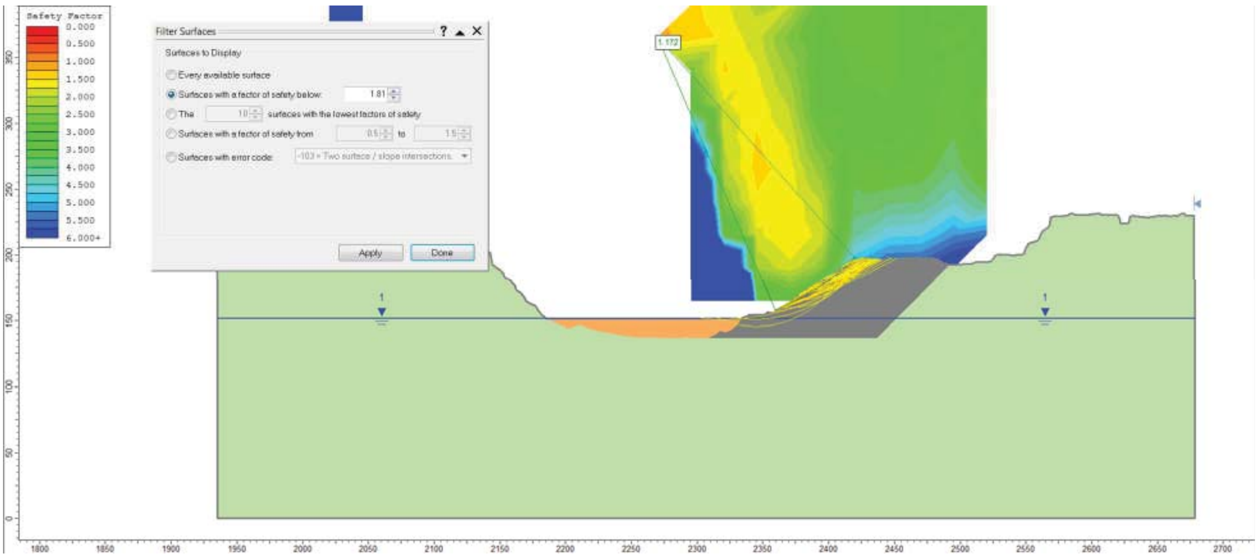
B. 15m tailings, water flat at top of tailings

- FOS min = 1.172, shallow, sloughing failure only, no change from dry condition
- FOS for slope scale failure = 1.36, tailings increase stability of overall waste slope
- FOS < 1.3, minor slope scale shallow sloughing failure indicated
- FOS for floor heave in tailings = 1.81

Slope scale failure case shown below (FOS=1.36):



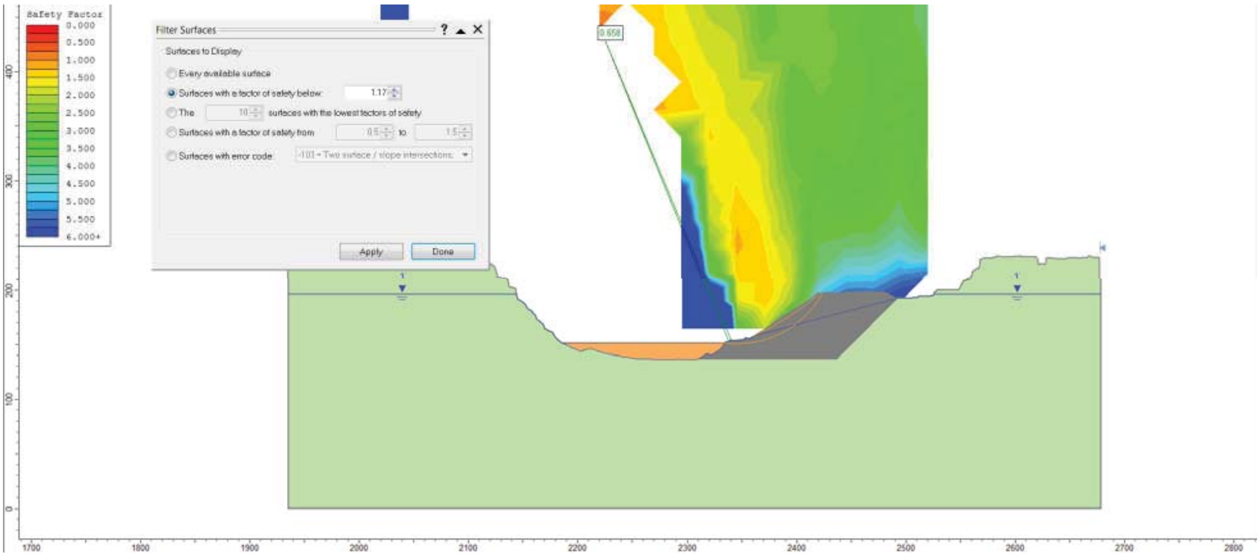
Floor heave through tailings case shown below (FOS=1.81):



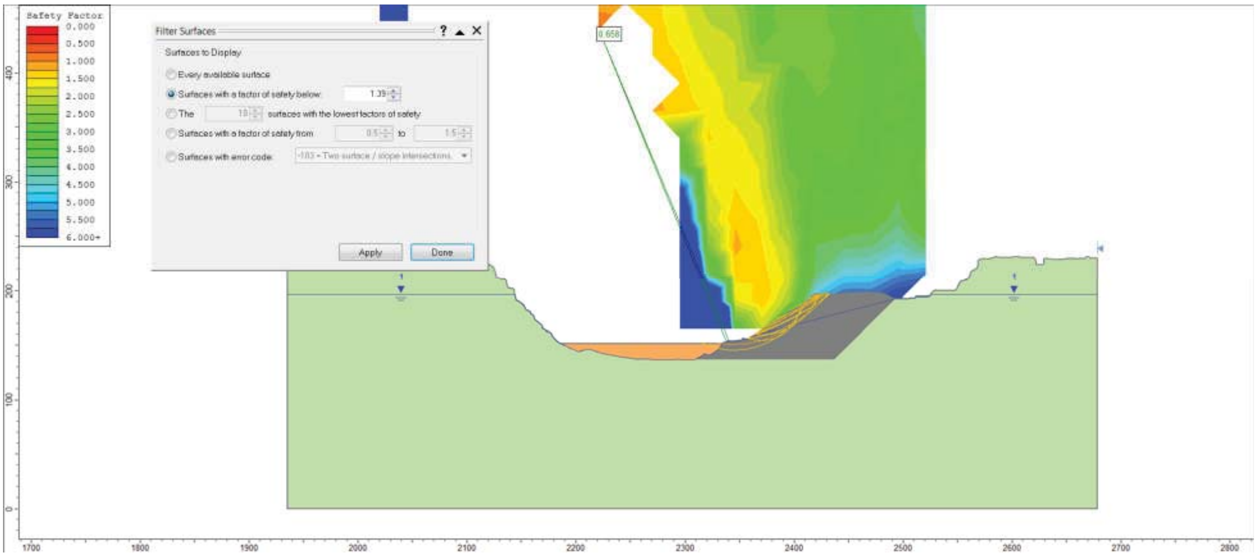
C. 15m tailings, water sloped from top of waste rock to top of tailings ("worst case")

- FOS min = 0.658, very shallow, minor failure only
- FOS for slope scale failure = 1.17
- FOS < 1.3, moderate slope scale failure indicated
- FOS for floor heave in tailings = 1.39

Slope scale failure case shown below (FOS=1.17):



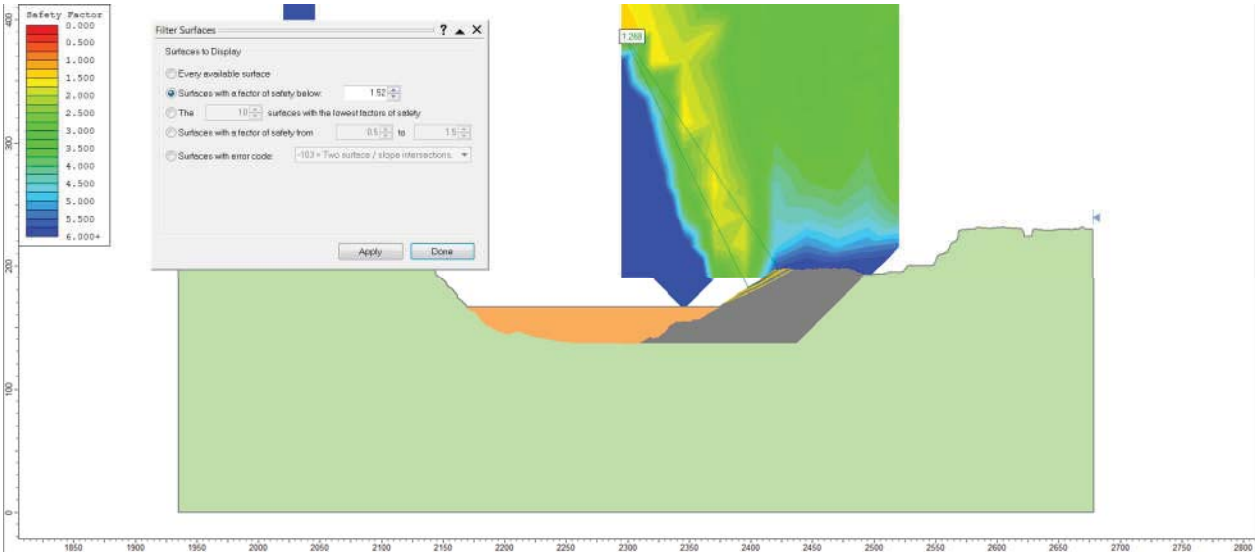
Floor heave through tailings case shown below (FOS=1.39):



Slope configuration #3 - 30m of tailings:

A. 30m tailings, no water

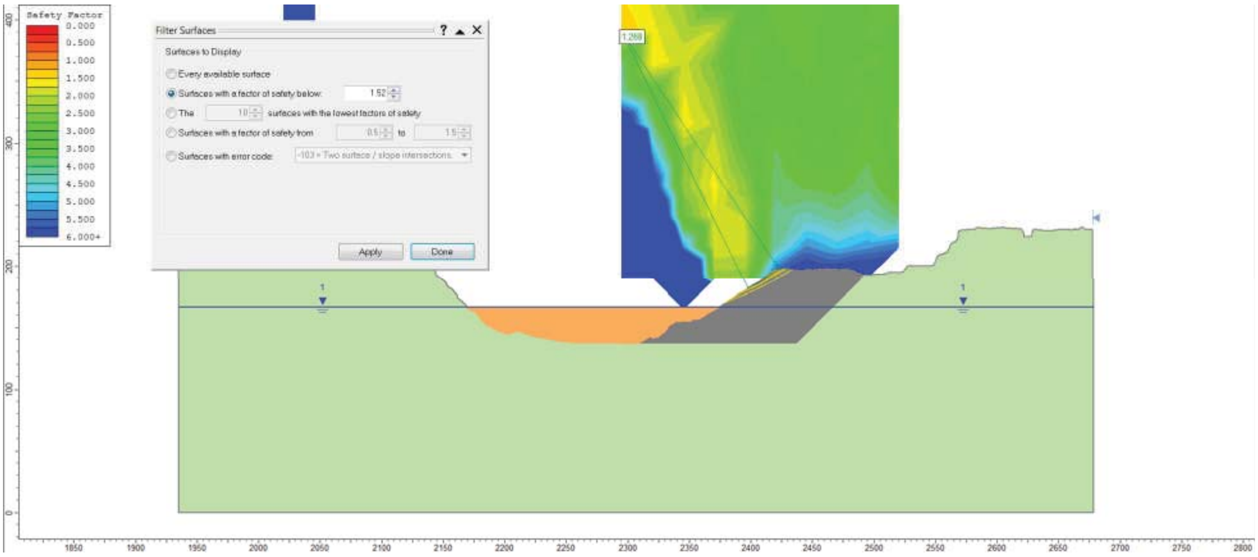
- FOS min = 1.268, very minor, shallow, sloughing failure only
- FOS < 1.3, very minor, shallow, sloughing failure only
- FOS for slope scale failure = 1.52 (upper exposed slope interval above tailings only), tailings increase stability of overall waste slope.
- FOS for floor heave in tailings = 1.83
- Tailings increase stability of overall waste slope when dry



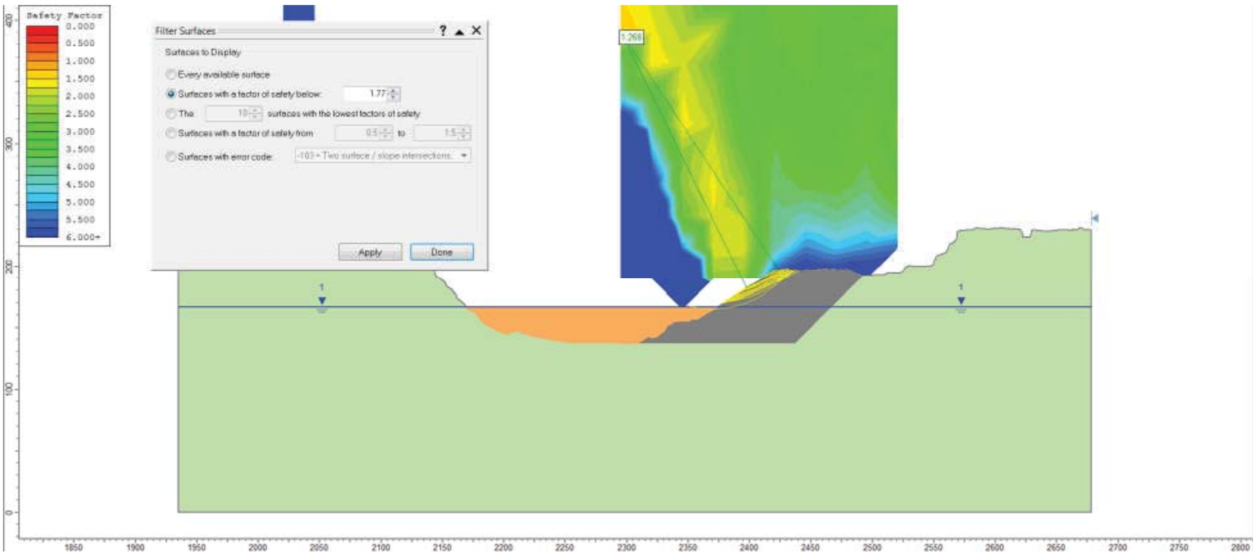
B. 30m tailings, water flat at top of tailings

- FOS min = 1.268, very minor, shallow, sloughing failure only
- FOS < 1.3, very minor, shallow, sloughing failure only
- FOS slope scale = 1.52 (upper exposed slope interval above tailings only), tailings increase stability of overall waste slope.
- FOS for floor heave in tailings = 1.77, reduction from 1.83 when dry. Not significant.
- Tailings increase stability of overall waste slope

Slope scale failure case shown below (FOS=1.52):



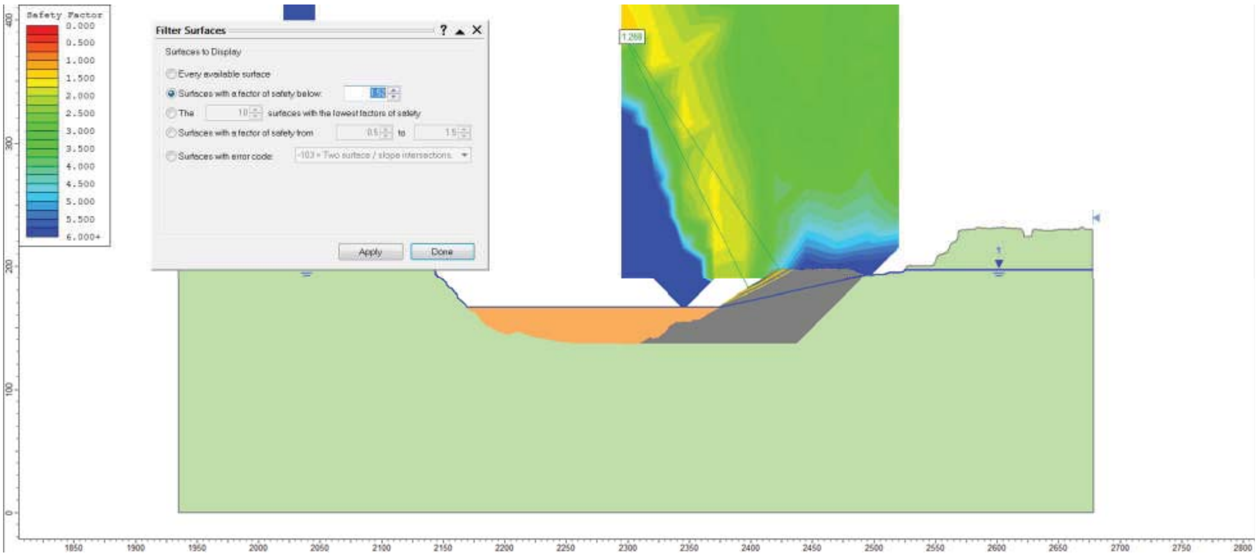
Floor heave through tailings case shown below (FOS=1.77):



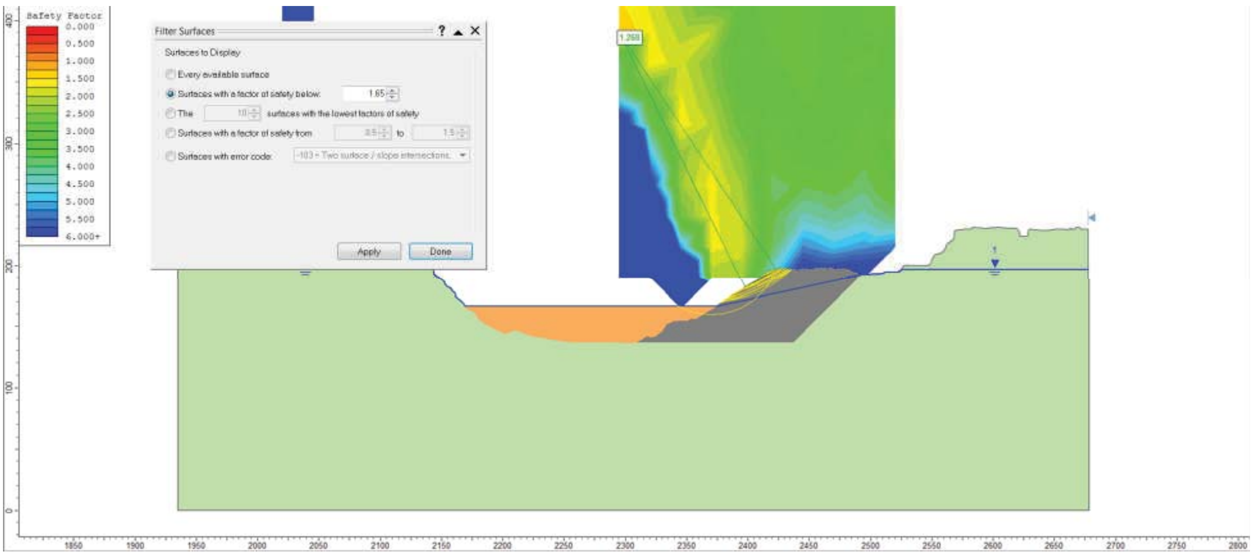
C. 30m tailings, water sloped from top of waste rock to top of tailings ("worst case")

- FOS min = 1.268, very minor, shallow, sloughing failure only
- FOS < 1.3, very minor, shallow, sloughing failure only
- FOS for slope scale failure = 1.52 (upper exposed slope above tailings only), tailings increase stability of overall waste slope.
- FOS for floor heave in tailings = 1.65, reduction from 1.83 when dry. Not overly significant.
- Tailings increase stability of overall waste slope

Slope scale failure case shown below (FOS=1.52):



Floor heave through tailings case shown below (FOS=1.65):



APPENDIX K

‘Rasp Mine – Potential Impact of Blasting on Tailings Storage Facility’ ref: 1896230-024-M-Rev0 dated 4 October 2019

GOLDER

TECHNICAL MEMORANDUM

DATE 4 October 2019 **Project No.** 1896230-024-M-Rev0

TO Andrew McCallum
Broken Hill Operations Pty. Ltd.

CC Gwen Wilson

FROM Fred Gassner **EMAIL fgassner@golder.com.au**

RASP MINE - POTENTIAL IMPACT OF BLASTING ON TAILINGS STORAGE FACILITY

Golder Associates Pty Ltd (Golder) was retained by Broken Hill Operations Pty Ltd (BHOP) to undertake an assessment of liquefaction potential of tailings storage facilities related to blasting activities for the Rasp Mine. This assessment is undertaken to also inform the risk of stored tailings inrush from the impacts of mine blasts. Two existing tailings storage facilities (TSF) exist on the mine and a third facility is being planned.

1.0 INTRODUCTION

1.1 Overview

Historic tailings storage facility (TSF 1)

TSF 1 is located to the south of the processing plant and has not been used for tailing deposition for more than 15 years. The TSF is a surface structure with the TSF constructed on top of the original ground surface. The top of the TSF is covered by a layer of slag and includes drainage slots to remove stormwater from the surface of the TSF.

An investigation comprising Cone Penetration Testing in 2008 indicated that the base of the tailings was saturated and low strength, but the rest of the tailings was partially saturated with strengths of soft to firm to stiff. From the 2008 investigation it was concluded that the base tailings at that time may be liquefiable under seismic loading. Since then the surface drainage of the TSF has been improved which may have improved the ground conditions.

Blackwood Pit TSF (TSF 2)

TSF 2 is the currently active TSF for the mine. The existing operation comprises of thickened tailings being deposited as a slurry into the Blackwood pit adjacent to the processing plant on site. This TSF has been operational for more than 10 years with the tailing elevation approaching the crest elevation of the pit. The TSF is currently being upgraded with three perimeter embankments constructed along the low areas of the pit rim. The upgrade also includes an emergency spillway at the north east end of the pit. The pit includes a number of old mine workings adjacent and below the pit. Prior to commissioning the TSF, the mine conducted risk assessments related to the potential risk of the tailings inrush to the proposed ongoing mine works, which are remote to the old workings.

Kintore Pit TSF (TSF 3)

BHOP is proposing to backfill its Kintore Pit with tailings. The tailings will be dewatered using vacuum filters, spread in layers and compacted with a roller. The pit itself is over 100 m deep with an adit near the base of the pit that leads to active underground workings. It is important that the in-pit tailings storage facility (TSF) be designed to mitigate the risk of sudden inflow of tailings and water to the underground workings. The design of the pre-deposition works for tailings deposition is currently being developed for consideration by the appropriate authorities.

1.2 Tailings

The current TSF (TSF 2) which is near full contains slurry deposited full stream tailings, or feed tailings. The tailings are sun dried in layers and can be accessed approximately 1 week after deposition. This is a very dry part of the country (200 mm to 400 mm rain per year and evaporation in excess of 2 metre per year). The deposition point is closest to a future boxcut area for a new adit to the mine and the decant end of the TSF beach is at the far end (north east end) of the pit. The rate of rise of tailings in TSF 2 is approximately 4 meter per year.

The future TSF (TSF 3) will contain an at least 30 m wide strip of dewatered (filter press) compacted full stream tailings around the perimeter of the pit, that is compacted at optimum moisture content, plus the finer and potentially slightly wetter tailings placed in the centre of the TSF. The finer tailings are related to proposed cyclone treatment of the full stream tailings with the coarse split being directed to the underground workings for backfill and the finer split being placed in the TSF. The finer split of the tailings will also be dewatered and compacted in layers in TSF 3.

Golder carried out the laboratory testing to assess the liquefaction potential of Rasp Mine tailings (Golder, 2018). The report concluded that static liquefaction of the compacted fine tailings at depth cannot be ruled out if the tailings remain saturated. The concept design for tailings placement in the Kintore pit therefore includes compacted full stream around the perimeter of the Kintore pit, a rockfill bridging layer and drain across the base of the pit and plugs in the existing MLD drive adjacent to the pit base. Note a length of the old MLD drive under the pit will be closed and plugged with a new section currently being planned to be constructed to the east of the pit floor to address the needs of ventilation to Shaft 6.

This report is prepared to assess the potential of liquefaction of the tailings related to anticipated future blasting operations at the mine.

1.3 Blasting

The following summarizes the blast parameter critical to this assessment, which have been provided by BHOP:

Table 1: Parameters for the Proposed Blast Types

Pit	Blast Type	Distance [1] (m)	MIC [2] (kg)	Blast Duration [3] (sec.)
TSF 1	Stope	> 500	250	4
	Boxcut	110	100	1
	Decline development	100	60 [4]	-
TSF 2	Stope	160	250	4
	Boxcut	120	100	1
	Development	95	60 [4]	-
TSF 3	Stope	200	250	4
	Boxcut	970	100	1
	Development	1020	60 [4]	-

1) *Minimum separation distance between the blast and tailings in TSF.*
2) *Maximum instantaneous explosive charge weight.*
3) *Maximum blast duration in seconds.*
4) *Twelve (12) holes on the same delay with 5 kg per hole.*

2.0 GROUND VIBRATION LIMITS

A peak ground acceleration (PGA) based method is commonly used to assess the earthquake-induced liquefaction potential of soils with the “simplified procedure” (Youd and Idriss, 2001). However, there are fundamental differences between blast-induced ground vibrations and ground vibrations caused by earthquakes. Ground vibrations initiated by blasts typically contain less energy, have a higher spectral frequency content, and have significantly shorter time duration than earthquake-induced ground vibrations (less than two seconds versus more than half a minute to several minutes). According to Pfeifer (2010), the amount of damage from blasting correlates best to the peak particle velocity (PPV), while PGA is more appropriate when evaluating damage from earthquakes.

Appropriate limits for blast-induced liquefaction and vibrations at earth dams and embankments have been discussed in numerous publications, including Charlie et al. (1987, 1992, 2001), Al-Qasimi et al. (2005) and Pfeifer (2010).

Charlie et al. (2001) found that no significant increase in residual Pore Water Pressure (PWP) was induced by explosives when the PPV was less than 15 mm/s to 35 mm/s. Charlie et al. (1987, 1992) suggested the following criteria for blasting near dams and embankments (Table 2) based on liquefaction potential and susceptibility to pore pressure increases.

Table 2: General Guidelines to Vibration Damage Thresholds for Blasting Near Dams and Embankments

Dam and Embankment Construction	PPV Limit (mm/s)
Dams and embankments constructed of or having foundation materials consisting of loose sand or silts that are sensitive to vibration	15
Dams and embankments having medium-dense sand or silts within the dam or foundation materials	50
Dams and embankment having materials insensitive to vibrations in the dam or foundation materials	100

Source: Charlie et al. 1987.

Al-Qasimi et al. (2005) described a research study with intended to determine the potential for explosive detonation to induce residual pore pressure and determine the possibility of triggering flow-liquefaction in the tailings located under an experimental embankment. Little or no excess pore pressure was induced from single or multiple detonations in a level deposit of loose, saturated, sand-size mine tailings when PPV was less than 10 mm/s. Blast-induced residual pore pressure and cyclic-liquefaction occurred for a single detonation at a PPV exceeding 650 mm/s and multiple detonations with millisecond delays at a PPV exceeding 130 mm/s.

As the containment of the proposed dewatered tailings in TSF 3 is the pit wall rock, a PPV limit of 100 mm/s would provide a reasonable level to avoid potential liquefaction. TSF 2 (where the future raise embankments are partially constructed on desiccated tailings) may contain foundation materials that are sensitive to vibration, a PPV limit of 15 mm/s would provide a reasonable level to avoid potential liquefaction. TSF 1 is an old tailings dam with most of the material is a relatively dry state, and moderate density based on old piezocone testing conducted on the TSF before the improved water management was implemented on the surface. The base of the TSF was saturated at that time, so for this TSF a PPV of less than 25 mm/sec would provide a reasonable level to avoid potential liquefaction. It is noted that these preliminary limits do not consider the energy related to the blasting, so these preliminary limits are conservative.

3.0 VIBRATION ATTENUATION MODEL

3.1 Predictive Vibration Model

Two of the most important variables that affect the PPV induced by a blast are the distance from the source (seismic waves attenuate with distance) and the maximum instantaneous explosive charge weight (MIC). The most common method of normalizing these two factors is by means of plotting the scaled distance (distance divided by the square root of the charge weight per delay) against the PPV.

The PPV (mm/s) is given by the following equation:

$$PPV = K(SD)^e \qquad \text{(Eq.1)}$$

where K and e are site constants and the Scaled Distance (SD) is defined as:

$$SD = \left(\frac{D}{\sqrt{W}}\right) \qquad \text{(Eq.2)}$$

where D is the distance (m) between the blast and receptor;

W is the MIC (kg) detonated.

According to the Australian Standards, the PPV can be estimated by the following equation when blasting to a free face in average conditions (JKMRC, 1996):$PPV = 1140(SD)^{-1.60}$

where PPV is the Peak Particle Velocity (mm/sec)

SD = Scaled Distance (m/kg$^{1/2}$) as defined above

The model is plotted on Figure 1.

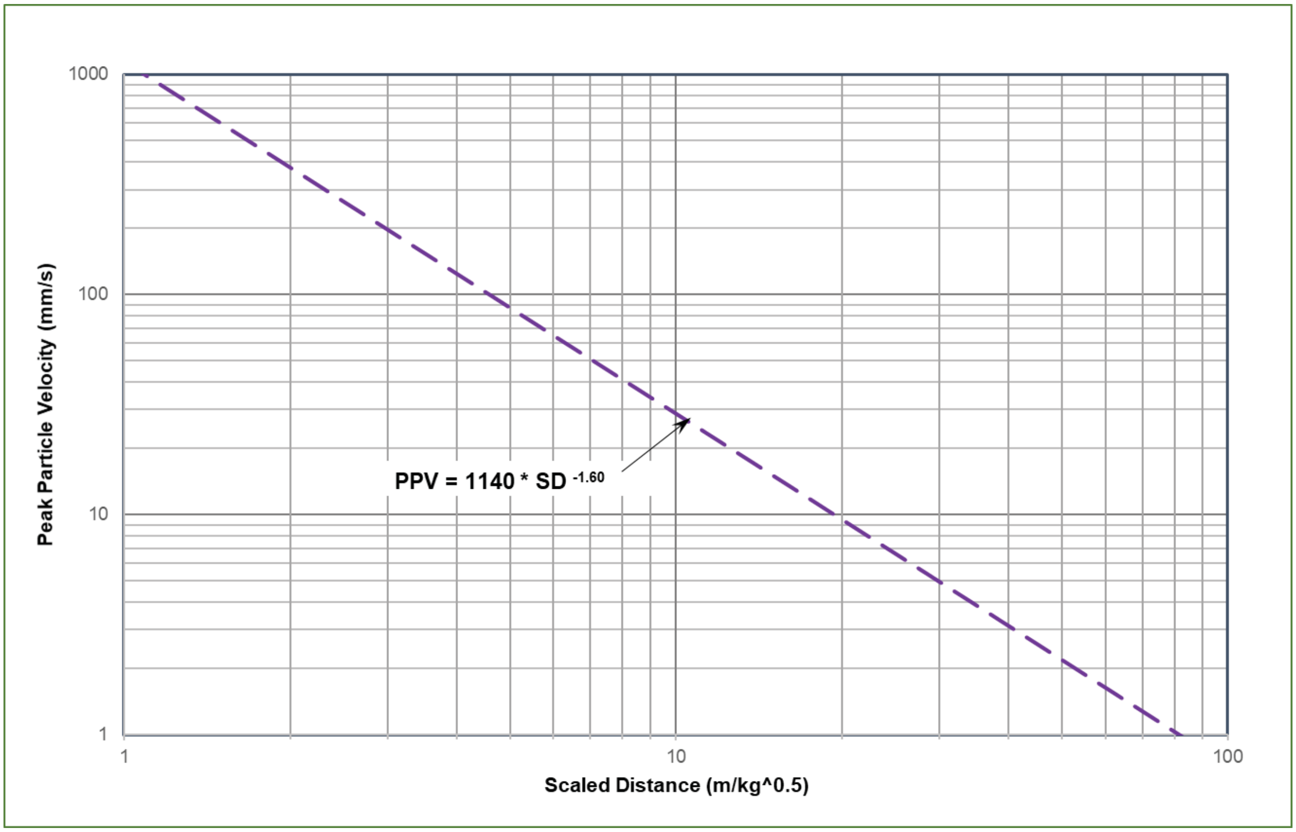


Figure 1: Proposed Ground Vibration Model

The vibration monitoring data was collected at receptors located from 300 m to over 1300 m from a given blast. Vibration monitoring has not been conducted at the tailings. Thus, the PPVs for the recorded events are likely significantly less than maximum anticipated vibration levels that could be expected at the tailings within the TSF's.

3.2 Impact of the Rock-Tailings Boundary

While most blast-induced tailings liquefaction assessments in literature consider the impact of the blasts on tailings embankments, the TSF 2 and 3 entails the pit wall rock as the retaining structure. Several authors have addressed blast induced vibrations on tailings backfill in underground stope. As part of their assessments, the effect of the rock-backfill interface was considered.

Mohanty and Trivino (2014) presented a blast vibration monitoring case study in a stope backfilled with 2-4% Cemented Paste Backfill (CPB) during its curing stage. A systematic seismic monitoring program was implemented to characterize the nature of CPB and its surrounding rock when subjected to a normal production blasting operation. The particle velocity and the frequency content in CPB compared to its surrounding rock is shown to be lower by almost two orders of magnitude for the PPV, and almost an order of magnitude lower in the frequency (Shasavari et al., 2014). The main reason is that the propagation of wave has been through two different media with different stiffness and elastic parameters.

Johnson et al. (2007) investigated the response of CPB to dynamic loads based on rockburst observations in the Galena mine. The results also showed that 95% of the initial energy was reflected away from the CPB specimen and only 5% of the energy was absorbed.

Studies have shown that much of the blast vibrations are reflected at rock CPB interface. Emad (2013) found that only 18% - 30% of the blast vibrations were transmitted into the CPB. The current assessment has considered transmission of 30% across the rock-tailings interface.

3.3 Tailings Raise Embankments

As mentioned in Section 2.0, the future raise embankments of TSF 2 are to be partially constructed on desiccated tailings and should have a PPV limit of 15 mm/s. In that case, the blast induced vibrations at the embankment toe will be those at the tailings surfaces that will form the foundation of the embankments.

As the pathway from the blast vibration source to the future embankment receptors differs for TSF 1 and TSF 2, the attenuation model will be different for each. That is, the vibration waves will have to cross the rock/tailings boundary for TSF 2 while those for TSF 1 may be affected by amplification at the top of the facility.

The northern embankment (Embankment 2) of the TSF 2 has been constructed and is founded on a rock and rockfill foundation.

The other two embankment raises (Embankments 1 and 3) are founded partially on rock and partially on tailings. The models used in this assessment is based on data collected at sensitive receptors surrounding the mine. It is proposed to also collect data at the sites of the future raise embankment sites. This would enable the development of refined models for each of the embankment raise sites to inform any modification to the nearby blasting design.

4.0 IMPACT ASSESSMENT

Based on the discussions above, an estimate of the of the PPV levels at the proposed pit tailings on both the rock wall and within the tailings. As the TSF 1 is on surface rather than within an excavated open pit, the predicted PPVs are represented by Figure 2. Figure 2 indicates that the TSF 1 embankment will not exceed the 25 mm/s limit for Stope, Boxcut and Development blast at distances greater than 171 m, 110 m and 85 m, respectively.

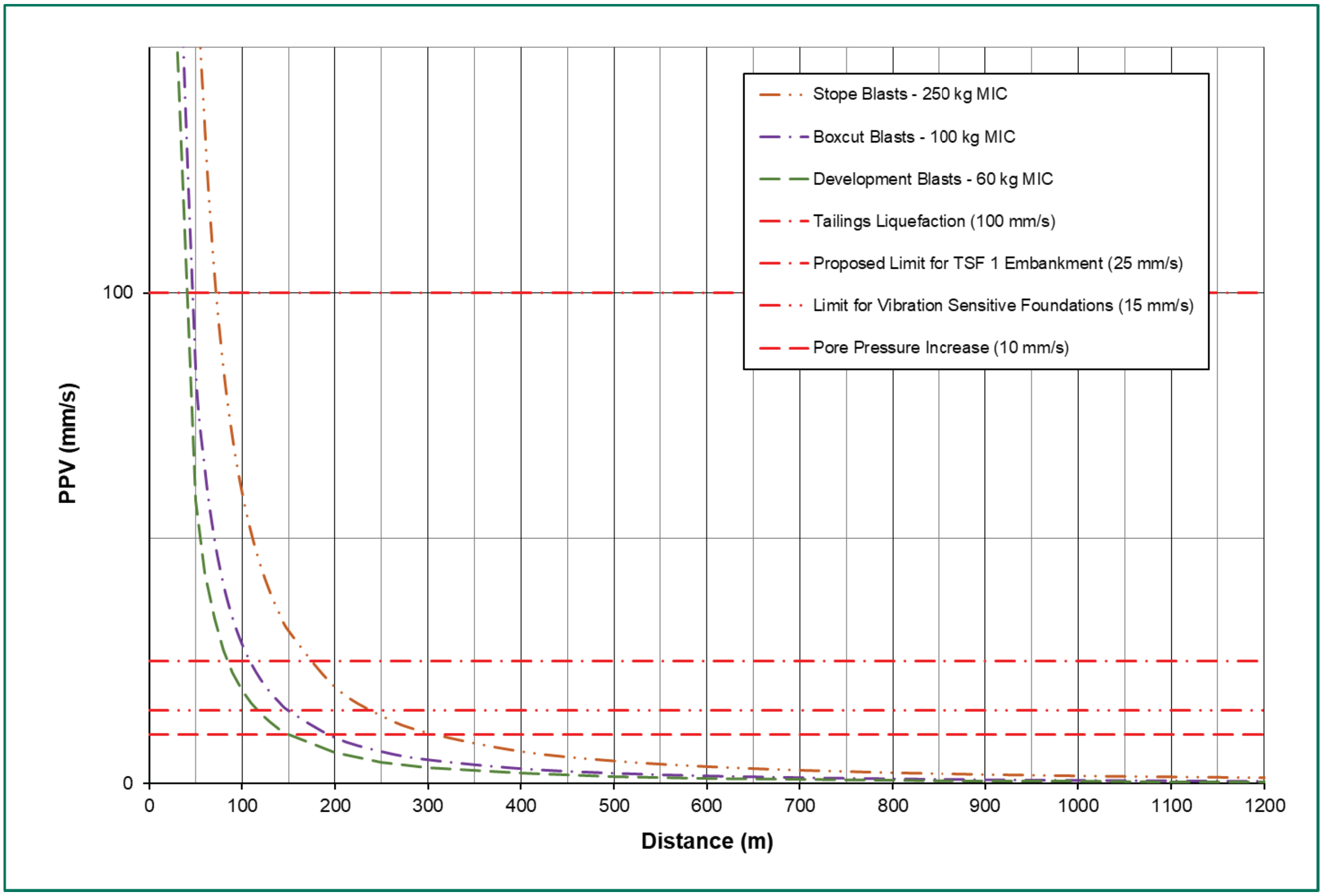


Figure 2: Estimated PPV in Rock at a Range of Separation Distances for the Proposed Blast Types

The estimated vibration levels within the tailings are shown in Figure 3. The estimated PPVs within the tailings suggest that all three proposed blast types will not exceed the tailings liquefaction threshold of 100 mm/s beyond 34 m from the blast.

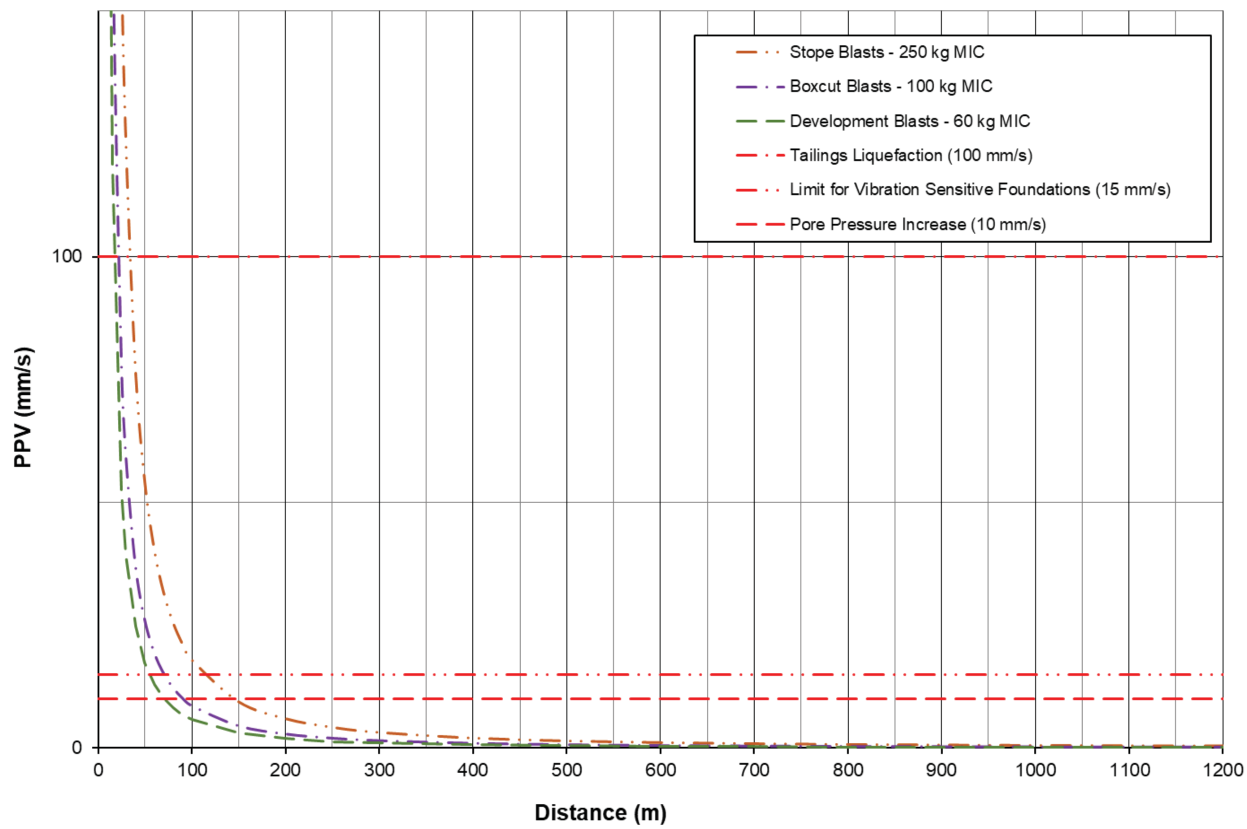


Figure 3: Estimated PPV in Tailings at a Range of Separation Distances for the Proposed Blast Types

The estimated PPVs for the proposed blast types at each of the pits are summarized in Table 3.

Table 3: Estimated PPV Levels for Proposed Blast Types

Pit	Blast Type	Distance [1] (m)	PPV (mm/s)	
			In Wall Rock	In Tailings
TSF 3	Stope	200	19.7	5.9
	Boxcut	970	0.76	0.23
	Development	1020	0.46	0.14
TSF 2	Stope	160	28.1	8.4
	Boxcut	120	21.4	6.4
	Development	95	20.7	6.2
TSF 1 [2]	Boxcut	110	Not applicable	24.6
	Decline Development	100	Not applicable	19.0

1) *Minimum separation distance between the blast and tailings in TSF.*
2) *Estimated PPV for the TFS 1 embankment.*

The estimated blast-induced vibrations will reach the threshold at which the PWP increases (10 mm/s). However, the energy related to the proposed blasts will be relatively low compared to the energy of an earthquake. Experience has shown that liquefaction has not occurred for earthquake events with a magnitude of 4 or less. Blast energy will be limited by overpressure, noise and vibration limitations set for the works related to the surrounding receptors. The tailings liquefaction is unlikely for the proposed blasting and minimum separation distances.

The blast vibrations predicted for the TSF 1 embankment are marginally below the limit of 25 mm/s for both the Boxcut and the Decline Development blasts at the estimated minimum separation distances to the structure.

5.0 SUMMARY AND RECOMMENDATIONS

Based on our analysis of data provided by BHOP and summary of the work carried out by numerous researchers on the potential liquefaction of tailings, the following provides our summary of findings and recommendations:

- The proposed blast types are unlikely to induce liquefaction in designed tailings at the TSF's.
- Vibration monitoring of the blasts should be carried at the facilities to verify the modelled vibration values. This would allow for the refinement of the vibration attenuation model based on site-specific data at distances where tailings liquefaction is a consideration.
- Monitoring of induced vibrations from the blasting as it approaches the tailings. This will provide a record of the PPV at the specific locations in question and enable refinements of the developed models. At TSF 2, the developed model could be used for assessing the potential impact of a future embankment raise.
- Instrumentation of a tailings should be undertaken. Ideally, this would include both ground vibration and porewater sensors. This would allow for the site-specific assessment of:
  - The PPV induced in the tailings (rather than in the rock only) and refinement of the vibration attenuation model within the tailings; and
  - Potential rises in pore water pressure for given recorded PPVs.
- Should vibration monitoring exceed a warning level of 70% of the limits described, a redesign of the blasts should be undertaken. This is particularly important for the TSF 1 embankment which is predicted to be marginally below the limit of 25 mm/s at the nearest approach of blasting.

6.0 CLOSURE

We trust that this report meets BHOP's needs and should you require any additional information, please do not hesitate to contact the undersigned.

Daniel Corkery
Associate, Senior Blasting Consultant

Fred Gassner
Senior Principal

DC/fwg/dc

https://golderassociates.sharepoint.com/sites/25201g/deliverables/024 blasting assessment/1896230-024-m-rev0.docx

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APPENDIX L

'RASP Mine - Site Water Management Plan' dated January 2019 (ref BHO-PLN-ENV-004) (the SWMP).

Rasp Mine

Zinc – Lead – Silver Project

Project Approval No. 07-0018

January 2011

Site Water Management Plan

BHO-PLN-ENV-004

Updated

January 2019

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Contents

1. Introduction

1.1 Overview

Broken Hill Operations Pty Ltd (BHOP), a wholly owned subsidiary of CBH Resources Limited (CBH), owns and operates the Rasp Mine (the Mine), is located centrally within the City of Broken Hill on Consolidated Mine Lease 7 (CML7). The Mine produces zinc and lead concentrates which it dispatches via rail to Port Pirie in South Australia and Newcastle in New South Wales.

Project Approval (PA) was granted in January 2011 (07_0018) and mining commenced in April 2012. Modifications to the PA have been granted on a number of occasions and details can be found on the CBH web site. The existing operations include underground mining operations, a processing plants, a rail siding for concentrate dispatch and other associated infrastructure.

Mining has been undertaken within CML7 since 1885 and the entire site has been disturbed with little or no remnant native vegetation.

The mine is located at a high point in the regional topography and is a prominent feature in the City of Broken Hill. Most of the site is raised from the adjoining area in the form of an extensive mound, formed from waste rock and tailing. Site elevations vary from 356 m AHD at the parking bay for the Miners Memorial to approximately 216 m AHD at the base of Kintore Pit.

The total area of CML7 is approximately 342 ha. There are several surface exclusion zones within CML7, these include rehabilitation areas and areas with no or limited surface rights. These exclusion zones comprise approximately 123.7 ha. BHOP is not responsible for the surface water management in these exclusion zones.

1.2 Purpose

The purpose of this Site Water Management Plan (SWMP) is to outline the responsibilities and actions for monitoring and managing water in relation to the operations of the Rasp Mine.

The SWMP has been developed in accordance with the:

- Project Approval 07-0018 Conditions (as modified);
- Rasp Mine Environment Protection Licence 12559;
- CML7 and Mining Purpose Leases (MPLs) 183, 184, 185 and 186, and
- Commitments made by Broken Hill Operations Pty Ltd to monitor and manage water related activities.

The SWMP satisfies the requirements for a *Water Management Plan* as outlined in Schedule 3, Condition 23 of the PA.

1.3 Objectives

The primary objectives for this SWMP are to:

- To comply with section 120 of the Environment Operations Act 1997, which prohibits the pollution of waters.
- Prevent discharge of potentially contaminated surface waters from active mine areas off-site.

- Separate runoff from the mine processing plant area and groundwater collection ponds from areas of general runoff.
- Limit disruption to the mining activities and provide a safe working environment.
- Identify erosion and sediment control measures for the site and outline control measures and a monitoring plan for areas considered susceptible to erosion
- Outline a water monitoring program for the site to include both surface and ground waters; Provide a site representative water balance.
- Provide reporting requirements based on statutory obligations and internal processes.

1.4 Surface Water Management Goals

The topography of the site and the arid climate conditions provide opportunities to develop a SWMP that satisfies the operational requirements of the mining activity and prevents release of runoff from active areas of the mine site for rainfall events up to the design frequency event – 100 year average recurrence interval (ARI) 24 hour rainfall event. A set of goals were developed in order to guide this SWMP, these goals are:

- Retain runoff from a 100 year ARI 24 hour rainfall event from the active mine areas. The high evaporation rate would allow retained water to evaporate in a relatively short period. This goal will minimise impact on the downstream environments.
- Retain runoff locally in small ponds / storages at various locations in the mine site, utilising the existing landform where feasible to maximise evaporation. This would:
    - Eliminate the need to construct a large storage and avoid hazards associated with large storages.
    - Help in the sedimentation process that would remove suspended solids from the runoff.
    - Minimise erosion potential by eliminating the requirement to carry large discharge to a smaller number of large storages.
- Provide appropriate spillways for the local ponds to convey flows greater than the 100 year ARI runoff event. Spillways will be set at the 100 year ARI 24 hour storm event storage level.
- Use the available capacity of Horwood Dam to contain the 100 year runoff event from various sub-catchments.
- Use the available capacity of S22 to contain runoff from TSF 1, Mt Hebbard (catchment 19) and adjacent catchments to the northwest, in addition provide storage for mine water settlement ponds including underground mine dewatering and groundwater from Shaft 7.
- Divert runoff away from Kintore Pit to reduce the flooding risks in the Pit and associated potential impact on mining operations.
- Provide appropriate sediment and erosion measures on site.
- Divert stormwater surface runoff from undisturbed areas around mining affected water storage facilities.
- Monitor the groundwater bores on site.
- Summarise the results of the site water balance model.
- Address the conditions of the PA, Statement of Commitments and Environment Protection Licence conditions.

1.5 Consultation

The SWMP has been prepared in consultation with the Department of Industry – Water (DI-W), the Environment Protection Authority (EPA) and the Division of Resources and Geoscience (DRG) as required by PA07_0018.

1.6 Supporting Plans and Documents

Table 1-1 lists the plans, procedures and associated forms developed in accordance with this Plan.

Table 1 - Water Management Associated Documents

Document Title	BHOP Document Code	Associated Forms
Pollution Incident Response Management Plan	BHO-PLN-ENV-002	• Incidents entered into INX inControl electronic database.
Site Water Monitoring Procedure	BHO-ENV-PRO-011	• Groundwater Monitoring Form • Surface Water Monitoring Form • Mine Water Monitoring Form
The Erosion and Sediment Control Monitoring Procedure	BHO-ENV_PRO-018	• Environmental Inspection Form
Eyre Street Dam Monitoring Procedure	BHO-PRO-ENV-027	• Eyre St Trench Inspection Form

2. Statutory Requirements

Table 2-1 details the statutory requirements as prescribed in the:

- Project Approval 07_0018 (modified) pursuant to the *Environment Planning and Assessment Act 1979*;
- BHOP Environment Assessments and Statement of Commitments, and
- Environment Protection Licence 12559 pursuant to the *Protection of the Environment Operations Act 1997*.

Table 2 - BHOP Water Management Requirements and Obligations

Reference	Requirement	Relevant Section within this Plan
Project Approval 07_0018 (modified)		
Sched 3 Cond 21	Except as may be expressly provided by an Environment Protection Licence issued under the Protection of the Environment Operations Act 1997, the Proponent shall comply with section 120 of that Act, which prohibits the pollution of waters.	Section 1.3
Sched 3 Cond 22	The Proponent shall ensure that it has sufficient water for all stages of the project, and if necessary, adjust the scale of mining operations to match its water supply. *Note: The Proponent is required to obtain the necessary water licences for the project under the Water Act 1912 and/or Water Management Act 2000.*	Section 11
Sched 3 Cond 23(a)	A Site Water Balance which must include details of: • Sources and Security of water supply; • Water use of site; • Water management on site; and	Section 11

Reference	Requirement	Relevant Section within this Plan
	• Any off-site water transfers. Investigate and implement all reasonable and feasible measures to minimise water used by the project	
Sched 3 Cond 23(b)	An Erosion and Sediment Control Plan, which must: • Identify activities that could cause soil erosion, generate sediment or affect flooding; • Describe measures to minimise soil erosion and the potential for transport of sediment to downstream water, and manage flood risks; • Describe the location, function and capacity of erosion and sediment control structures and flood management structures; and • Describe what measures would be implemented to maintain the structures over time.	Section 8 Sections 7, 8, 9 Sections 7, 8, 9 Sections 8 and 14.2
Sched 3 Cond (c)	A Surface Water Management Plan, which must include; • Detailed baseline data on surface water flows and quality in creeks and other waterbodies that could potentially be affected by the project; • Surface water and stream health impact assessment criteria including trigger levels for investigating any potentially adverse surface water impacts. • Program to monitor and assess: o Surface water flows and quality o Impacts on water users o Stream health; and o Channel Stability	Section 13 There are no surface rivers, streams or creeks on site.
Sched 3 Cond (d)	A Groundwater Monitoring Program, which must: • Provide a program to monitor seepage movement within and adjacent to the tailings storage facility; • Include details of parameters and pollutants to be monitored for: o Water from mine dewatering o Groundwater locations to the east of TSF1 o Surface water represented by Horwood Dam o Water captured by the toe drains of the tailings storage facility. o Water seepage from the tailings storage facility; and o The background local groundwater system • Outline performance parameters against monitoring data will be compared to determine whether seepage is occurring, and whether an unacceptable impact on local groundwater may be occurring; and • Include details of contingency measures to be implemented in the event that an unacceptable impact is identified	Section 12
Sch4, 1	**Environmental Management Strategy** The Proponent shall prepare and implement an Environmental Management Strategy for the project to the satisfaction of the Director-General. This strategy must: (a) be submitted to the Director-General for approval by the end of June 2011; (b) provide the strategic framework for the environmental management of the project; (c) identify the statutory approvals that apply to the project;	See Environmental Management Strategy

Reference	Requirement	Relevant Section within this Plan
	(d) describe the role, responsibility, authority and accountability of all key personnel involved in the environmental management of the project; (e) describe the procedures that would be implemented to: • keep the local community and relevant agencies informed about the operation and environmental performance of the project; • receive, handle, respond to, and record complaints; • resolve any disputes that may arise during the course of the project; • respond to any non-compliance; and • respond to emergencies; and (f) include: • copies of any strategies, plans and programs approved under the conditions of this approval; and • a clear plan depicting all the monitoring required to be carried out under the conditions of this approval. Management Plan Requirements The Proponent shall ensure that the management plans required under this approval are prepared in accordance with relevant guidelines, and include: (a) detailed baseline data; (b) a description of: • the relevant statutory requirements (including any relevant approval, licence or lease conditions); • any relevant limits or performance measures/criteria; and • the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the project or any management measures; (c) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria; (d) a program to monitor and report on the: • impacts and environmental performance of the project; and • effectiveness of any management measures (see (c) above); (e) a contingency plan to manage any unpredicted impacts and their consequences; (f) a program to investigate and implement ways to improve the environmental performance of the project over time; (g) a protocol for managing and reporting any: • incidents; • complaints; • non-compliances with the conditions of this approval and statutory requirements; and • exceedances of the impact assessment criteria and/or performance criteria; and (h) a protocol for periodic review of the plan. Note: The Secretary may waive some of these requirements if they are	

Reference	Requirement	Relevant Section within this Plan
	unnecessary or unwarranted for particular management plans.	
Sch4, 2	Management Plan Requirements The Proponent shall ensure that the management plans required under this approval are prepared in accordance with relevant guidelines, and include: (a) detailed baseline data; (b) a description of: • the relevant statutory requirements (including any relevant approval, licence or lease conditions); • any relevant limits or performance measures/criteria; and • the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the project or any management measures; (c) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria; (d) a program to monitor and report on the: • impacts and environmental performance of the project; and • effectiveness of any management measures (see (c) above); (e) a contingency plan to manage any unpredicted impacts and their consequences; (f) a program to investigate and implement ways to improve the environmental performance of the project over time; (g) a protocol for managing and reporting any: • incidents; • complaints; • non-compliances with the conditions of this approval and statutory requirements; and • exceedances of the impact assessment criteria and/or performance criteria; and (h) a protocol for periodic review of the plan. Note: The Secretary may waive some of these requirements if they are unnecessary or unwarranted for particular management plans.	Section 7.2 Section 2 Section 2, Sections 7, 8, 9 Sections 5, 7, 8, 9, 10, 11 Section 11 Sections 7.3, 8.4, 10 Section 11 Sections 11 Section 11.3
Sch4, 3	**Annual Review** By the end of June 2012, and annually thereafter, the Proponent shall review the environmental performance of the project to the satisfaction of	Section 11.2

Reference	Requirement	Relevant Section within this Plan
	the Secretary. This review must: (a) describe the development (including any rehabilitation) that was carried out in the past year, and the development that is proposed to be carried out over the next year; (b) include a comprehensive review of the monitoring results and complaints records of the project over the past year, which includes a comparison of these results against the: • relevant statutory requirements, limits or performance measures/criteria; • monitoring results of previous years; and • relevant predictions in the documents referred to in Conditions 2 of Schedule 2; (c) identify any non-compliance over the past year, and describe what actions were (or are being) taken to ensure compliance; (d) identify any trends in the monitoring data over the life of the project; (e) identify any discrepancies between the predicted and actual impacts of the project, and analyse the potential cause of any significant discrepancies; and describe what measure will be implemented over the next year to improve the environmental performance of the project.	
Sch4, 4	**Review of Strategies, Plans and Programs** Within three months of: (a) the submission of an annual review under Condition 3 above; (b) the submission of an incident report under Condition 5 below; (c) the submission of an audit report under Condition 7 below, or (d) any modification of the conditions of this approval (unless the conditions require otherwise), the Proponent shall review, and if necessary revise, the strategies, plans, and programs required under this approval to the satisfaction of the Secretary. *Note: This is to ensure the strategies, plans and programs are updated on a regular basis, and incorporate any recommended measures to improve the environmental performance of the project.*	Section 11.3
Sch4, 5	**Incident Reporting** The Department must be notified in writing to compliance@planning.nsw.gov.au immediately after the Proponent becomes aware of an incident. The notification must identify the project (including the application number and the name of the project if it has one), and set out the location and nature of the incident.	Section 11.1

Reference	Requirement	Relevant Section within this Plan
Sch4, 5A	**Non-compliance Notification** The Department must be notified in writing to compliance@planning.nsw.gov.au within 7 days after the Proponent becomes aware of any non-compliance with the conditions of this approval. The notification must identify the project and the application number for it, set out the condition of approval that the project is noncompliant with, the way in which it does not comply and the reasons for the non-compliance (if known) and what actions have been done, or will be, undertaken to address the non-compliance.	Section 11.1
Sch4, 6	**Regular Reporting** The Proponent shall provide regular reporting on the environmental performance of the project on its website, in accordance with the reporting arrangements in any approved plans or programs of the conditions of this approval.	Section 11.2
Sch4, 7	**Independent Environmental Audit** By the end of December 2011, and every three years thereafter, unless the Secretary directs otherwise, the Proponent shall commission and pay the full cost of an Independent Environmental Audit of the project. This audit must: (a) be conducted by suitably qualified, experienced and independent team of experts whose appointment has been endorsed by the Secretary; (b) include consultation with the relevant agencies; (c) assess the environmental performance of the project and whether it is complying with the relevant requirements in this approval and any relevant EPL or Mining Lease (including any assessment, plan or program required under these approvals); (d) review the adequacy of any approved strategies, plans or programs required under these approvals; and, if appropriate (e) recommend measures or actions to improve the environmental performance of the project, and/or any strategy, plan or program required under these approvals. *Note: This audit team must be led by a suitably qualified auditor and include experts in any fields specified by the Secretary.*	Section 11.3
Sch4, 8	**Independent Environmental Audit** Within six weeks of the completing of this audit, or as otherwise agreed by the Secretary, the Proponent shall submit a copy of the audit report to the Secretary, together with its response to any recommendations contained in the audit report.	Section 11.3
BHOP Statement of Commitments		
EA	BHOP is committed to the following water conservation measures: • Treatment of mine dewatering to enable usage in the processing plant;	Section 5 and 8

Reference	Requirement	Relevant Section within this Plan
	• Tailings water to be returned to the processing plant for reuse; • Water to be recycled from Horwood Dam to the processing plant; • The silver tank is a raw water holding tank for water to be used in the processing plant, reducing the potential for evaporation from open type storages; • Investigate the use of grey water from domestic facilities for use in ground management; and • Installation of flow metres to monitor water usage.	
EA	Measures to manage water quality that will be included in BHOP's water management program include: • Provision and location of spill kits and requirements for training; • Design and installation of chemical storage to include bunds with suitable sumps, and where appropriate roofed to prevent stormwater entry; • Bunding of the diesel refuelling station; • Oil / water separators to be installed at vehicle wash facilities and the diesel refuelling station; • Management of sediment and sludge from vehicle washing facilities; • Water quality monitoring including groundwater (represented by mine dewatering) and at locations to the east of TSF1, and surface water represented by Horwood Dam; • Monitor the quality and quantity of water captured by the toe drains on the Tailings Storage Facility (TSF); and • Monitor the movement of seepage sourced from the TSF and to monitor the quality of the local groundwater system.	Section 5
EA	In addition the recommendations from the Stormwater Management Plan as proposed by Golder Associates (Golder 2010, Annexure J) will be implemented and will address potential impacts from new Project activities prior to the commencement of those activities. This Plan includes: • Erosion and sediment control measures; • Design requirements for on-site retention evaporation basins; • Requirements for management of catchment areas, including drains, pipework, bunding and sumps; and • Quarterly inspections of the site storm water management structures to confirm that they are operational.	Section 9
EA	A Groundwater Management Plan will be prepared to provide details of the monitoring of seepage movement within and adjacent to the TSF.	Section 5.3, 7.1
EA	If sufficient water is not available, the scale of their operations will be adjusted to match the licensed water entitlements.	Section 11
EA	Finally, all necessary licences under the *Water Act 1912* will be obtained prior to the commencement of activities on site.	Section 1.2
MOD1	Divide Catchment 25 into two catchments, 25A and 25B with two smaller storm water storage basins, S25A which diverts water away from the vent shaft and flows into S25B.	Section 3.2
MOD4	The following mitigation measures will be implemented for water seepage: • Incorporate TSF2 seepage controls recommended by Golder and as required by the DSC.	Section 7.1

Reference	Requirement	Relevant Section within this Plan
	• Line each embankment of the TSF with a geomembrane liner. • Collect seepage in a filter sand layer on the upstream slope of each embankment of the TSF extension where collection drains will be installed. • Periodically monitor seepage at the TSF extension via inspection chambers installed on the drainage pipes.	
MOD4	The following mitigation measures will be implemented for stormwater: • Review and update the BHOP Site Water Management Plan to address stormwater management at the CBP and TSF2 embankments to collect and retain a 1:100 year, 72 hour rainfall event. • Construct a spillway at TSF2 to meet the NSW DSC requirements.	Section 5.3
Environment Protection Licence 12559		
Section 3 L1.1	Except as may be expressly provided in any other condition of this licence, the licensee must comply with section 120 of the Protection of the Environment Operations Act 1997.	Section 1.3
Section 3 L8.1	All storm water and other surface water holding ponds identified in the Site Water Management Plan must be designed, constructed and maintained to accommodate the stormwater runoff generated in a 100 year (24 hour) Average Recurrence Interval rain event.	Sections 6, 7, 8, and 9
Section 3 L8.2	The water storage ponds listed below must have the base and wall artificially lined with an impermeable high density polyethylene liner: 1) "Mine Settlement Ponds" and "Backfill Plant Sediment Pond" identified in Figure 3 of the Rasp Mine Site Water Management Plan. 2) "Plant Event Pond" and the "Overflow Event Pond" identified in Figure 4 of the Rasp Mine Site Water Management Plan.	Sections 2.1, 2.2, 12.1.7, and 9
Section 4 O4.1	All surface water storage ponds must be maintained to ensure that sedimentation does not reduce their capacity by more than 10% of the design capacity.	Section 8
Section 5 M1.1	The results of any monitoring required to be conducted by this licence or a load calculation protocol must be recorded and retained as set out in this condition.	Sections 11, 12, 13, and 15
Section 5 M1.2	All records required to be kept by this licence must be: a) in a legible form, or in a form that can readily be reduced to a legible form; b) kept for at least 4 years after the monitoring or event to which they relate took place; and c) produced in a legible form to any authorised officer of the EPA who asks to see them.	Section 15
Section 5 M1.3	The following records must be kept in respect of any samples required to be collected for the purposes of this licence: a) the date(s) on which the sample was taken; b) the time(s) at which the sample was collected; c) the point at which the sample was taken; and d) the name of the person who collected the sample.	Sections 12, 13, and 15

Reference	Requirement	Relevant Section within this Plan
Section 5 M2.1	For each monitoring/discharge point or utilisation area specified below (by a point number), the licensee must monitor (by sampling and obtaining results by analysis) the concentration of each pollutant specified in Column 1. The licensee must use the sampling method, units of measure, and sample at the frequency specified.	Table 7.1
Section 5 M2.2	Lists the water monitoring requirements for nominated locations and includes – pollutant, unit of measure, frequency and sampling method. Surface Waters points 29, 31, 32, 33, 34 Receiving waters points 35 and 36 Ground waters points 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52 Water from shaft 7 and mining extraction points 53 and 54	Table 7.1, 8.1, 8.2
Section 5 M5.1	The licensee must keep a legible record of all complaints made to the licensee or any employee or agent of the licensee in relation to pollution arising from any activity to which this licence applies.	Sections 12, 13 and 15
Section 5 M5.2	The record must include details of the following: a) the date and time of the complaint; b) the method by which the complaint was made; c) any personal details of the complainant which were provided by the complainant or, if no such details were provided, a note to that effect; d) the nature of the complaint; e) the action taken by the licensee in relation to the complaint, including any follow-up contact with the complainant; and f) if no action was taken by the licensee, the reasons why no action was taken.	Section 15
Section 5 M5.3	The record of a complaint must be kept for at least 4 years after the complaint was made.	Section 15
Section 5 M5.4	The record must be produced to any authorised officer of the EPA who asks to see them.	Section 15
Section 6 R1	Details requirements for reporting water monitoring results in the Annual Return to the EPA.	Section 15
Section 6 R2	Details requirements for notifying of environmental harm to the EPA.	Section 11.1.2
Section 6 R3	Details requirements for written reports that can be requested by the EPA.	Section 11.1.2

3. Site Description

The Mine is located centrally within the City of Broken Hill and is surrounded by transport infrastructure, areas of commercial and industrial development and some residential housing. The Mine is bounded by Eyre Street and Holten Drive to the south and east, Perilya's Broken Hill North Mine to the east and its South Mine to the west, and the commercial centre of Broken Hill to the north. The Mine site is dissected by two major State roads, South Road (Silver City Highway SH22) to the southwest and Menindee Road (MR66) to the northeast. The Broken Hill railway station is located directly to the north of the Mine and lies on the main Sydney – Perth railway line. Residential and commercial areas surround the Mine with pasture land to the southeast.

3.1 Site Facilities

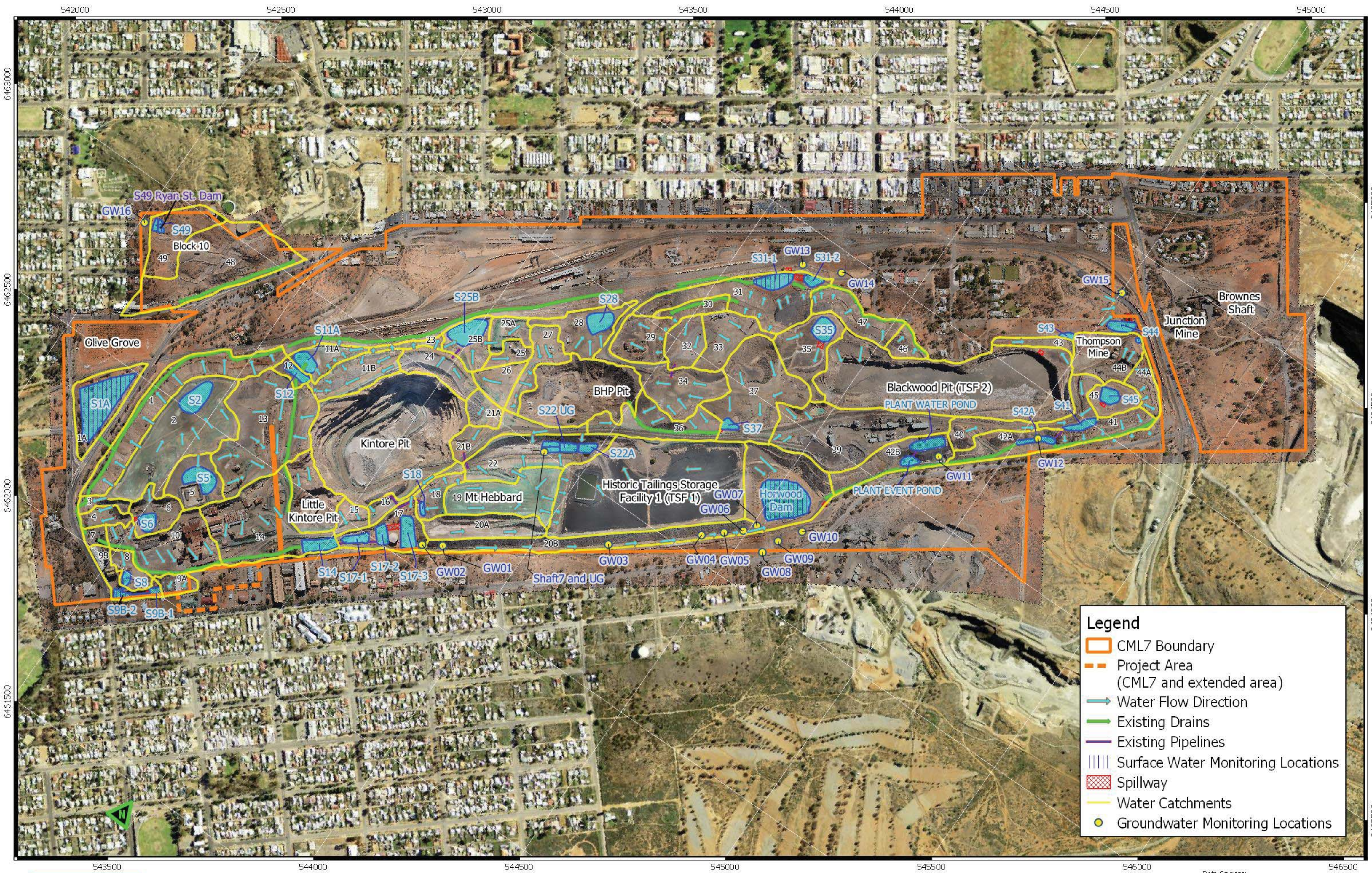
The Mine consists of the following site facilities:

- Open Pit and Waste Rock Dumps;
- Workshops;
- Processing Plant;
- Services – Primary Ventilation, Concrete Batching Plant, Backfill Plant and Sub-Stations;
- TSF1 historic tailing storage;
- TSF2 current tailing deposition;
- Sealed and unsealed roads; and
- Free Areas (non-active mining areas).

3.2 Site Catchment Areas and Water Storage Locations

The site has been subdivided into 60 catchment areas, with 39 storage locations. Figure 1 outlines catchment boundaries within the Mine as well as water flow direction and water storage locations.

Figure 1 - Site Water Management Plan



0 100 200 300 400 500 m

Scale 1:12000 Datum: MGA Zone 54

TITLE: Site Water Management Plan

Data Sources:
Aerial 25/04/2016 MGA54 10cm provide by BHOP
DCDB supplied by NSW Department of Lands
Rasp Mine Features - BOP.
NSW Six Map Best Imagery © Department Finance, Services & Innovation 6/03/2018

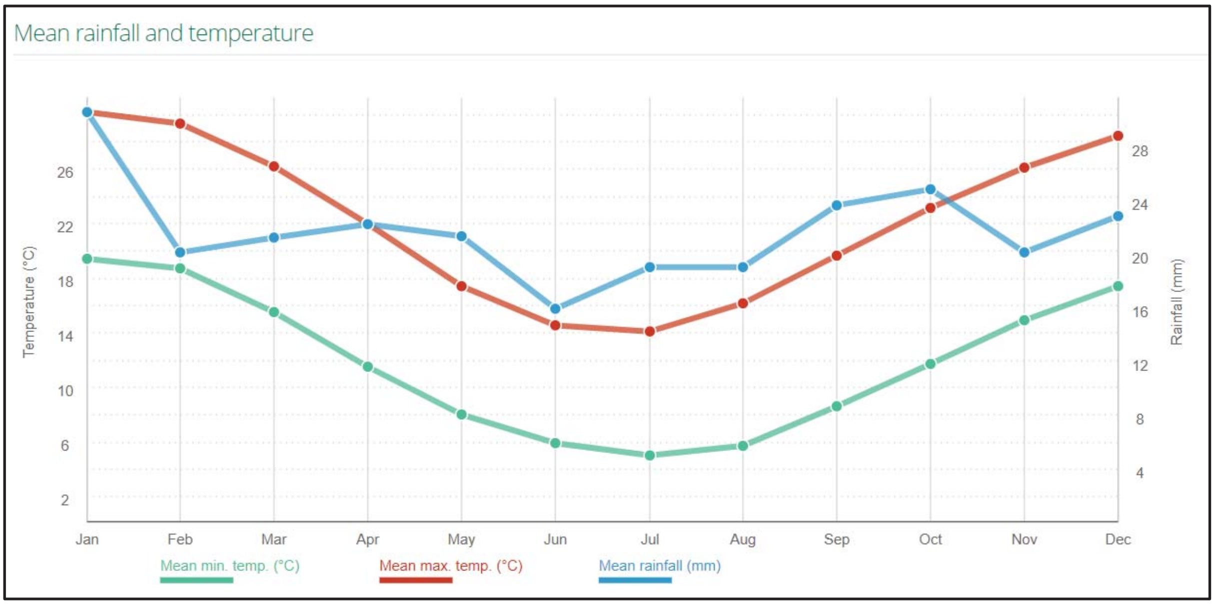
File Reference: JMC-003-008 V7
Date: 10/12/2018

3.3 Surface Hydrology

3.3.1 Rainfall and Temperature

The local climate is arid with an average annual rainfall of approximately 250 mm. A review of the Bureau of Meteorology (BOM) data for the last 120 years indicates limited seasonal variation in average rainfall depths, with mean monthly rainfall varying within a narrow band from approximately 17 mm to 24 mm during the year. The monthly mean temperature varies from 33°C in January to 15°C in July. **Figure 2** shows the monthly variations of rainfall and temperature.

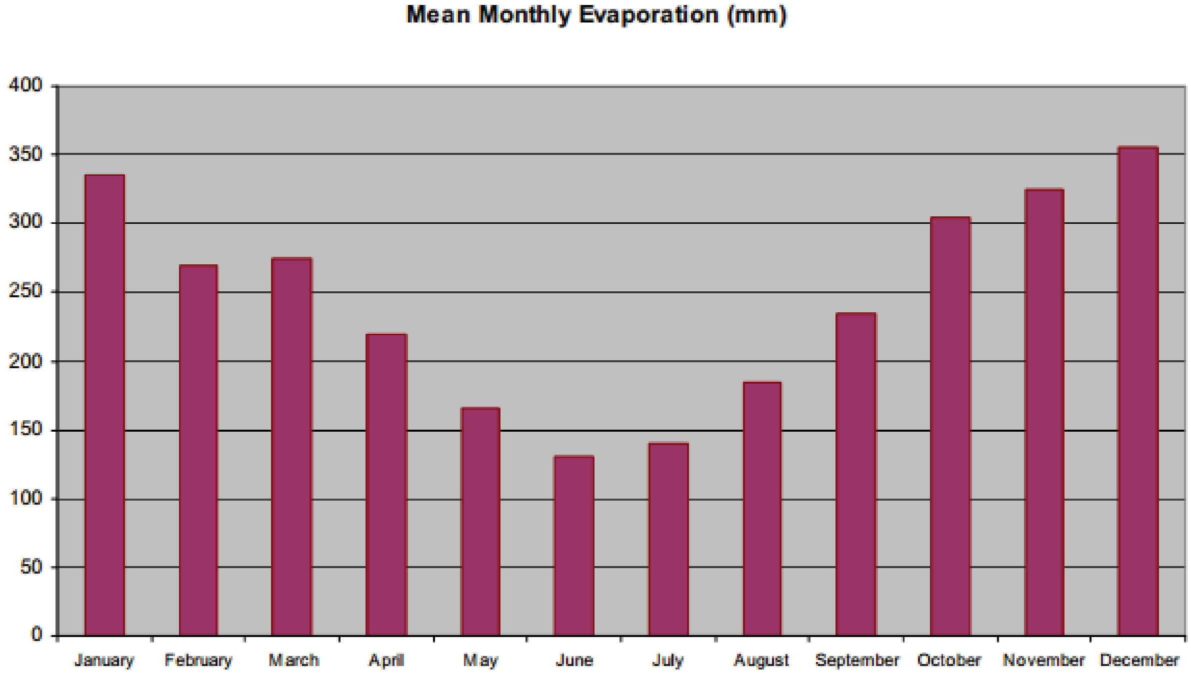
Figure 2 Average Temperature and Rainfall Summary



3.3.2 Evaporation

The average annual evaporation is approximately 2,614 mm. This estimate has been derived from the BOM grid data for the entire Australian Continent. The evaporation rate varies from approximately 12 mm/day in December to 4mm/day in June. The monthly variations for evaporation are presented in **Figure 3**.

Figure 3 Average Monthly Evaporation



Evaporation far exceeds the rainfall in the Broken Hill area, with mean monthly evaporation more than 15 times the mean monthly rainfall in January and approximately 5 times more in July.

3.3.3 Rainfall data

Rainfall data were sourced from BOM and is displayed is **Table 3**.

Table 3 - Design Rainfall Data

DURATION	Rainfall (mm)			
	10 years ARI	20 Years ARI	50 years ARI	100 Years ARI
30 minutes	23.7	28.3	34.5	39.3
1 hour	30.9	36.8	44.9	51
2 hours	38.2	45.6	55.8	64
3 hours	42.6	51	62	71
6 hours	51	61	75	86
12 hours	61	73	90	104
24 hours	73	87	108	124
48 hours	83	101	124	142
72 hours	87	105	130	149

3.3.4 Rainfall Excess Estimation

The surface water storage and drainage of the Mine is designed to manage runoff volumes generated from a 100 year ARI rainfall event. Before runoff can occur, a portion of rainfall is lost to initial absorption by the materials to bring them to field moisture capacity. This loss is termed initial loss which is approximately 15 mm, while a continuing loss due to infiltration is estimated to be 4 mm per hour (Golders 2012). The adopted loss rates were used in conjunction with the design rainfall to derive the rainfall excess or the volume of runoff from each catchment. The estimated rainfall excess for the 100 year event is presented in **Table 4**.

Table 4 - Estimated Rainfall Excess for 100 Year ARI Rain Event

Duration	Rainfall Excess (mm)
30 minutes	28.3
1 hour	39.2
2 hours	49.6
3 hours	55.4
6 hours	64
12 hours	70
24 hours	**73**
48 hours	62
72 hours	55

The critical duration for the 100 year ARI event is the one that corresponds to the largest rainfall excess and hence the volume of runoff. For the 100 year event, the critical rainfall excess occurs for the 24 hour event and is equal to 73 mm, **Table 4**.

3.3.5 Drainage Layout

The drainage layout for the Rasp Mine site is based on the rainfall data and excess rainfall outlined in Sections 3.3.3 and 3.3.4.

Based on the runoff management criteria, the Mine site is subdivided into 64 small catchments and sub-catchments with various engineered water diversions to retain the 1:100 year rainfall event. The catchment runoff volumes and catchment areas are presented in the **Tables 5 and 6**.

4. Water Catchments and Storage

4.1 Water Catchments and Storage

The Mine site has been divided into water catchments which are detailed in **Table 5** and **Figure 1.** **Table 6** provides details of the 64 catchment areas in regards to runoff management and details which catchment areas report to which individual storage area. Individual catchment calculations were provided by Golders Associates in the original SWMP (2011).

Table 5 - Catchment Details

Catchment Number	Area (ha)	Runoff Volume (100 year event) (m^3)	Catchment Number	Area (ha)	Runoff Volume (100 year event) (m^3)
1	5.099	3,739	**26**	1.669	1,224
1A	4.223	3,097	**27**	1.062	779
2	6.822	5,003	**28**	2.414	1,771
3	0.528	387	**29**	2.083	1,526
4	0.726	533	**30**	0.852	625
5	2.065	1,514	**31**	5.426	3,980
6	1.504	1,103	**32**	1.507	1,105
7	0.842	618	**33**	2.155	1,580
8	0.863	633	**34**	2.937	2,154
9A	0.602	441	**35**	6.152	4,512
9B	0.598	439	**36**	3.002	2,202
10	3.513	2,576	**37**	2.571	1,886
11A	1.355	994	**39**	3.430	2,515
11B	2.298	1,685	**39A**	1.732	1,270
12	0.485	355	**40**	1.345	986
13A	6.658	4,883	**41**	1.241	910
13B	0.652	478	**42A**	3.760	2,758
14	6.299	4,620	**42B**	2.823	2,070
15	0.769	564	**43**	0.45	383
16	0.773	567	**44A**	1.695	1,243
17	2.353	1,725	**44B**	2.606	1,911
18	1.102	808	**45**	1.215	891
19	3.817	2,799	**46**	1.065	781
20A	2.394	1,756	**47**	2.181	1,600
20B	1.513	1,110	**48**	6.881	5,047
21A	1.396	1,024	**49**	2.660	1,951
21B	1.931	1,416	**Horwood Dam**	5.152	3,779
22	4.188	3,071	**Kintore Pit**	13.376	9,810
23	0.392	287	**Little Kintore Pit**	2.623	1,924
24	1.566	1,148	**BHP Pit**	5.984	4,388
25A	1.238	908	**TSF 1**	14.050	10,304
25B	2.164	1,609	**Blackwood Pit**	13.135	9,633

The storage requirements for these water catchments are outlined in **Table 6**.

Table 6 - Water Storage Requirements

Storage	Reporting Catchments	Runoff Volume for Storage (m^3)	Surface Area of Storage (m^2)	Maximum depth of storage (m)[1]	Lined or unlined	Spillway	Comments
C1 West Drain	1	3,739	N/A	N/A	Unlined	No	The West Drain acts as an attenuation drain for the 100 year ARI rainfall event. Overflows from the West Drain for events greater than 100 year ARI event are directed through an existing box culvert S1A.
S1A	1A, 3, 4	4,017	16,300	0.56	Unlined	Yes	Catchment forms storage. Direct runoff from C3 and C4 report to the existing box culvert crossing under the road before discharging into S1A. Overflows from C1 for events > the 100 year ARI event also report through the box culvert under south road to S1A. Underground water storage tanks south of C7, pump sump water into the existing drain in C4 where flow is diverted into S1A. Storage S1A has the capacity to retain the 500 year ARI storm event.
S2	2	5,003	5,320	1.24	Unlined	Yes	Existing storage S2 retains the 100 year ARI storm event with overflows discharging to the drainage channel, via a spillway located in C13A.
S5	5	1,514	2,380	0.94	Unlined	Yes	Overflow path to catchment 13B drainage channel.
S6	6	1,103	2,195	0.80	Unlined	Yes	Storage to retain 100 year ARI storm event, overflowing to S1A through C4.
S8	8	633	815	1.08	Unlined	Yes	S8 does not have the capacity for a 100 year ARI storm event, and overflows to S9B-2.
S9B-1 and S9B-2	9A and 9B	880	1,700	0.82	Unlined	Yes	Retains a 1:100 storm event then overflows to street system.
S11A	11A	994	3,460	0.59	Unlined	Yes	Existing pond, overflows report to S12.
S11B	11B	1,685	3,500	0.78	Unlined	Yes	Existing pond, capacity large enough for a 100 year ARI storm, with overflows diverted into S12 and eventually Horwood Dam.
S12	12	355	1,800	0.50	Unlined	Yes	Existing pond. Overflow reports to drainage channel located in C13A and eventually into Horwood Dam.
S14	7, 10, 13 and 14	13,174	3,467	2.25	Unlined	Yes	S14 receives direct runoff from C7, C10, C13 and C14. Overflow for events greater than a 100 year ARI storm report to C17.
S17-1, S17-2 and S17-3	15, 16, 17 and part of 18 and 20B	4,265	7,425	0.87	Unlined	Yes	Three existing storage areas located either side of the existing tank. Storage areas S17-1 and S17-2 are connected by existing pipes with overflow to be pumped to Horwood Dam.
S18	Part of C18	389	397	1.28	Unlined	Yes	Existing pond receives partial runoff from C18. This pond will capture part of a 100 year ARI storm event, overflows report to S17-3.
Plant Water Pond and Plant Event Pond	39, 39A	3,785	2,150	2.06	Lined	Yes	Receives runoff from Process Plant site and decant water pumped from Blackwood Pit. Water is reused in the Plant and augmented by water from the lined mine water ponds at Mt Hebbard Gully (S22). Overflows from the Plant Water Pond discharge to the Plant Event Pond located in C42B, any overflows are directed to Horwood Dam.
S22	18 (partial), 19, 20A, 21A, 21B, 22 and TSF1	20,489	5,606	3.95	Lined, Mine water compartments only	No	Existing storage area. In addition to providing storage for a 100 year ARI storm event from catchments 18, 19, 20A, 21A, 21B, 22 and TSF1, S22 is used for the storage and settling of water from the operating underground mine workings, and groundwater from Shaft 7. Mine dewatering occupy 2 storage areas within S22. No over flow path is required as the capacity of the gully is in excess of 40,000 m^3.
S22A	Direct	Direct Rainfall	18,000	4.00	Lined	No	Receives excess direct from Shaft 7 water when S22 Lochness is full. A pipe is installed to

Storage	Reporting Catchments	Runoff Volume for Storage (m^3)	Surface Area of Storage (m^2)	Maximum depth of storage (m)[1]	Lined or unlined	Spillway	Comments
	rainfall						provide gravity flow back into S22 when required.
North-Western Drain	23	287	N/A	N/A	Unlined	Outlet	Existing storage channel located within exclusion and rehabilitation zone will receive runoff from the embankment located in C23. BHOP are not responsible for controlling drainage works outside of the exclusion and rehabilitation zones.
S25B	24, 25, 25A, 25B, 26	4,889	2,405	1.45	Unlined	No	Storage volume is sized to contain the 100 year ARI storm, with overflows spread over the floor of C25B.
S28	27, 28, 29, and partial 34	4,613	3,895	1.48	Unlined	Yes	S28 to receive runoff from C28, C29 and part of C34. Overflow will flow onto the existing road and into the existing railway drainage system off site.
S31-1 and S31-2	30, 31, 46, 47	6,761	5,330	2.01	Unlined	Yes	Capacity for a 100 year ARI storm. Overflows from S31-1 to S31-2. Pond includes flow from Federation Way. S31-2 overflows to railway drain.
S35	33, 35	6,092	4,255	1.73	Unlined	Yes	Runoff from C33 flows through existing pipes prior to entering C35. Overflows from S35, for events greater than a 100 year storm, ARI report to Blackwood Pit.
S37	Partial 37	943	1,215	1.08	Unlined	Yes	Receives runoff from approximately half of C37. Overflows to drainage channel in C36 and into BHP Pit. The remaining discharge from C37 flows through to S41.
S41	37 (partial), 38, 38A, 40, 41	3,994	1,980	2.32	Unlined	Yes	None
S42A	42A	2,758	2,565	1.38	Unlined	Yes	Runoff from C42A captured in an existing drainage channel and into S42A. Overflows from S42 report to Horwood dam.
S43	43	383	450	0.5	Unlined	Yes	Receives direct runoff from C43. Designed for 1 in 100yr rainfall event.
S44	44A, 44B	3,154	2,135	1.78	Unlined	Yes	None
Sediment Pond in C44B.	Rail siding area	N/A	N/A	N/A	Unlined		None
S45	45	891	2,170	0.71	Unlined	Yes	None
Drainage Channel in C48	48	5,047	N/A	N/A	Unlined	N/A	None
S49	49	1,951	1,560	1.55	Unlined	Yes	Catchment 49 is a rehabilitated area within CML7. Runoff from this catchment is captured in three small detention ponds within S49.
Little Kintore Pit	Little Kintore Pit	1,924	N/A	N/A	Unlined	No	Only direct rainfall onto catchment reports to Little Kintore Pit.
Kintore Pit	Kintore Pit	9,810	N/A	N/A	Unlined	No	Estimation of direct rainfall volume on Kintore Pit for the 100 year storm event.
BHP Pit	32, Partial 34 and 36, BHP Pit	9,312	N/A	N/A	Unlined	No	Receives runoff from catchments without storage areas and overflows from S37.
Blackwood Pit	Blackwood	9,633	N/A	N/A	Unlined	No	Blackwood Pit receives overflows from S35 when in excess of a 1 in 100 year ARI.

Storage	**Reporting Catchments**	**Runoff Volume for Storage (m^3)**	**Surface Area of Storage (m^2)**	**Maximum depth of storage (m)[1]**	**Lined or unlined**	**Spillway**	**Comments**
Horwood Dam	42B, 20C, Horwood Dam	7,663	24,729 m^3	N/A	Unlined	Yes	Catchments 20C and 42B report directly to Horwood Dam, with overflows from S14, S17-1, S17-2, S17-3, S41, S42A, S45 also reporting to Horwood Dam. Storage can retain 100 year ARI storm event. However, a spillway is required to provide controlled discharge during extreme storm events (i.e. in excess of a 100 year ARI storm).
Pattos Pond	Direct rainfall	Direct rainfall	1,500	0.5	Lined		Receives water from S22.
Sump at CBP	Direct rainfall	Direct rainfall	2.5	0.5	Unlined		Receives water from batching plant.
Sump at Backfill Plant	Direct rainfall	Direct rainfall	2.5	0.5	Lined		Receives water from backfill plant.

Note 1 = Includes 0.3 m freeboard.

4.2 Peak Flow Estimation

The rational method was applied in estimating the peak flow rates from selected catchment areas that outfall through proposed hydraulic structures, such as culverts and pipes, or into proposed drainage channels. The estimated peak flow may be applied in the preliminary sizing of culverts or in selecting geometric dimensions of drainage channels. The peak flow accounts for flow from basins overflowing into other basins up to a 100 year ARI rainfall event. The construction and shaping of the drainage channels and culverts will include a freeboard of 300 mm above the estimated water level for the 100 year ARI event.

The Rational Method formula applied in the estimation of peak flow is:

Qy = 0.278 CIA (Engineers Australia 1998)

Where:

Qy = Peak flow rate (m^3/s)

C = Runoff Coefficient

I = Average rainfall intensity (mm/hr)

A = Area of the catchment (km^2)

The average rainfall intensity for the time of concentration (Tc) and a 100 year ARI storm was estimated based on BOM design rainfall intensity chart for Rasp Mine area and the Bransby-Williams formula for time of concentration (Engineers Australia 1987). The peak flow rates entering drainage channels and hydraulic structures were estimated by Golder Associates.

5. Site Water Sources

The system for managing water at the Mine is specific to the types of water on the site and are summarised in the following sections.

Broken Hill's water supply comes from the Stephens Creek Reservoir, Umberumeka Reservoir, Imperial Lake and the Menindee Lakes Scheme on the Darling River. Water extracted from underground and Shaft 7 is also used on the Mine site.

The Mine also uses reclaimed water from various sources wherever possible, for example, Horwood Dam, Plant Water Pond, Patto's Pond and any other water storage areas that have sufficient water for pumping.

5.1 Potable and Waste Water

Potable water is supplied by Essential Water from Menindee Lakes. This water is treated raw water. Potable water is stored in a 22.5kL poly tank located near the Mine site boom gate. Potable water is pumped to the Processing Plant, Backfill Plant, workshops, ablution blocks and administration offices. Potable water is used for safety showers and eye-washers, crib huts, ablution blocks, laundry and other washing facilities. It is stored in poly tanks at various locations.

Bottled water is used as drinking water.

Waste water is not treated on site and is removed via the Broken Hill City Council sewerage system.

5.2 Raw Water

Raw water is externally supplied to the Mine from Essential Water and comes from Menindee Lakes. It is used for top up water in the Processing Plant. The main storage tanks for raw water are the Silver Water Tank and the Mill Raw Water Tank.

5.3 Dirty Water

Dirty water from Mine activities typically consists of surface runoff generated within active mining areas of the site including diesel refuelling area (including wash bay), site vehicle wash bay, maintenance workshop area, processing area, backfill plant, concrete batching plant, haul road and general roads and core storage.

Dirty water from these activities is directed to a series of dirty water ponds, open cut pits, and tailings storage facilities, to allow for evaporation, treatment or reuse on the site.

Runoff from the diesel refuelling area and maintenance workshops is directed to an oil/water separator for treatment and reused for site dust suppression. Localised hydrocarbon spills will be contained and controlled using spill kits provided at various locations around the site. Chemical and hydrocarbon storage and management on site is outlined in the Chemical Management Plan.

Runoff from the Processing Plant area is directed to the lined Process Plant Pond where it is collected for reuse in the Processing Plant, this in turn overflows to the Process Event Pond, which will contain a 1:100 year rainfall event and overflows are directed into Horwood Dam.

Blackwood Pit (TSF2) retains the tailings from the Processing Plant, and supernatant water, when available is transferred to the Process Event Pond and reused in the Plant.

The Backfill Plant is located to the south west of the site in C27. This catchment includes a lined Backfill Plant sediment pond, isolating any potentially contaminated runoff in this area from the general runoff of the site.

A sump collects waste water runoff from the Concrete Batching Plant.

All stormwater is treated as contaminated once it enters the Mine and makes contact with the disturbed surface. A series of sediment / water storage basins across the site is used to collect and manage stormwater runoff and prevent its release. Overflow from dirty water storage basins can be directed to Horwoods Dam where it will be stored temporarily until transferred to process ponds.

TSF2 Embankment Lift

With the lift of the TSF2 embankments a spillway will be installed on the north-eastern corner of TSF2 and direct overflow from TSF2 to storage pond S42A which will overflow to Horwood Dam.

The existing tension cracks at the edge of the Pit at Embankment 1 will be filled with tailings prior to construction of this Embankment. This will occur at the same time as repair works around the existing edge bund located at the Pit rim to the south of British Flats and the old mining residence. Drainage pipes with inspection chambers will also be installed. These minor works will involve the use of a small excavator and roller with manual labour for the placement of the pipes and fill.

Embankments 1 and 3 will be constructed over some tailings as well as weathered bedrock and will require deposition of tailings within the embankment footprint to form a well-drained foundation for the embankments to be confirmed by inspection and assessment of geotechnical condition, and may require the construction of a pioneering layer comprising compacted rockfill over a geotextile. Geomembrane liners will be constructed over the upstream faces over a sand filter curtain. The geomembrane liner will be keyed into the tailing beach.

A Stormwater Collection Pond will be constructed to the north of Embankment 2 to store rainwater from runoff from the outer slope of Embankment 2. The Stormwater Collection Pond will be excavated into in situ materials to form a 1.5 m deep pond for the collection and retention of rainwater runoff from Embankment 2. It is intended to be an evaporation pond similar to some of the other stormwater control ponds at the Mine and will contain a 1 in 100 year 72 hour rainfall event.

5.4 Shaft 7 and Mine Water

Water is extracted from underground via pumps at Shaft 7 and underground mine workings to maintain safety of personnel in the Rasp Mine and also the adjacent Perilya South Mine. This groundwater has been contaminated by the naturally elevated metals consistent with a zinc/lead/silver orebody and by historic mining activities. Water is extracted and stored within lined facilities located within water storage basin S22. S22 has a total storage capacity of approximately 40,000 m^3 and receives runoff from the surrounding catchments and water pumped from the S17 ponds. Lined compartments have been installed within this area for the separate storage and settling of underground extracted water. This water is returned underground for reuse and is treated (in Patto's Pond) and used in the Processing Plant.

5.5 Eyre Street Dam

TSF1 is an historic tailing storage facility and is not used as a tailing facility by the Rasp Mine. According to historical documents Eyre Street Dam was situated adjacent to TSF1 and formed part of the then mine's water management system. An open cut trench running along the toe of TSF1 formerly directed water to the Eyre Street Dam. Water was then pumped from the Eyre Street Dam to the adjacent Horwood Dam which in turn was pumped to the Western Dam now rehabilitated and houses the Olive Grove. The original trench and Eyre Street Dam were decontaminated and filled in as part of rehabilitation works in the early 1990's.

A 2011 investigation into the seepage at the Eyre Street Dam resulted in the construction of a new trench which was designed to intercept potential seepage from TSF1 and direct the water into Horwoods Dam via a pump and pipe system. As part of the groundwater monitoring program, the trench will be inspected weekly to assess changes to water levels that may indicate seepage. Inspection sheets are completed at each inspection. A float pump is installed at the downstream end of the trench to direct any seepage into Horwood Dam.

6. Water Balance

Figure 4 provides a schematic diagram summarising the site water balance. The diagram identifies the water sources, the use and management of water on site.

The primary user of water on site is the Processing Plant and underground mining operations. Water losses occur in water retained in the tailings, water in concentrate, water used for dust suppression, concrete batching, and seepage at the TSF.

The closed water circuit for the mining operations results in complete management of process water with no off-site wastewater discharge directly from the operations. The Plant Water Pond, Plant Event Pond, and TSF2 capture and return potentially mineralised sediment to the processing circuit.

Key aspects of the water management strategy include:

- The separation of raw water and potable water requirements. Raw water requirements includes processing, workshop, vehicle wash-bay and dust suppression, while potable water requirements include showers, toilets and laundry;
- Reclaiming of water from the tailings storage facility to the Processing Plant; and
- Reclaiming of water for preparation and pumping of underground backfill.

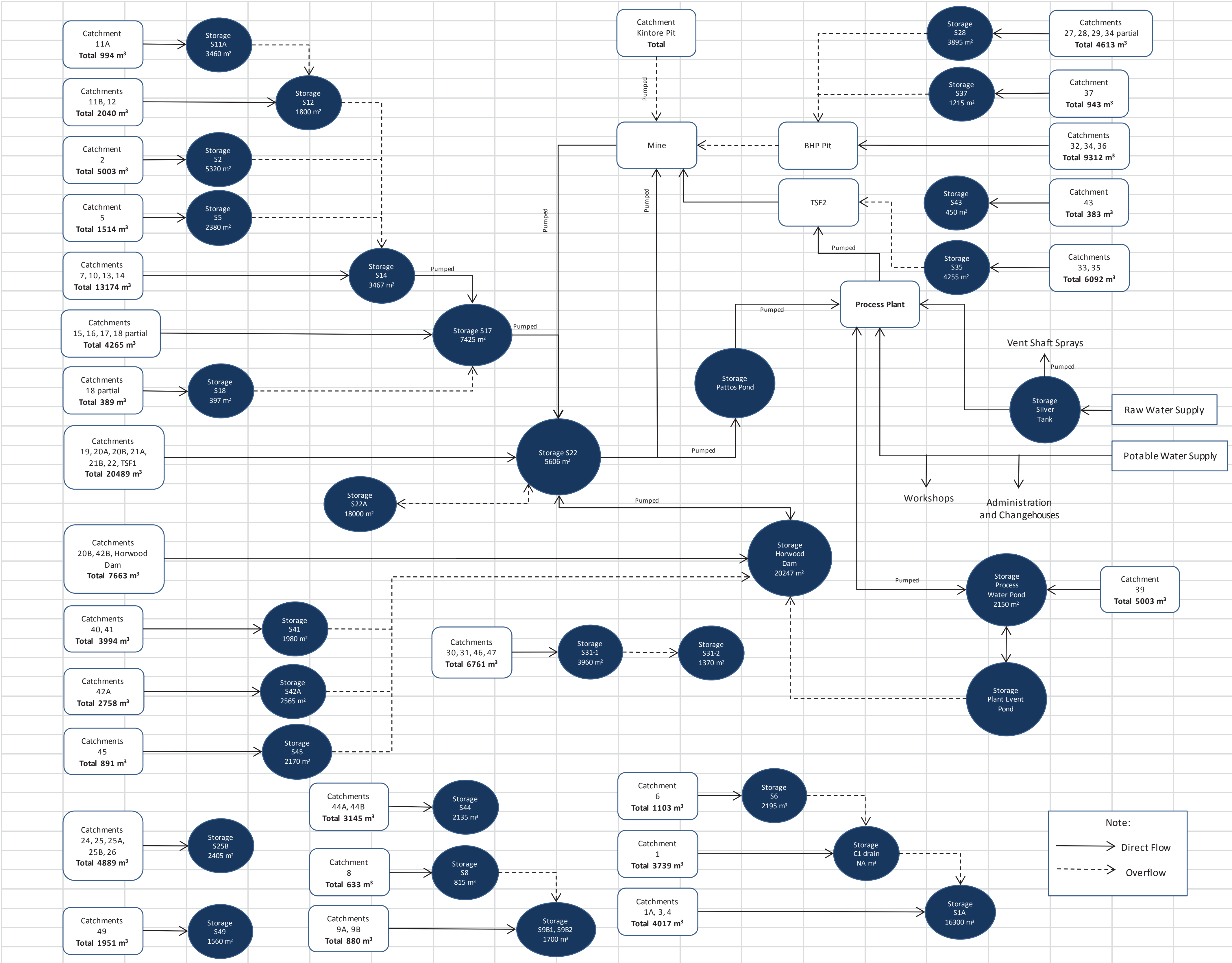
Observations regarding the rate of water usage on site are monitored.

Figure 4 - Schematic for Site Water Balance

Broken Hill Operations Pty Ltd – RASP Mine

Site Water Management Plan

BHO-PLN-ENV-004



7. Groundwater Monitoring Program

The regional groundwater near the site is depressed due to long term pumping from the underground mines in the area, resulting in the depressed groundwater level below the site being more than 100 m below the surface level, with a hydraulic gradient into the site at depth. The groundwater monitoring program will be undertaken with the purpose of recording perched groundwater movement. Due to the depth of the regional groundwater at the site there is little interaction between the shallow perched groundwater and the regional groundwater.

The objectives of the groundwater monitoring program are to:

- Provide a program to monitor seepage movement within and adjacent to the tailings storage facility (TSF2).
- Provide details of parameters and pollutants to be monitored and background local perched groundwater parameters.
- Establish a contingency measure in the event that an unacceptable impact is identified.

7.1 Seepage movement monitoring

Short term perched seepage may occur from surface water infiltration into the permeable rock mounds on the site. When the volume of infiltrated water is high, resulting from sufficient rainfall volume at the site, the rock mounds may reach field capacity and result in seepage through the mound. The seepage may exit laterally from the rock mounds, when the seepage front reaches the high strength low permeable rock formation generally below the site. This form of short term seepage may present itself as near surface seepage zones. Stormwater management has been designed to reduce the extent of surface ponding near those areas (**Table 7-1**) to limit the volume of water infiltration into the rock fill mounds.

The perched groundwater monitoring bores will record the depth at which seepage may occur. The monitoring bore depths do not extend to the drawn down regional groundwater.

Monitoring of the existing and constructed boreholes will provide an early warning if seepage is occurring near the CML7 lease boundary. Water from mine dewatering at Shaft 7 and from underground mine dewatering will form part of the groundwater monitoring program. Samples of groundwater from boreholes is collected every three months; permitting water is present at these times. Mine water samples (Shaft 7 and Mine Dewatering) are collected monthly, with pH recorded using field sheet BHO-FRM-ENV-007.

A summary of the location and function of each borehole is listed in **Table 7** and their locations indicated in **Figure 1**.

Table 7 - Location and Function of Mine Dewatering Samples and Groundwater Monitoring Boreholes

Borehole ID / Mine Dewatering	Monitoring Frequency	Location	Function / Purpose
GW01, GW02	Quarterly	South-East of Mt Hebbard	To monitor if seepage is occurring from Mt Hebbard

GW03, GW04, GW05, GW06, GW07, GW08, GW09	Quarterly	South east of TSF1	To monitor potential seepage flows from the historic TSF1 and Horwoods Dam towards the CML7 boundary. The Eyre Street pit sump was installed to intercept potential seepage from TSF1 and direct the water to Horwoods Dam via a pump and pipe system.
GW10	Quarterly	Downstream of Horwood Dam	According to the investigation of 2011, perched seepage measured at this bore is not considered to be related to water from Horwood Dam and is used to monitor potential seepage from Eyre Street Dam.
GW11, GW12	Quarterly	East of Blackwood Pit	The ground conditions to the south-east of Blackwood Pit are relatively intact with no or limited mine workings in the area. Due to the north-east and south-west length of the Pit there is a possibility for the formation of a perched aquifer as a result of groundwater mounding around the south-east side of the Pit whenever the Pit is receiving tailings. BoresGW11 and GW12 are installed to the south east of the Pit to a depth of 5 m below the base level of Blackwood Pit. These bore locations were selected based on the lower ground level towards the south-east of the Pit, and to be outside the area of influence of the isolated mine drives on the south-east side of the Pit. Borehole to monitor potentially perched water as a result of potential groundwater mounding from TSF2 water
GW13, GW14, GW15	Quarterly	Adjacent to storage areas S44, S31-1 and S31-2	To monitor if movement of perched groundwater is occurring from the storages
GW16	Quarterly	To the west of storage area S49	To monitor potential seepage from S49 towards Ryan Street
Shaft 7	Monthly	Shaft 7 (S22)	To assess groundwater quality of pumped water from Shaft 7
Mine Dewatering (underground feed)	Monthly	Decline at Kintore Pit (S22)	To assess groundwater quality at decline

The area located to the north and east of the Rasp Mine forms part of the adjacent Perilya mine lease. The ore body strikes from the north-east of the Rasp Mine to Shaft 7, where dewatering takes place. The regional groundwater cone of depression is therefore expected to exist along this ore body alignment, resulting in significant depth to regional groundwater north-east and south-west of the CML7.

The south-west to the north-west area of the Rasp Mine was historically extensively mined by underground workings comprising shafts, drives and stopes and as such is not expected that groundwater will be encountered due to the existence of the drained old mine workings.

Seepage collection outlet pipes installed in the TSF2 embankments will include inspection chambers to be inspected and recorded on a monthly basis.

7.2 Groundwater Quality Parameters

7.2.1 Baseline Chemical Properties of Groundwater

Groundwater quality monitoring was undertaken in May 2007 and August 2011 at Shaft 7.

As seasonal or other non-mining influences haven not been characterised at Rasp Mine, these water quality monitoring results act to establish initial baseline parameters and trigger levels for the monitoring program. Groundwater quality results for August 2011 will be used as baseline data for assessing changes in groundwater and perched groundwater quality results.

Groundwater quality results for May 2007 and August 2011 are provided as Appendix E.

7.2.2 Selected Groundwater Quality Monitoring Parameters

Groundwater quality monitoring at the groundwater monitoring locations described in **Table 7** is undertaken in accordance with conditions of the Rasp Mine Environment Protection Licence 12559. **Table 8** indicates the groundwater analytical suite to be monitored.

Table 8 - Groundwater Analytical Suite

Parameter	Unit	Analytical Method	2007 Results	2011 Results	30% Trigger Value
pH1	-	Field Meter	6.1	5.8	4.06 - 7.54
Electrical Conductivity	µS/cm	APHA Method 2510 B	NS	13900	9730
Total Dissolved Solids (TDS)	mg/L	APHA Method 2540 C	11000	8000	5600
Major Ions					
Total Alkalinity	mg/L as $CaCO_3$	APHA Method 2320 C	42	18	12.6
Sulphate (SO_4)	mg/L	APHA 4110	4300	9660	6762
Chloride (Cl)	mg/L	APHA 4110	1500	1360	952
Calcium (ca)	mg/L	USEPA 3015A	575	472	330
Magnesium (Mg)	mg/L	USEPA 3015A	NS	395	277
Sodium (Na)	mg/L	USEPA 3015A	1830	3550	2485
Metals (Dissolved)					
Iron (Fe)	mg/L	USEPA 3015A	0.252	0.2502	0.175

Cadmium (Cd)	mg/L	USEPA 3015A	NS	6.91	4.84
Lead (Pb)	mg/L	USEPA 3015A	0.05	2.02	1.4
Manganese (Mn)	mg/L	USEPA 3015A	340	865	606
Zinc (Zn)	mg/L	USEPA 3015A	790	2890	2023

7.3 Contingency Measures

It is necessary to establish the quality of surface water collected from waterbodies within the Mine lease to compare the results to the measured groundwater quality. This is done to assess whether a change in groundwater and surface water conditions on site is occurring. Any changes will be assessed based on trend changes relative to the baseline chemical properties of 2011.

7.3.1 Groundwater

The site's groundwater is deep and is extracted as part of mining. The underground extraction system results in inward flow of the groundwater into the Mine. Hence, groundwater at the Mine is likely to be impacted by off-site sources due to the inward hydraulic gradient into the Mine. If contaminants are detected greater than 30% above the baseline 2011 groundwater quality values of collected water in the S22 mine water compartments, then an investigation will take place.

7.3.2 Perched Groundwater

Perched groundwater quality is expected to contain significant concentrations of lead, manganese and zinc due to the seepage contact with the near surface materials on site and the surrounding areas. Perched groundwater occurs periodically after significant rainfall, so monitoring ability in some bore locations may be sporadic. Where frequent groundwater seepage is identified, BHOP will investigate options to intercept the seepage and direct the water into an onsite storage area. Measures may include seepage collection drains with a sump, lining of the area related to the source of the seepage or construction of additional surface water management structures to direct flow away from the perched groundwater affected area. Contingency measures to address groundwater impact may also include the investigation of groundwater extraction at the area of concern.

Potential seepage from Blackwood Pit-related tailings may occur. Most of this seepage will occur in the underground workings and will be managed as part of underground water extraction. If seepage occurs towards the east of the area, it is expected to be measured in monitoring bores GW11 and GW12 to the east of Blackwood Pit. If a trend is suspected, or if contaminates are detected at greater than 30% above the 2011 baseline values, an investigation will be undertaken to determine the source of contamination and the level of environmental risk and the remedial action required. Options for remedial actions include the following:

- Changes to the tailing deposition method and strategy to limit water storage on the tailing surface.
- Changes to the tailing deposition water content to reduce the amount of water in the tailing storage facility.
- Installation of a perched groundwater extraction system through a series of bores or a cut-off trench adjacent to the site boundary.

8. Surface Water Monitoring

8.1 Monitoring Program for Stormwater Ponds

Monitoring of water quality is conducted in accordance with PA07_0018 and EPL 12559 conditions at the following locations listed in **Table 9**. These ponds have the potential to overflow off-site.

Table 9 - Monitored Surface Water Storage Ponds

Storage Ponds w/ Potential for Off-site release	Depth (m)	Surface Area of Storage (m^2)	Location	Description and Flow
S1A	0.56	16,300	Bounded by South Rd, Mine and Olive Grove	Located on a non-active mining area of the site. A large storage and is likely to discharge in very rare events. Capacity to hold a 1:500 storm event then discharges through a culvert in a southerly direction.
S9B-2	0.82	1,700	Adjacent south Rd, at the south east corner of the site	Holds a 1:100 storm event. The contributing catchments to this pond are quite small, discharges to the town's stormwater system.
S31-1	2.01	3,960	North Mine boundary at Federation Way.	Holds a 1:100 storm event. Located on a non-active mining area of the site. A discharge from these slopes flows to the water storage ponds located at the rail complex.
S44	1.78	2,135	Northeast corner of Rail Loadout	Discharges into the existing rail complex surface water storage pond.
S49	1.55	1,560	Below the Block 10 lookout	Located on a non-active mining area of the site. As part of detailed design the option to discharge excess runoff to a local depression immediately to the North West of the storage would be investigated to limit the likelihood of excess flow down Adelaide Street.
Horwood Dam		NA	East of TSF1	Holds four times the est. 1 in 100yr storm event. Discharges off-site into Stephen's Creek catchment.

Sampling is undertaken twice per year at 6 monthly intervals, this has been determined as October, being the wettest month historically and April (meeting the 6 month requirement). The water quality results will also be used to compare groundwater quality measured in groundwater monitoring bores near four of these ponds.

To obtain a representative sample, the pond water quality is measured when the pond has contained water for at least one week and the pond is at a minimum of 20% capacity.

It is expected that the ponds listed above will remain dry for majority of the year so the subgrade around the pond will be partially saturated, resulting in very low permeable conditions. Hence, short term storage of water is expected to result in limited moisture migration into the subgrade which will be extracted by evaporation once the pond is empty again.

8.2 Monitoring Program for Off-site locations

Two off-site locations are included in the surface water monitoring program conducted in accordance with PA07_0018 and EPL 12559 twice per year in October and April (refer above). These are described as Downstream 1 and Downstream 2. The Downstream 1 sampling point is located within a drainage line upstream of Acacia Creek at Bonanza Street, 1.5 Km to the south of the mine. Downstream 2 is located within Stephens Creek, directly upstream of the Stephen's Creek bridge on the Barrier Highway, 7.91 Km to the east of the site. **Appendix 1** shows these locations.

8.3 Selected Surface Water Quality Monitoring Parameters

No initial background water quality values were identified for surface water at the site. **Table 10** provides the surface water analytical suite used to measure surface water quality.

Table 10 - Surface water quality monitoring parameters

Parameter	Unit	Recommended Analytical Method
pH[1]	pH Unit	Field Meter
Electrical Conductivity	µS/cm	APHA Method 2510 B
Total Dissolved Solids (TDS)	mg/L	APHA Method 2540 C
Major Ions		
Sulphate (SO_4)	mg/L	APHA 4110
Chloride (Cl)	mg/L	APHA 4110
Sodium (Na)	mg/L	USEPA 3015A
Metals (Dissolved)		
Cadmium (Cd)	mg/L	USEPA 3015A
Lead (Pb)	mg/L	USEPA 3015A
Manganese (Mn)	mg/L	USEPA 3015A
Zinc (Zn)	mg/L	USEPA 3015A

Note 1 = Field analysis only.

8.4 Contingency Measures

Should the measured water quality in Horwood Dam be considered to present a significant risk to the receiving environment (such as the downstream creek and Stephens Creek Reservoir) or have the potential to discharge water, then the water level in Horwood Dam will be lowered by pumping to increase its storage capacity for subsequent rainfall events. Water pumped from Horwood Dam will be stored either in the BHP Pit, Blackwood Pit, or S22. All of these storages have additional capacity compared to the estimated 1:100 year storm event runoff from each of the respective catchments.

The risk to receiving waterbodies is based on the background water quality in the waterway and the water quality of runoff from the catchment of the creek.

8.5 Site Water Management Equipment

All equipment used in the management of site water (eg. pumps and pipes) is included on the routine maintenance schedule to ensure optimum operational condition. Any maintenance works carried out on equipment is recorded on the Pronto maintenance database.

8.6 Water Transfer between Dams

Water transfers from Shaft 7 to S22 and from the Eyre St Trench to Horwoods Dam are measured using flow meters and recorded.

9. Erosion and Sediment Control

Mining activities and weather conditions may result in soil erosion, generation of sediment or flooding.

Mining activities include:

- Underground works with limited surface stockpiling;
- Transportation activities; and
- Maintenance activities on the surface and landscape.

The main prime source for erosion at the Mine is related to weathering due to wind and water runoff.

The susceptibility to soil erosion, the generation of sediment and flooding as a result of water erosion has been minimised by dividing the site into small catchments. The catchment layouts generally conform to the existing landform and where practical, storage areas have been provided within the catchment. The majority of catchments have their own storage pond capturing rainfall and sediment from the surrounding area. Where storage areas are not provided within a catchment, due to site restrictions, drainage channels discharge runoff into nearby catchment storage ponds. This design approach limits the potential for the transportation of sediment to downstream waters and manages the risk of flooding within local catchments. The capacity of the required water storages and channels to meet the requirements of the 1:100 year storm event is described **Table 6**.

9.1 Stormwater Structures Monitoring

The Mine assesses the continued capacity of each storage pond against the required capacity quarterly or after storm events, identifying where repair or upgrade works, desilting, dewatering, or other relevant action is required in order to create and maintain the required water storage capacity. A Surface Water Structure Inspection Form is used for the reporting requirements of this SWMP.

The Erosion and Sediment Control Inspection Procedure outlines the requirements for conducting these inspections.

A storm event is defined as either:

- at least 30 mm of rain is recorded within a 2 hour period; or
- at least 75 mm of rain is recorded within 3 consecutive days.

Pond storage capacity reduction (due to sediment build-up) is monitored using surveying. Where storages are reduced by a maximum of 10% of the design requirement (i.e actual storage capacity is 90% of the design storage requirement), the Mine will carry out de-silting works.

Routine ESC inspections consist of a visual assessment for erosion, flooding, trash, algal growth, or significant sediment build-up. Storage capacity is assessed by viewing sediment depth markers, and volume assessment based on survey data, where appropriate (eg. after significant de-silting). Observations and recommendations are recorded on the ESC Inspection Checklist.

The integrity of the engineered bunds at storage areas S1A, S9B-1 and S9B-2, S31, S44 and S49 will be assessed after heavy rain events to investigate whether additional methods need to be put in place to ensure seepage is prevented / stopped. Observations are recorded in the Surface Water Structure Inspection Form.

9.2 Removal of Sediment from ESC Structures

Accumulated sediment within designated stormwater drains and water storage ponds removed and disposed into one of the existing mine pits on-site. Disposal of sediment into the existing pits reduces the likelihood of the sediments being remobilised. Removal and disposal of sediment from the drainage network is recorded in the ESC Inspection Checklist. The Surface Water Structure Inspection Form highlights areas within the drainage network that are in frequent need of repair and allows the Mine to make informed decisions on the need, location, function, and capacity of additional erosion and sediment control structures.

9.3 Erosion Maintenance on Batter Slopes

As the majority of batter slopes exist on the mine boundary, are relatively steep, and consist of weathered rock or predominantly large rock particles, it is not practical to reshape slopes as an ESC control measure. Historical erosion to the slopes has removed most of the finer materials and the existing surfaces now comprise relatively large and course particles resulting in a self-armoured surface with limited erosion potential. As a control measure to limit further erosion to batters, surface water is diverted away from the batter slopes or to open drainage channels which report to water storages. Most slopes include a stormwater collection drain along the toe draining to a water storage within the catchment.

Soil binder additives are also utilised across all accessible slopes (and free areas) throughout the site. Liquid dust suppressant (usually mixed with green dye) is mixed with water and applied by water truck or water cannon to exposed surfaces annually or as required.

10. Trigger Action Response Plans

Aspect	Normal	Trigger 1	Trigger 2	Notifications
Surface water storage	Storages function as designed and meet design criteria by containing stormwater events.	**Trigger:** Storages fill quicker than expected or are not dewatered prior to a rainfall event. **Response:** Dewater and survey to ensure there is no excess sediment collection and review catchment runoff calculations. Staff training and communication.	**Trigger:** Emergency discharge from Storages **Response:** Collect samples of discharge water. Dewater as soon as possible. Investigate cause. Review storage design. Staff training and communication.	**Trigger 1**: Notify Environmental staff. **Trigger 2:** Notify external stakeholders as required by PIRMP.
Erosion and Sediment Control	There is no evidence of erosion or sediment build-up.	**Trigger:** Evidence of surface erosion or sedimentation (storage capacity <90%). **Response:** Repair erosion and address	**Trigger:** Offsite erosion or sediment transport **Response:** Contain cause and impact where possible including	**Trigger 1**: Notify Environmental staff. **Trigger 2:** Notify external stakeholders as required by PIRMP.

Aspect	Normal	Trigger 1	Trigger 2	Notifications
		runoff cause. Remove sediment.	diverting flows. Review controls.	
Groundwater quality	Variation in long-term groundwater monitoring results <30%.	**Trigger:** >30% variation in long-term results from one monitoring event. **Response:** Re-sample and re-test. Investigate source of variation with aim of determining mine-related impact.	**Trigger:** >30% variation in long-term results from more than one scheduled event. **Response:** Expand investigation with use of specialists. Increase monitoring frequency. Review monitoring locations.	**Trigger 1**: Notify Environmental staff. **Trigger 2:** Notify external stakeholders as required by PIRMP.
Perched groundwater levels (G11 and G12)	Groundwater level within long-term range	**Trigger:** Increase in level outside expected range **Response:** Re-sample. Investigate source of variation with aim of determining mine-related impact.	**Trigger:** Level does not decrease after one quarter. **Response:** Expand investigation with use of specialists. Increase monitoring frequency. Review monitoring locations.	**Trigger 1**: Notify Environmental staff. **Trigger 2:** Notify external stakeholders as required.
Groundwater levels	Groundwater level within long-term range considering rainfall	**Trigger:** >1m drop in level **Response:**	**Trigger:** >1m drop in level does not recover after one quarter	**Trigger 1**: Notify Environmental staff. **Trigger 2:**

Aspect	Normal	Trigger 1	Trigger 2	Notifications
		Re-sample. Investigate source of variation with aim of determining mine-related impact.	**Response:** Expand investigation with use of specialists. Increase monitoring frequency. Revise monitoring locations and potential for bore recovery.	Notify external stakeholders as required.
Surface water quality	Variation in long-term surface water monitoring results <30%.	**Trigger:** >30% variation in long-term results from one monitoring event. **Response:** Re-sample and re-test. Investigate source of variation with aim of determining mine-related impact.	**Trigger:** >30% variation in long-term results from more than one scheduled event. **Response:** Expand investigation with use of specialists. Increase monitoring frequency. Review monitoring locations.	**Trigger 1**: Notify Environmental staff. **Trigger 2:** Notify external stakeholders as required.

11. Reporting and Review

11.1 Reporting Groundwater or Surface Water Incidents

11.1.1 Internal

All incidents related to ground and surface water shall be recorded and reported using the INX InControl system for incident reporting and investigation.

Any operational incident related to ground or surface water includes:

- Any off site release, eg. seepage, leakage, discharge.
- Any exceedances of trigger levels or trend changes to chemical parameters, against the August 2011 groundwater quality results used as baseline data or established values based on monitoring data over time.

11.1.2 External

Incidents that have the potential to cause environmental harm are required to be reported to the:

- Department of Planning and Environment;
- Environment Protection Authority; and
- Other relevant government agencies eg. BHCC, Health, WorkCover, Fire and Rescue.

Notification shall be made immediately to each relevant authority when material harm to the environment is caused or threatened in accordance with the relevant legislation. In this case the Pollution Incident Response Management Plan (PIRMP) shall be implemented and the EPA notified via the Environment Line on 131 555 as soon as practicable.

BHOP will provide a report, as required, within seven days of the date of the incident.

The Senior Environmental Advisor will be responsible for preparing reports to the government agencies which will be signed off by the General Manger prior to submission.

Complaints will be recorded, managed and documented in accordance with the Complaints Handling Procedure.

11.2 Regular Reporting

The following reports shall be prepared and submitted.

11.2.1 Monthly Management Report

- Summary of incidents, including cause and actions taken (or to be taken) to reduce the risk of a reoccurrence.
- Summary of monitoring results.

11.2.2 Rasp Mine Website

- Summary of water quality monitoring results, updated monthly.
- Summary of community complaints, updated monthly.
- A current copy of the approved SWMP.

11.2.3 Annual Environment Management Report / Annual Review

The Annual Environment Management Report / Annual Review shall be complied and submitted each year in accordance with conditions of Consolidated Mine Lease 7 (Condition 3) and the Project Approval 07_0018 (modified) (Schedule 4 Condition 3).

The review will:

- Include a comprehensive review of the monitoring results and complaints records of the project over the past year, which includes a comparison of these results against the:
- Relevant statutory requirements, limits or performance measures/criteria
- Monitoring results of previous years
- Relevant predictions in the documents EAR, PPR and their respective response to submissions and BHOP Statement of Commitments.
- Identify any non-compliance over the past year, and describe what actions were (or are being) taken to achieve compliance.
- Identify any trends in the monitoring data over the life of the project.
- List any incidents occurring during the period as described in **Section 10.1.1**.
- List any works to be undertaken in the following year to rectify or improve site water management.

The AR will be submitted to the Director General – DP&E to meet this condition.

The Report / Review will be prepared in accordance with relevant guidelines and provided to government agencies for consultation prior to submission to the Department of Planning and Environment (DP&E), and the Division of Resources and Geoscience (DRG) each year.

11.2.4 Annual Return

An Annual Return outlining ground and surface water quality monitoring results, non-compliances (with respect to EPL 12994) and community complaints will be prepared on the appropriate form and submitted to the EPA as required each year.

11.3 Auditing and Review

11.3.1 Site water Management and Review

The SWMP will be reviewed, and if necessary revised, within three months of submission of:

- An Annual Review.
- An Incident Report related to ground or surface water.
- Any modification of the Project Approval.
- Variation to the EP License.

Any reviews will reflect changes in environmental expectations, technology and operational procedures as well as operational experience gained as mining progresses.

In addition to the above review requirements, reviews will be conducted to assess the effectiveness of procedures against the objectives of the SWMP. This Plan will be revised due to:

- Deficiencies being identified.
- Extremes in environmental conditions.
- Improvements in knowledge or technology advancements.
- A change in the activities or operations associated with the Rasp Mine.

Any amendments to the SWMP will be undertaken in consultation with the appropriate regulatory authorities and approved in the same manner as the initial SWMP.

The Senior Environment Advisor is responsible for the audit and review of the SWMP under any of the above triggers.

An Independent Environmental Audit of the project will be conducted every three years from December 2011 and will assess the performance of the project and compliance with the approval and any relevant EPL or Mining Lease. Within six weeks of completing the audit, a copy of the audit report will be submitted to the Secretary of the DPE. This plan will be reviewed during the audit.

12. References

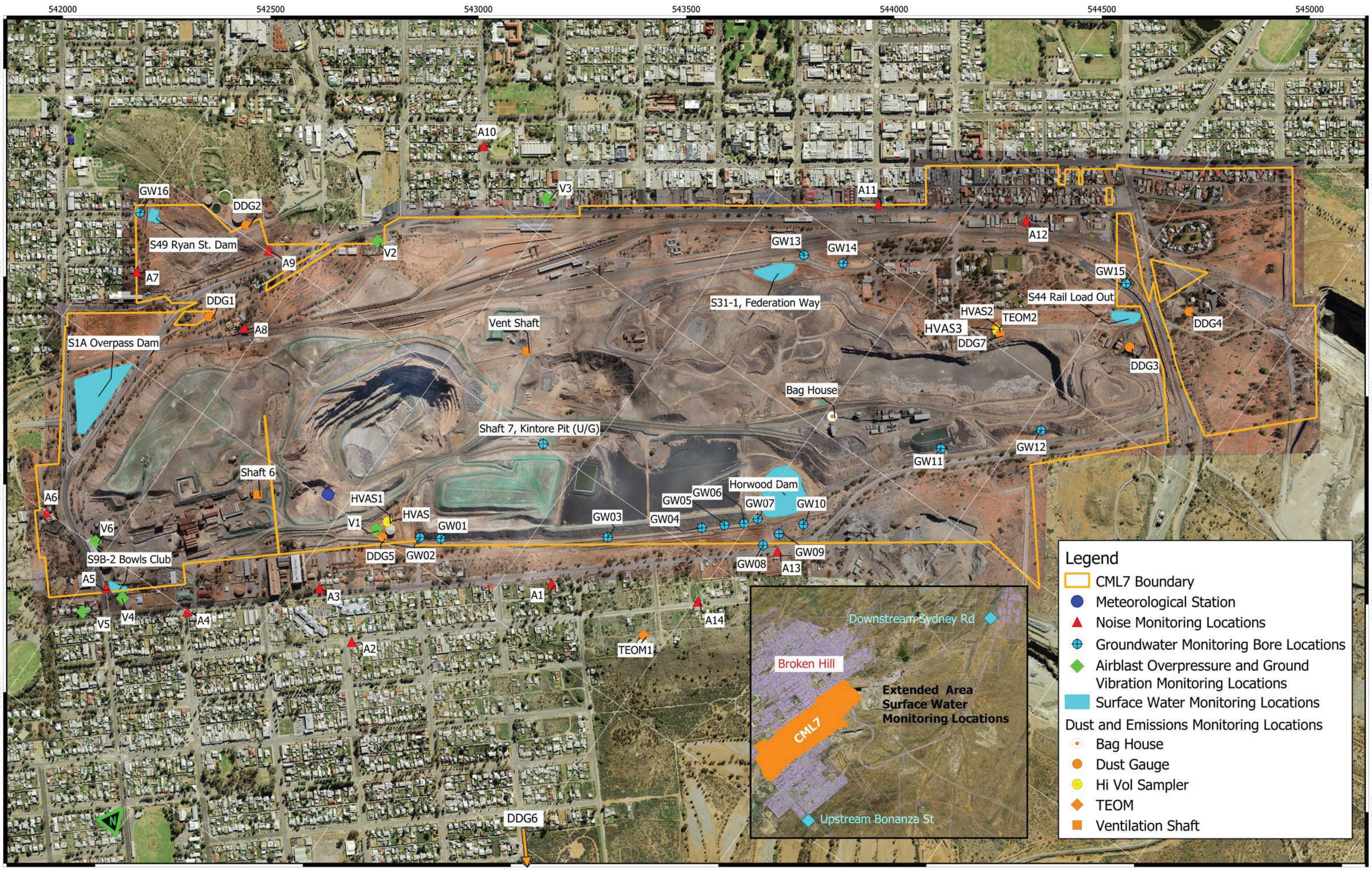
Institution of Engineers, Australia (1987) *Australian Rainfall and Runoff: A Guide to Flood Estimation* , Vol. 1, Editor-in-chief D.H. Pilgrim, Revised Edition 1987 (Reprinted edition 1998), Barton, ACT

Landcom. (2004) *Managing Urban Stormwater – Soils and Construction.* 4th Edition, March 2004. Volume 1. (Reprinted edition 2006). Parramatta, NSW

ANZECC. (1992) Australian water quality guidelines for fresh and marine waters. Australian and New Zealand Environment and Conservation Council, Canberra

13. Appendices

Appendix 1 – CML7 Environmental Monitoring Location



0 100 200 300 400 500 m

Scale 1:10,000 Datum: MGA Zone 54

Map of CML7 Environmental Monitoring Locations

Data Sources:
Aerial 25/04/2016 MGA54 10cm - CBH
Environmental Monitoring Locations and
CML7 Boundary - CBH.
NSW Six Map Best Imagery © Department Finance, Services & Innovation 6/03/2018

File Reference: JMC-C003-002 V2
Date: 26/04/2018

APPENDIX M

BHOP Report ‘Project Brief – Kintore Pit TSF3’ dated September 2020.

Rasp Mine

Zinc – Lead – Silver Project
Project Approval No. 07-0018 (SSD-814)

Project Brief

Kintore Pit TSF3

September 2020

Broken Hill Operations Pty Ltd
BROKEN HILL

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EXECUTIVE SUMMARY

Broken Hill Operations Pty Ltd (BHOP) [a wholly owned subsidiary of CBH Resources Limited (CBH)] owns and operates the Rasp Mine (the Mine), located centrally within the City of Broken Hill on Consolidated Mine Lease 7 (CML7). The Mine produces zinc and lead concentrates which are dispatched via rail to Port Pirie in South Australia and Newcastle in New South Wales.

Mining has been undertaken within CML7 since 1885. The existing operations at the Mine include underground mining, processing plant, rail siding for concentrate dispatch and other associated infrastructure. These operations are undertaken in accordance with Project Approval PA07_0018 (as modified) (PA) granted from the then Minister for Planning on 31 January 2011, under Part3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

Pursuant to Section 4.22 of the EP&A Act, BHOP seeks to modify its Project Approval primarily to allow for tailing to be co-deposited with excess waste rock from underground mining operations into Kintore Pit. This would also require relocation of the underground mine access portal and decline. A number of minor modifications to the PA will also form part of the modification and these are summarised below.

The purpose of this document is to provide preliminary information, including an overview of the proposed Modification (MOD6), its location and setting within the environment, to assist with identifying the potential key issues to be addressed in the Environment Impact Statement (EIS). The EIS will be submitted to the Department of Planning, Industry and Environment (DPIE), to support the application. Results from preliminary risk reviews and early consultation with regulators are also provided.

Proposed Modification

Summary of proposed MOD6:

- Establish Kintore Pit as Tailing Storage Facility 3 (TSF3) for naturally dried tailing co-disposed with excess underground waste rock;
- Relocate the mine portal and access decline with associated infrastructure, to a new boxcut;
- Utilise Blackwood Pit TSF2 for harvesting solar and wind dried tailing;
- Conduct periodical crushing of non-ore material in Kintore Pit and/or BHP Pit;
- Utilise waste rock for rehabilitation capping; and
- Administrative amendments for annual reporting and noise criteria.

Predictions for the life of TSF2, following installation of the embankments (MOD4), is now late 2022. The extended life of the facility is due to improved tailing settling rates and reduction in mine production. Mining will cease at that time if no other tailing storage facility is available.

BHOP engaged Golder Associates Pty Ltd (Golder) to undertake a review of potential sites in and around the Rasp Mine and it was concluded that Kintore Pit would be the optimum location for tailing storage. Studies have shown that in establishing Kintore Pit as TSF3, tailing would need to be further dewatered from the current 35% moisture content achieved by the milling process, to reduce inrush / inundation risk to underground mining operations. BHOP propose to utilise the natural solar and wind drying process offered within Blackwood Pit TSF2 to harvest thin layers (up to 1m) of naturally dried tailing prior to stockpiling and transferring to Kintore Pit.

Excess waste rock from underground mining, in particular any material that is greater than 0.5% lead, would continue to be placed in Kintore Pit and be co-disposed with tailing. Some waste rock that has a lead content greater than 0.5% would also be permanently stored in the infill area of BHP Pit. Waste rock suitable for rehabilitation capping would be separated and placed on the current Kintore Pit Tipple or BHP Pit prior to confirmation testing of lead levels.

BHOP currently conduct crushing activities of non-ore materials in Kintore Pit (EA) and BHP Pit (MOD7) and propose to continue these activities using a mobile crusher when required to produce material for road base, bunding and / or other site requirements.

BHOP seek to commence progressive rehabilitation activities over 'free areas' (ie non-active mining areas) across CML7 by using excess waste rock from underground that has been tested and contains less than 0.5% lead.

BHOP also seek to adopt new noise criteria as identified during the noise modelling assessment for MOD6 in accordance with the NSW EPA *Noise Policy for Industry (2017)* and attended noise monitoring results. BHOP also propose to seek a change to the reporting period and submission date for the Annual Review (required under PA) to align reporting requirements with the annual Environment Management Report (required under the CML7).

Summary of Potential Key Risks

A risk review workshop was facilitated by HMS Consultants Australia Pty Ltd (HMS) on the proposed conversion of Kintore Pit to a tailing storage facility. The objective of this risk review was to assist in determining a safe and suitable option for converting the Kintore Pit into a TSF. In addition BHOP sought feedback from regulators to identify their requirements for the development of the Project. Risks were considered for both construction activities and future operations of the Project. Additional risks from new activities eg tailing harvesting, have been identified and included in this Brief.

A number of key potential risks have been identified that require further investigation. A summary of the main risks identified is provided below:

Inrush – From seepage and liquefaction of deposited tailing entering mine workings beneath Kintore Pit and from liquefaction of tailing contained in TSF1 and TSF2 as a result of blasting for the new portal and decline. BHOP has opted to further dewater the tailing prior to deposition into Kintore Pit and will include a stand-off distance from the portal and decline to TSF1 and TSF2. A number of studies have been commissioned to inform the design and assess and advise on the implementation of strategies to protect safety of personnel, these include liquefaction, tailing compaction testing, seepage modelling and seismic assessments.

Ground failure Kintore Pit – From the load of tailing / waste rock placed within Kintore Pit given the removal of crown pillars beneath the Pit and depth to the base of the Pit (10 m). Suitably qualified consultants have been engaged to undertake a geotechnical study and stability analysis to determine potential risks and recommendations for safety assurance.

Ground failure Blackwood Pit – From tailing harvesting activities potentially impacting the integrity of the embankment structures and from high rainfall events impacting Blackwood Pit tailing surface. Suitably qualified consultants have been engaged to provide a geotechnical study for tail harvesting activities which will also address water management and surface stability. Importantly the Dam Design Engineer for Blackwood Pit TSF2 MOD4 has been engaged to design the tailing harvesting process to assure integrity of embankment design.

Dust – Primarily from earthworks, truck movements, crushing and tailing harvesting. Dust from the site has the potential to contain lead. Suitably qualified consultants have been engaged to undertake a comprehensive air assessment and conduct a human health risk assessment to provide predictions for blood lead levels (BLL) in the community, in particular any impact on children's BLL.

Noise, vibration and overpressure – From mobile equipment, truck movements, trafficking the tailing surface and vibration and overpressure from blasting activities. Suitably qualified consultants have been engaged to undertake a noise assessment and a vibration and overpressure assessment. An assessment of flyrock from surface blasting for the proposed new portal will also be undertaken with stand-off distances identified.

Vibration Blackwood Pit – From trafficking on the tailing surface by trucks and mobile equipment, subsidence within cell structures causing vehicles to sink. Suitably qualified consultants have been engaged to assess vibration risks including the potential for liquefaction of the tailing.

Water – Surface water management around rehabilitation capping and water quality. Water management around the rehabilitation capping forms part of the scope of works for the design engineer for this capping. An assessment of the impacts to the current Site Water Management Plan is also part of this study. A consultant has also been engaged to assess potential impacts to water quality from tailing placement in TSF3 and waste rock used for rehabilitation capping.

Waste rock contamination – From waste rock used for progressive rehabilitation capping. A consultant has been engaged to conduct an assessment of the potential for contamination from the waste rock including a long term assessment.

There will be no further land disturbance as all Project activities are located in mining areas that are already highly disturbed. No vegetation will be disturbed. No heritage items will be impacted.

Benefits of the project

The proposed modification would:

- Permit mining at the Rasp Mine to continue post 2022 with additional storage of tailing;
- Significantly reduce the surface distance of hauling ore from underground to the ROM Pad;
- Provide rehabilitation capping over free areas of the site with material lower in lead content;
- Ensure continued employment of 186 full-time employees, 32 full-time contractors and indirectly over 200 casual contractors that provide specialist services when required;
- Engagement of approximately 20 contractors during construction and an additional 6 full time employees for operations;
- Allows the filling of legacy open pits;
- Allow the resource to be fully utilised, and
- Allow BHOP to continue to support the sustainability and economy of Broken Hill.

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1.0 INTRODUCTION

This Section provides an introduction to Broken Hill Operations Pty Ltd and the Rasp Mine, and outlines the purpose of this document and the proposed modification, the need for the modification and highlights changes from the current Project Approval. Future consultation commitments are also outlined.

1.1 Background

Broken Hill Operations Pty Ltd (BHOP) [a wholly owned subsidiary of CBH Resources Limited (CBH)] owns and operates the Rasp Mine (the Mine), which is located centrally within the City of Broken Hill on Consolidated Mine Lease 7 (CML7). The Mine produces zinc and lead concentrates which are dispatched via rail to Port Pirie in South Australia and Newcastle in New South Wales.

Mining has been undertaken within CML7 since 1885. The existing operations at the Mine include underground mining, processing plant, rail siding for concentrate dispatch and other associated infrastructure. These operations are undertaken in accordance with Project Approval PA07_0018 (as amended) (PA) granted from the then Minister for Planning on 31 January 2011, under Part3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

BHOP will seek to modify its Project Approval, pursuant to Section 4.22 of the EP&A Act, primarily to allow for tailing to be co-deposited with excess waste rock from underground into Kintore Pit. This would also require relocation of the underground mine access portal and decline. A number of minor modifications to the PA will also form part of the modification and these are summarised below.

The purpose of this document is to provide preliminary information, including an overview of the proposed Modification (MOD6), its location and setting within the environment, to assist with identifying the potential key issues to be addressed in the Environment Impact Statement (EIS). The EIS will be submitted to the Department of Planning, Industry and Environment (DPIE), to support the application. Results from preliminary risk reviews and early consultation with regulators are also provided.

1.2 Proposed Modification

Summary of proposed MOD6:

- Establish Kintore Pit as Tailing Storage Facility 3 (TSF3) for naturally dried tailing co-disposed with excess waste rock;
- Relocate the mine portal and access decline with associated infrastructure, to a new boxcut;
- Utilise Blackwood Pit TSF2 for harvesting solar and wind dried tailing;
- Conduct periodical crushing of non-ore material in Kintore Pit and/or BHP Pit;
- Utilise waste rock for rehabilitation capping; and
- Administrative amendments for annual reporting and noise criteria.

Predictions for the life of TSF2, following installation of the embankments (MOD4), is now late 2022. The extended life of the facility is due to improved tailing settling rates and reduction in mine production (July 2020 revised). Mining will cease at that time if no other tailing storage facility is available.

BHOP engaged Golder Associates Pty Ltd (Golder) to undertake a review of potential sites in and around the Rasp Mine and it was concluded that Kintore Pit would be the optimum location for tailing storage. Studies have shown that in establishing Kintore Pit as TSF3, tailing would need to be further dewatered from the current 35% moisture content achieved by the milling process, to reduce inrush / inundation risk to underground mining operations. BHOP propose to utilise the natural solar and wind drying process offered within Blackwood Pit TSF2 to harvest thin layers (up to 1 m) of dry tailing prior to stockpiling and transferring to Kintore Pit. This would allow continued fresh tailing to be deposited into this facility which would be naturally dried and removed, resulting in cyclical rotation of depositing, drying, harvesting and transferring of tailing to Kintore Pit TSF3.

Current underground mine access is via a portal located in Kintore Pit. It is proposed to establish a new portal to be located within a boxcut.

Excess waste rock from underground mining, in particular any material that is greater than 0.5% lead, would continue to be placed in Kintore Pit and be co-disposed with tailing. Waste rock suitable for rehabilitation capping would be separated and placed on the current Kintore Pit Tipple or BHP Pit prior to confirmation testing of lead levels. Waste rock that has a lead content greater than 0.5% would be permanently stored in Kintore Pit or in the in-fill area of BHP Pit.

Crushing of non-ore material is currently undertaken in Kintore Pit (EA) and BHP Pit (MOD7) and BHOP propose to continue these activities using a mobile crusher when required to produce material for road base, bunding and / or other site requirements. Crushing is undertaken on an ad hoc basis only when required typically 2 or 3 times per year over a few days during daytime hours only.

BHOP seek to commence progressive rehabilitation activities over ‘free areas’ (non-active mining areas), across CML7 by using excess waste rock from underground that has been tested and contains less than 0.5 percent lead (<0.5%Pb).

BHOP propose to adopt new noise criteria as identified during the noise modelling assessment for MOD6 in accordance with the NSW EPA *Noise Policy for Industry (2017)* and attended noise monitoring results.

BHOP also propose to seek a change to the reporting period and submission date for the Annual Review (AR) (required under PA conditions) to align reporting requirements with the annual Environment Management Report (EMR) (required under the CML7).

1.3 Proposed Changes to the Project

The current Project Approval permits underground mining of the Western Mineralisation, the Centenary Mineralisation and Main Lode from Blocks 7 to 12 until 31 December 2026 extracting up to 750,000 tonnes of ore per annum and 8,450,000 tonnes of ore over the life of the Project. It also permits the processing of ore and the dispatch of concentrate products from the Mine by rail. There are a number of auxiliary facilities including maintenance workshops, inventory, chemical and explosives storages, backfill and concrete batching plants and a rail siding. **Table 1-1** provides a summary of existing approved project components compared to the proposed modifications.

Table 1-1 Comparison of Existing Approval and Proposed MOD6

Component	Approved Rasp Mine	Proposed MOD6
Mine Life	15 years (includes construction and closure) from 2011 to 2026.	No change, however operations will cease in 2022 without approval for additional capacity for tailing storage.
Tenement Status	CML7 – Incorporates the Rasp Mine.	No change
Mining Methods	Underground mining using various methods including long hole, benching, modified Avoca, room and pillar or uphole retreat. Within Western and Centenary Mineralisation and Main Lodes Blocks 7 to 12.	No change to mining methods. MOD6 proposes a new access portal to the underground mine, within a boxcut, and access decline.
Mining Rate and Total Production	750 000 tpa ore. Total production over life of Project: Approximately 8,450,000 t	MOD6 is based on a mine plan to the end of 2026 based on 500,000 tpa ore, 146,000 tpa of waste (to surface) and 480,000 tpa of tailing harvested and transferred to Kintore Pit TSF3.
Waste Rock Disposal	Underground: Backfill. Surface: Material (<0.5% Pb) to be used for road repair and bunding and rehabilitation at closure	MOD6 proposes that excess waste rock from U/G mining be: - co-disposed with tailing in TSF3 and/or placed permanently in BHP Pit, - testing confirms <0.5%Pb and can be used for rehabilitation capping, and - material from construction of the boxcut and decline be permanently stored in Little Kintore Pit and BHP Pit.
Underground Ventilation	2 x 450 kW primary ventilation fans located 160 m	No change

Component	Approved Rasp Mine	Proposed MOD6
	below ground and exhausting centrally within CML7.	
Processing Methods	Crushing, grinding, flotation, thickening and filtration at on-site processing facilities.	No change
Processing Rates	250 tph in crushing plant and 93.8 tph in grinding plant.	No change
Concentrate Production	Lead: 44,000 tpa (concentrate 73% Pb and 985 g/t Ag) Zinc: 87,000 tpa (concentrate 50% Zn)	No change
Tailing Disposal	Course stream returned to mine void and finer stream to be directed to tailing storage facilities.	MOD6 proposes to: - establish a tailing storage facility at Kintore Pit TSF3 with an approximate 10 year life, and - utilise the surface of TSF2 to naturally dried tailing which will be harvested and relocated to TSF3.
Facilities	Other associated facilities such as Backfill Plant including a cement silo, Concrete Batching Plant, Rail Loadout, Warehouse, core preparation and inventory storage and workshops.	Periodic surface crushing to continue in Kintore Pit (EA) and BHP Pit (MOD7) for road base and bunding requirements.
Services	Extensions to existing substations, water lines and phone lines. New 22kV overhead power lines to be constructed.	MOD6 proposes to relocate services currently within Kintore Pit that support the underground mining to an area adjacent the proposed boxcut. This would include portable buildings used for underground equipment, crib and substation.
Water Supply / Extraction	Potable / treated water 9 ML/a Raw untreated water 139 ML/a Reclaimed / recycled water 300 ML/a Extraction up to 390 ML/a.	No change.
External Roads	No changes to external road network.	No change.
Employment Numbers	Current numbers are: Employees: 186[1] Contractors: 32	MOD6 proposes increases in personnel: During construction: Employees – 0 Contractors – 20 For operations: Employees – 6 Contractors – 0
Hours of Operation	Underground Operations: 7 days per week, 24 hours per day Shunting 7 days per week, 7am to 6pm (not conducted). Construction hours 7am to 6pm Mon-Fri and 8am to 1pm Sat, no construction work on Sundays or Public holidays. Activities not listed above – 7 days per week, 24 hours per day.	No change to operating hours of current activities. MOD6 proposes to campaign harvesting tailing from TSF2 over a roster basis which will occur only on day shift. MOD6 proposes to construct the boxcut – 7am to 6pm Monday to Saturday and Sunday 8am to 6pm.
Disturbance Footprint	CML7 consists of 342.66 Ha Current land disturbance due to Rasp Mine activities is 28.4 Ha	MOD6 will require review to clarify disturbance areas in line with the rehabilitation capping.

Note 1: New employee and contractor numbers reflect Rasp Mine restructure in July 2020.

1.4 Regulatory Framework

The Rasp Mine was declared a Major Project under the *State Environment Planning Policy (SEPP) (Major Development) 2005* (now repealed) and was approved in January 2011 by the then NSW Minister for the Department of Planning and Infrastructure under Part 3A of the EP&A Act. Following repeal of Part 3A and Section 75W (transition provision) of the EP&A Act, the application for this Modification is made pursuant to Section 4.55 of the EP&A Act. The Rasp Mine Project has been transitioned to a State Significant Development (SSD-814) and MOD6 will be considered under the assessment pathway for State Significant Development (SSD).

1.5 Existing Environment

The Mine is located centrally within the City of Broken Hill and is surrounded by transport infrastructure, areas of commercial and industrial development and some residential housing **Figure 1-1**.

The Mine is bounded by Eyre Street and Holten Drive to the south and east, Perilya's Broken Hill North Mine to the east and South Mine to the west, and the commercial centre of Broken Hill to the north. The Mawsons Concrete and Quarry Pty Ltd lies adjacent to the Mine on Holten Drive. The Mine site is dissected by two major State roads, South Road (Silver City Highway SH22) to the southwest and Menindee Road (MR66) to the northeast. The Broken Hill railway station is located directly to the north of the Mine and lies on the main Sydney – Perth railway line. Residential and commercial areas surround the Mine with pasture land to the southeast.

The land within CML7 has several surface exclusion zones, which contain rail lines and stock yards to the north, Perilya employee housing to the north east, the former Italo International (Bocce) Club (now Southern Cross Care Broken Hill Ltd) and previous lawns bowling club to the south west (now Silver City Removals) and other commercial and residential properties.

The site has been mined for over 135 years leaving the site highly disturbed with a number of heritage buildings and structures. The majority of the site is covered with historic waste rock or tailing material, there is little topsoil and vegetation.

1.6 Reason for the Proposed Modification

At current tailing deposition (following installation of the TSF2 embankments (MOD4)), the life of Blackwood Pit TSF2 will be completed in late 2022. In MOD4 it was identified that under current volumes storage capacity within TSF2 would cease in mid-2021. Actual experience has indicated that the tailing is settling with a higher density, increasing the maximum volume for deposition and extending the life of the facility. In addition the current mine plan has changed to a high grade lower tonnes strategy which results in less tailing production. This has resulted in an increase to the life of the current tailing storage facility with a new fill date to late 2022.

In the original Environment Assessment (EA) for the Project it was planned for tailing to be placed in both above ground tailing storage facilities and underground, via the Backfill Plant, to fill mining voids. The tailing waste stream from ore processing has been approved to be deposited in the historic tailing facility (TSF1) and in the disused Blackwood Pit (TSF2). BHOP chose to deposit tailing in TSF2 and not use TSF1. This decision was based on the greater capacity of TSF2 (3.1 Mt) compared to the capacity of TSF1 (970,000 t) and the significant construction costs associated with the use of TSF1 ($7.2 M) compared to the cost of extending TSF2 ($3.5 M).

In the initial EA BHOP underestimated the amount of mine development that was required to access the Main Lode and Western Mineralisation ore bodies. The need to undertake more underground mining development has impacted the amount of waste generated. In the original EA it was predicted that approximately 250,000 t of waste rock would be produced each year for a production rate of 750,000 t of ore. Actual total waste rock produced has averaged 368,000 t per year since commencement of operations peaking in 2015 and 2018 with 452,000 t. BHOP has chosen to place the additional waste rock underground to fill voids and stopes, as it is more economic to dispose of waste rock underground where possible rather than transporting waste to the surface. Thus there has been no suitable void space underground for the backfill of tailing**. Table 1-2** summarises tailing and waste rock placement as predicted in the original EA (at a production rate of 750,000 t) and what has actually been placed since commencement of operations.

A review was conducted by Golder Associates Pty Ltd (Golder) of potential off-site locations for tailing storage in and around the vicinity of the Mine (within 10 kms of the Rasp Mine site). A summary of this review will be included in the EIS. Acting on this review BHOP has determined to use Kintore Pit (the Pit) as TSF3, which will necessitate the relocation of the Mine access portal currently located within Kintore Pit.

Figure 1-1 Location of Kintore Pit within CML7

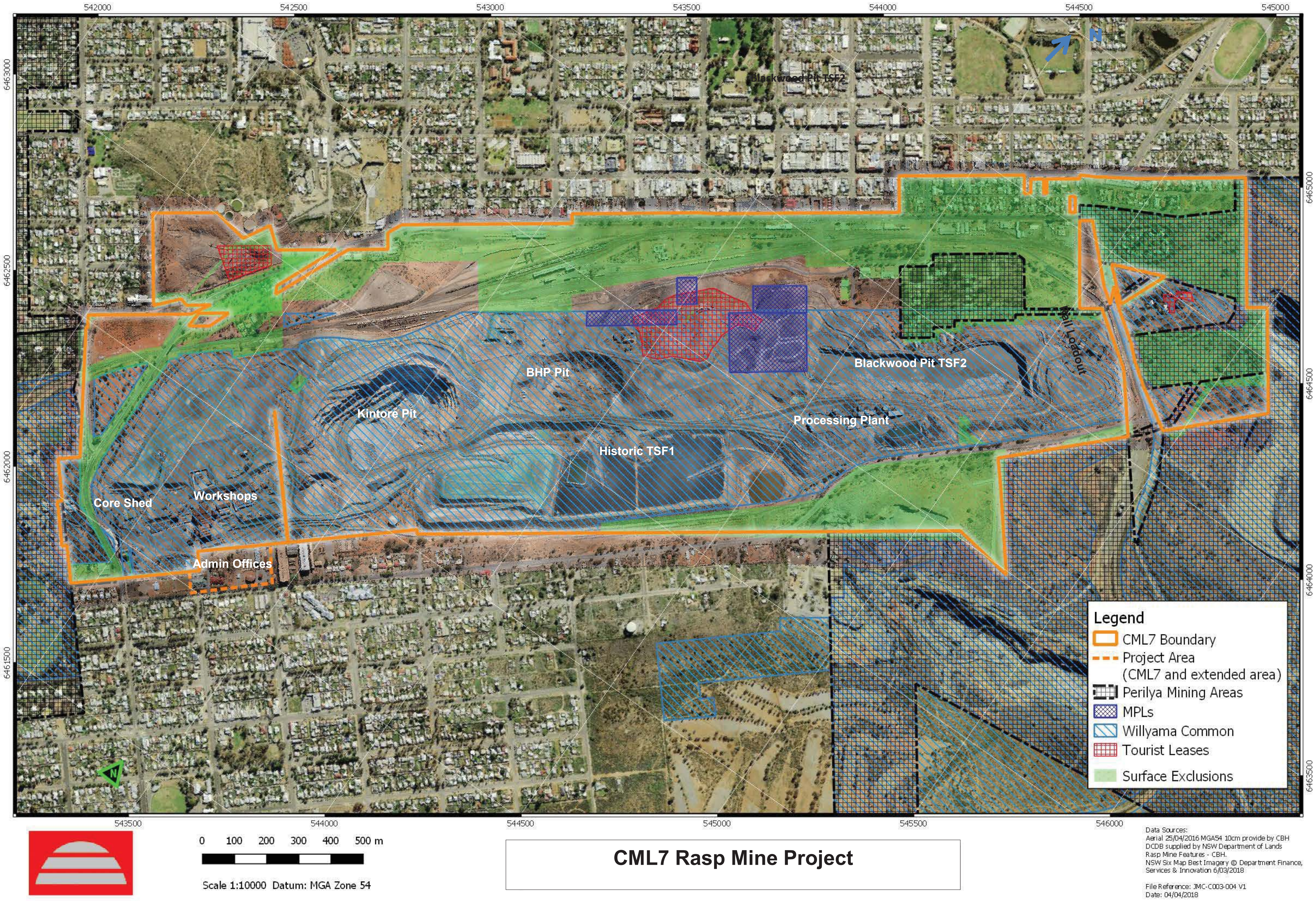


Table 1-2 Summary of Proposed (EA) and Actual Placement of Waste Rock and Tailing

Year (to 30 June)	EA Tailing in Underground backfill per year (t)	EA Tailing deposited in TSF1 (t)	EA Tailing deposited in TSF2 (t)	EA Waste Rock U/G (t)	Actual/ Planned[2] Tailing in TSF2 (t)	Actual waste rock placed underground (t)	Actual waste rock stored Kintore Pit (t)	Actual Total waste rock (t)
2012	97,969	273,281	0	250,000	322,111	47,527	150,000[1]	197,527
2013	195,938	195,138	0	250,000	574,833	230,607	150,000[1]	380,607
2014	195,938	195,138	0	250,000	486,749	223,473	163,304	386,777
2015	216,563	216,563	0	250,000	499,598	223,611	228,942	452,553
2016	247,500	88,281	159,219	250,000	555,837	265,369	96,888	362,257
2017	278,438	0	278,438	250,000	622,161	215,897	76,578	292,475
2018	309,375	0	309,375	250,000	644,828	330,577	121,864	452,441
2019	309,375	0	309,375	250,000	588,407	242,626	28,841[3]	401,811[4]
2020	309,375	0	309,375	250,000	488,789[2]	199,637[2]	135,000[2]	389,637[2/4]
TOTALS	**2,160,471**	**968,401**	**1,365,782**	**2,250,000**	**4,783,313**	**1,979,324**	**1,410,989**	**3,316,085**

Note[1]: Estimated
Note[2]: Planned
Note[3]: Waste material to surface totaled 2019 - 159,185t with 28,841t was placed in Kintore Pit and 130,344t placed in BHP Pit due to safety issues re- use of tipple in Kintore Pit. Planned waste material to surface 2020 – 389,637t with 135,000t to be placed in Kintore Pit and 55,000t in BHP Pit.
Note[4]: Also includes waste material placed in BHP Pit.

Waste rock will continue to be generated from mining activities in excess of suitable voids underground and require surface storage. This has resulted in the placement of this waste rock for co-disposal with the tailing in TSF3 and for rehabilitation capping.

Crushing of non-ore material is currently undertaken in Kintore Pit (EA) and BHP Pit (MOD7) and BHOP propose to continue these activities using a mobile crusher to produce material primarily for underground road base, surface bunding and / or other site requirements. The alternative is to buy-in aggregate type material at considerable cost.

Requests for administrative changes are also included in this EIS to:

- Seek new noise criteria for operations. This is to address the results of additional noise monitoring identified during completion of noise modelling for MOD6 and requirements outlined in the NSW EPA *Noise Policy for Industry (2017)*; and
- Align reporting requirements for the annual Environment Management Report (EMR) required by the mining lease and Schedule 4 Condition 3 of the PA requirements for an Annual Review (AR). These reports although similar have different time periods requiring two separate reports to be written and submitted within months of each other. Aligning these reports will streamline their formulation by BHOP and review by the regulator, removing duplication.

1.7 Consultation and Key issues

Meetings have been held with the relevant regulators to discuss the proposed modification - DPIE, the Broken Hill City Council (BHCC), Resource Regulator (RR) and the Environment Protection Authority (EPA). Requirements suggested by these regulator meetings are summarised in **Table 1-3**. This document details the aspects of the proposed modification and will be used to formalise consultation with these agencies. Consultation is planned with regulators to review the proposed tailing harvesting for the (naturally) drying, retrieval and transferring of tailing from Blackwood Pit TSF2 to Kintore Pit TSF3.

The Briefing Paper is being updated to alert regulators to proposed changes since the original Briefing Paper was first issued in June 2018, and to seek any changes, additions or amendments to issues to be addressed in the EIS (to those listed in **Table 1-3**).

Further consultation with the community will be undertaken during the formulation of the EIS and a community briefing meeting will be held to outline the proposed project and seek feedback.

Once the proposed concepts are developed consultation will also be undertaken with the Resources Regulator in regards to safety matters.

Table 1-3 Summary of Agency Requirements

Government Agency	Issues Identified
Broken Hill City Council Meeting: 25 June 2018	The BHCC does not have any initial concerns with the proposed project however dust and noise should be controlled and heritage structures avoided. There is no issue with visual amenity as it was considered an already disturbed mine site.
EPA Meeting: 27 June 2018	• Provide a description of waste rock to be transported to stockpiles including, particle size and metals content. • Human health risk assessment and in particular an assessment of potential impact on children's blood lead levels and describe air quality control measures used to ensure there is no net increase in blood lead levels. • Air quality assessment. • Noise assessment. • Provide groundwater assessment following tailing placement in Kintore Pit. • Provide seepage analysis for Kintore Pit. • Clarify and justify construction hours and describe the process to provide breaks from noise and activities for local residents. • Assessment of vibration and overpressure from new portal and decline development. • Provide summary of community consultation with local residents particularly in regards to noise and working hours. • Provide details in rehabilitation plan of methods to ensure minimum dust emissions from the site.
DP&E Meeting: 28 June 2018	• Project to follow the assessment pathway for a State Significant Development with MOD3 as the baseline. DPE to provide further information, include summary of assessment pathway in EIS. • Clarify and justify why waste rock stockpile capacities exceed requirement. • Consult with Resource Regulator re safety issues for underground mine workers. • Seepage analysis for Kintore Pit. • Groundwater quality assessment for Kintore Pit. • Air quality assessment. • Human Health Risk Assessment, indicating impact to children's blood lead levels. • Describe the dewatering/filtering system for tailing and its location. • Provide a summary of BHOP contributions to Health NSW. • Provide an assessment of blasting vibration and over pressure at portal and decline. • Provide assessment of the requirement for controlled actions under the EPBC Act, in relation to Broken Hill status on the National Heritage List (BH). • Provide an assessment for fauna (bats) habitat in old shafts / adits within Kintore Pit. • Provide an assessment of any visual impacts from the modification.
DRG Meeting: 29 June 2018	• Provide stability analysis of TSF1 (from collapse beneath) and TSF2 (from batter/embankment failure) for safe storage of waste rock. • Provide details for stormwater management on stockpiles. • Provide information on the geochemical characteristics of the boxcut material, variation within the material, and waste rock generally, this includes all relevant metals. Also its homogeneity. • Provide details of potential impact of tailing on ground water. • Provide an assessment of slumping of tailing in Kintore Pit at closure (also Blackwoods). • Justify the use of waste rock armouring against other dust mitigation measures. • Provide details of water management including seepage management, water expression through the pit walls and excess water from dewatering tailing. • Provide seepage analysis for Kintore Pit and detail methods to eliminate/minimise seepage. • Provide a noise assessment with modelling particularly in relation to the development of the boxcut. • Provide details for heritage within BHP Pit and how it will be protected. • Outline how noise and dust will be managed and any impacts to visual amenity. • Provide details of the design of the boxcut and entry point to Haul Road, e.g. final height of exit from boxcut to the ROM. • Provide assessment of potential liquefaction of Blackwood Pit tailing and the required stand-off

Government Agency	Issues Identified
	distance for new underground workings. • Show sizing of materials – waste rock and from boxcut and if fines show how they will be removed prior to covering 'free areas'. • Provide details for monitoring – air, water, slumping or subsidence (post closure). • Provide any details of waste generation e.g. fines from dewatering and how they will be treated. • Provide an assessment of long term geochemical degradation i.e. 100 to 500 years of waste rock used on surface coverings. • Provide assessment of alternatives for rehabilitation (for dust suppression). • Explain what the final landform will be.

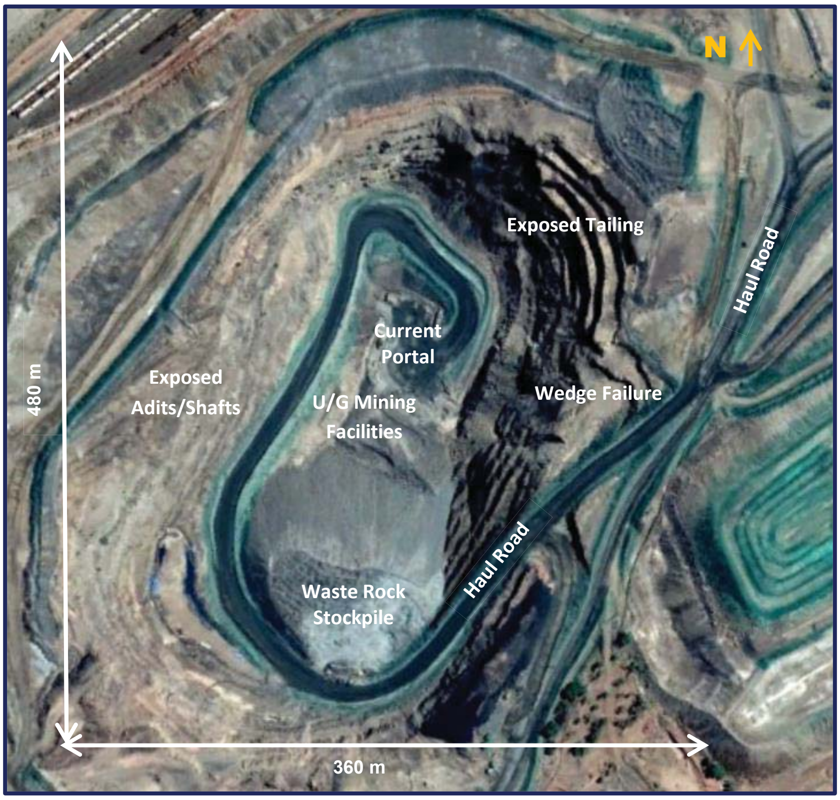
2.0 LOCATION OF PROPOSED MODIFICATION

This Section describes the location for tailing placement (Kintore Pit), the location for the new mine access portal and decline, tailing harvesting, non-ore crushing activities, waste rock placement and rehabilitation capping.

2.1 Kintore Pit

Kintore Pit (the Pit) is a large open pit mined in the 1970s currently used for underground mining access via a mine portal and decline and is located to the west of CML7, **Figure 1-1**. The Pit is approximately 100 m deep (RL210 to RL310) on the southern perimeter and approximately 480 m (north to south) by 360 m (east to west), **Figure 2-1**. Waste rock is used to fill underground voids and is stored in the Pit when there are no suitable voids available. On average 159,000 t per year has been stored in the Pit since mining commenced in 2012 to the end of 2019 (**Table 1-2**). An additional 135,000 t is planned to be placed during 2020 bringing the total stored in Kintore Pit to 1,410,989 t. This material will remain in the Pit. The current Haul Road will remain to provide access to the Pit.

Figure 2-1 Kintore Pit

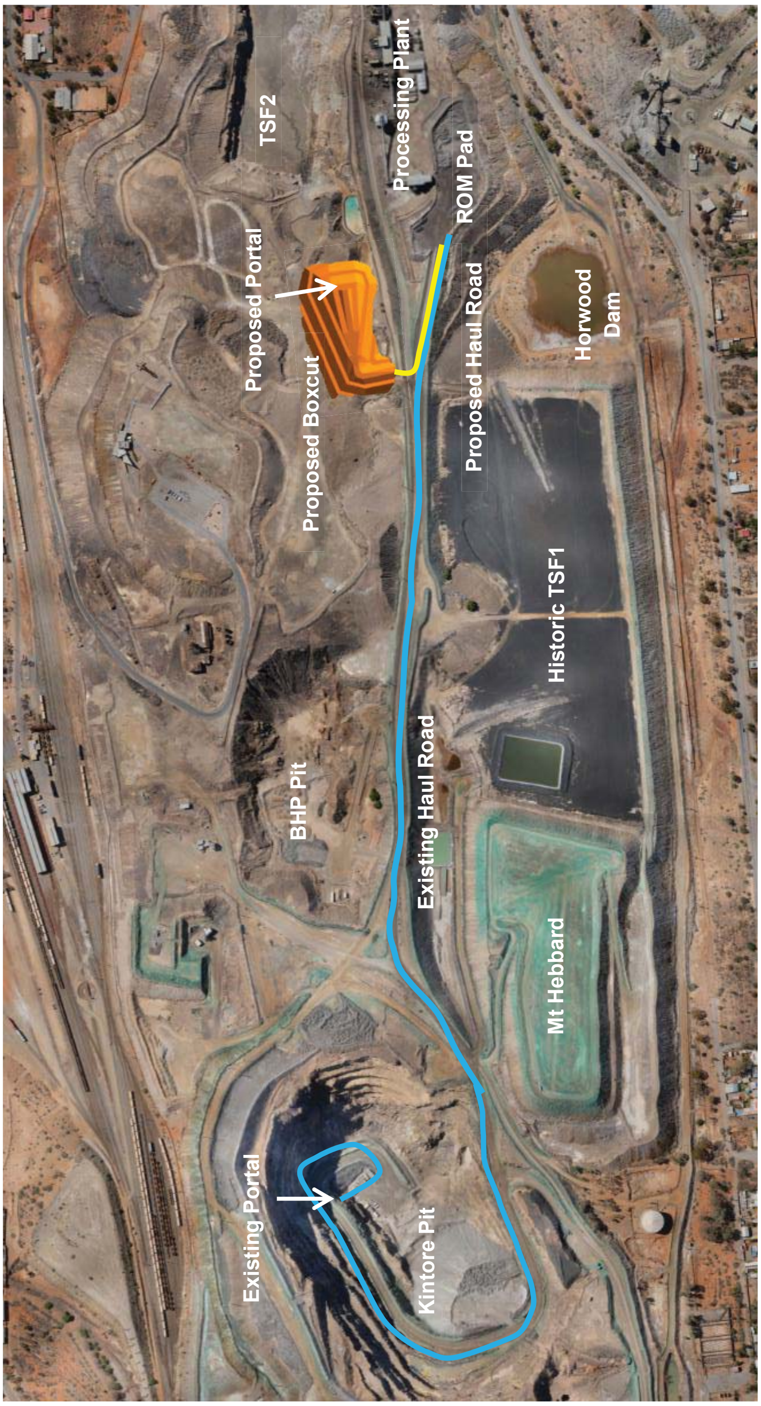


No vegetation is required to be removed, there are no heritage items located in the vicinity and there will be no additional land disturbance. There are no known fauna (eg bats) living in the old adits and shafts visible within the Pit. As part of operations of TSF3, voids will be inspected and an assessment for bat habitats would be conducted as they become safely accessible within the Pit. This will be outlined in the EIS.

2.2 New Portal

It is proposed to access underground mine workings via a new portal to be located adjacent to the Haul Road north-west of TSF1, **Figure 2-2**.

Figure 2-2 Indicative Proposed Portal Location



This will require the construction of a boxcut to obtain the required depth to connect to competent rock. The Haul Road will be realigned to meet this boxcut. The decline will be located to the northeast of the boxcut heading northwest to join existing and planned underground development.

This location will allow underground access to northeast areas of the Mine and will be closer to the ROM Pad which is used to stockpile ore prior to crushing, resulting in a reduction of the surface haul road route, from 2 km to 200 m. The area contains an historic waste rock dump and is already disturbed; no vegetation or heritage items are in the vicinity. It was included as a 'free area' in the original EA. There will be no additional land disturbance.

2.3 Periodic Crushing

Crushing activities are currently undertaken in Kintore Pit (EA) and BHP Pit (MOD7) and BHOP propose to continue these activities using a mobile crusher to produce material for road base, bunding and / or other site requirements. The location for these crushing activities is depicted in **Figure 1-1**.

2.4 Waste Rock Placement and Rehabilitation Capping

Since the commencement of mining operations BHOP has placed approximately 1,410,989 t of waste rock from underground workings into Kintore Pit (end 2019). Current mine plans (under the reduced production rates) have calculated total waste rock from mining operations to be brought to the surface from 2021 to the end of 2026 (current approved mining) as approximately 920,000 t.

It is proposed to co-dispose waste rock in Kintore Pit with the tailing (naturally dried that will be transferred from Blackwood Pit TSF2) with some material containing low or nil lead stored on the Kintore Pit Tipple or in BHP Pit where it would be tested and once its lead (Pb) content confirmed to be below <0.5%Pb used for rehabilitation capping.

In addition the development of the boxcut may generate approximately 440,000 t of waste material. This material has been deemed to be >0.5%Pb and will be permanently stored in Little Kintore Pit and in the infill area of BHP Pit, and then capped. Material from the new section of decline, to be installed to join existing and planned underground development, would be placed underground until the new portal opens and subsequently in the infill area of BHP Pit. All of this material is deemed to have a lead content >0.5%Pb.

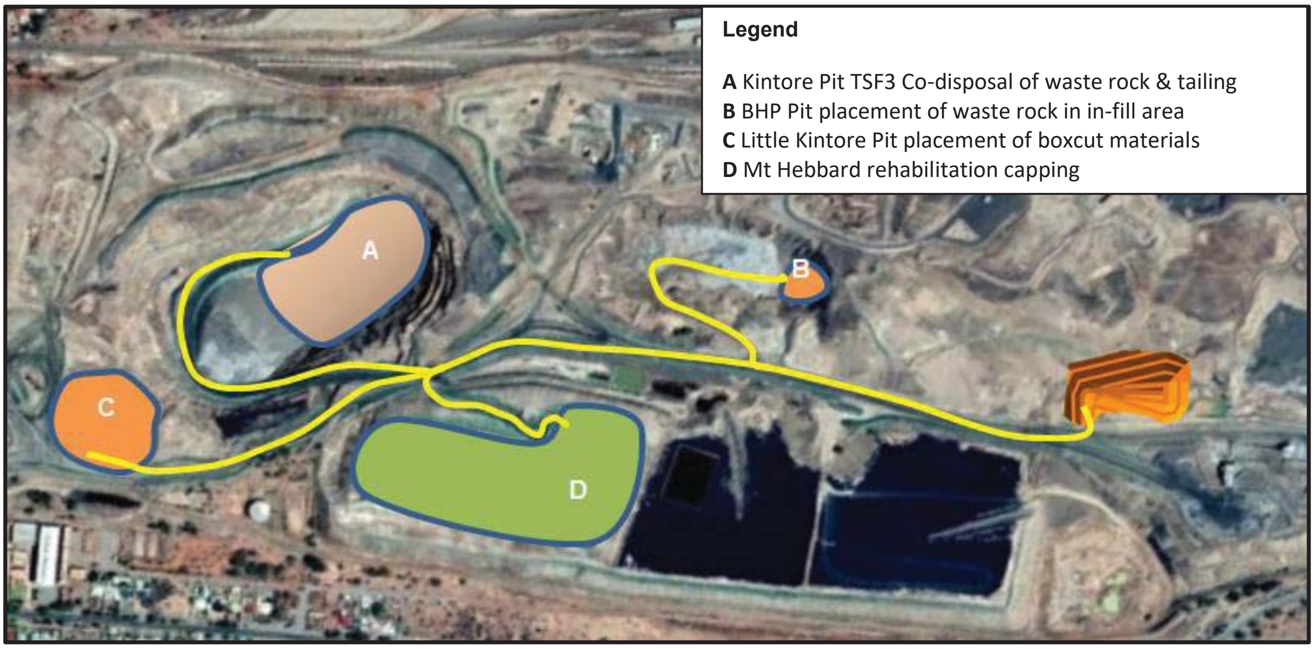
Table 2-1 provides a summary of the proposed placement for waste rock and quantities to be used for progressive rehabilitation capping. **Figure 2-3** indicates the proposed locations.

Table 2-1 Options for Waste Rock Placement and Rehabilitation Capping

Option	Location	Dimensions (at widest points) (m)	Area (m^2)	Lift Height (m)	Capacity (kt)
A	Kintore Pit co-disposed with tailing	W 360 L 480	NA	210	11,350
B	BHP Pit infill area only	D 14 W 80 L 80	NA	Infilled to current Pit floor level	197
C	Little Kintore Pit	D 17 W 125 L 130	NA	Infilled to current surface level	310
D	Atop Mt Hebbard historic tailing storage facility as rehabilitation capping.	L 320 W 130	32,000	NA	90
				TOTAL STORAGE CAPACITY	11,947

Note: 1 Waste Rock Loose density 2.2 g/cm^3
2 Final tonnages are indicative only and will be refined during final design, accuracy of final waste tonnage ±20%

Figure 2-3 Indicative Location Options for Waste Rock Placement and Rehabilitation Capping



3.0 DESCRIPTION OF PROPOSED MODIFICATION

This Section outlines details for the placement of tailing co-deposited with waste rock in Kintore Pit, installation of a new mine access portal and decline, tailing harvesting activities, non-ore crushing, waste placement and rehabilitation, and required administration changes.

3.1 Tailing and Waste Rock Co-disposal in Kintore Pit

Process tailing is currently deposited into Blackwood Pit TSF2 which will reach capacity in late 2022 when mining will cease if no alternative location has been approved for tailing disposal. Excess waste rock from underground mining is currently stored in Kintore Pit.

BHOP engaged Golder to undertake an investigation of both on-site and off-site opportunities for tailing storage. Golder identified several off-site possibilities all requiring land acquisition and extensive earthworks. The placement of tailing into Kintore Pit was the preferred option as there is no increase to the disturbance footprint and less impact to public and private land with the installation of pipe-works and access tracks. It was also the most cost effective option. Filling the Pit also provides a safer option at mine closure. An alternative analysis of these options will be provided in the EIS.

A general layout for the Pit is provided in **Figure 3-1**.

Investigations undertaken by Golder identified a number of issues that need to be considered in the design of the Pit as a storage facility, these include:

- Open cut excavations of the Pit that have exposed tailing from an old storage facility in the northern batter of the Pit.
- Old timber supports from crushed relict mine workings.
- Adits and shafts to old workings that are present in the batters on each side of the Pit, including behind the waste rock storage pile.
- Current Main Lode Drive (MLD) and old mine workings which are located below the Pit floor with a minimum rock cover thickness to the old workings of (approximately 10 m) and to the MLD (about 15 m). Once current mining operations are completed future access to the MLD will not be required and prior to commencement of tailing / waste rock disposal into the Pit, the MLD will be filled with waste material and barricaded to prevent access,

- Crown pillars separating the Pit floor from the old workings that were removed either during open pit mining or by previous underground remnant mining.
- A slope wedge failure that has occurred in the eastern batter of the Pit where the intersection of discontinuity planes in the rock slope have day-lighted in the batter slope. Failure of the wedge occurred in 2014 following a period of heavy rain.

Access to the current underground mine workings is via a portal and decline located at the base of the Pit into the toe of the western batter slope. The lower slopes of the western batter above and around the decline portal have been supported by a combination of resin bolts, split sets, cable bolts and fibre reinforced shotcrete. A plan view of the decline and access ramp is presented in **Figure 3-1** and shows the MLD branching at about 160 m with one ramp continuing to the northern mine workings and one turning back under the pit floor and connecting to the southern mine workings (Block 7).

The storage capacity of the Pit has been estimated by Golder at approximately 4.2 Mm^3. At current production rates for both waste rock generation and tailing placement, this provides approximately 12 years of capacity. There is the opportunity for this capacity to be extended by installing wall raises to the perimeter of the Pit however this will not form part of the MOD6 application.

The use of Kintore Pit as a tailing and waste rock storage facility requires closing the current underground mine access portal and decline. This will require managing old workings and recent mine workings beneath and around the Pit, to ensure dried and compacted tailing is contained within the Pit and address the risk of inrush to the underground workings. It will also involve the filling of the MLD and installing barricades to prevent access as this drive will no longer be required.

Based on current knowledge Golder have provided a concept design to install a concrete monolithic plug seal (20 m length) down the decline from the portal, followed by 50 m of waste rock backfill into the current decline. There are a number of safety measures being considered for the Pit and the plug seal will be designed as an additional safety measure against uncontrolled flow of seepage water or tailing into the mine workings. The final design of the plug will be made following a detailed geotechnical and risk assessment of the portal and decline rock conditions and will be provided in the EIS together with other required preparations within the Pit.

BHOP mining personnel are undertaking a review of all possible seepage / water flows through underground workings, including known historic workings, to identify any routes that may pose a risk to safety and require barriers. Where potential risks are identified Golder will design appropriate barriers with timing for their installation which will be reviewed by a geotechnical consultant.

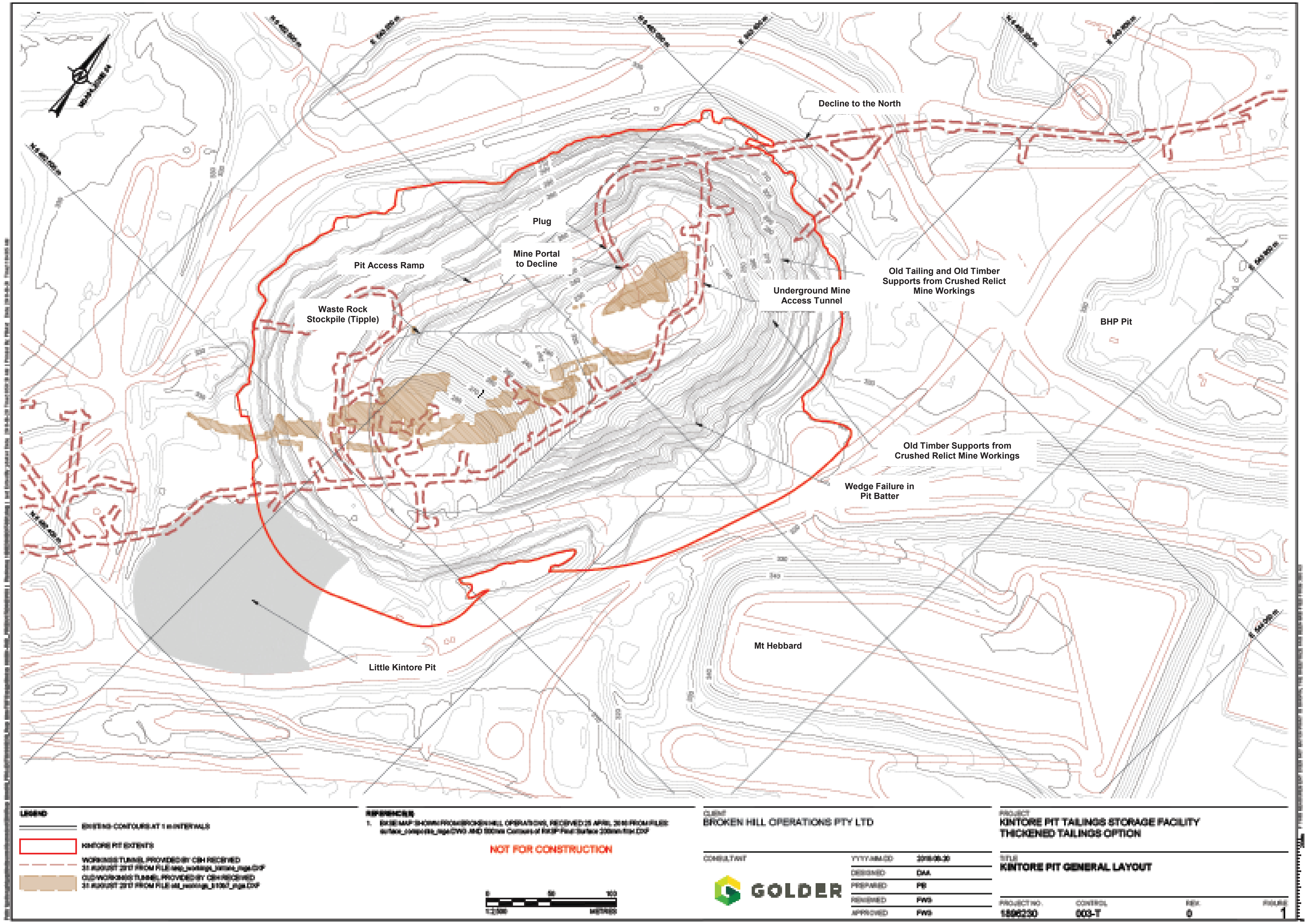
3.2 Tailing Harvesting

A risk assessment workshop held to address the risk of tailing inrush concluded that the tailing would need to be dewatered prior to deposition within the Pit, **Section 4.0**. BHOP engaged Golder to identify the maximum water content of the tailing to minimise the risk of inrush/inundation into underground mine workings. Golder concluded that to further minimise the potential for liquefaction of the tailing the optimal compaction moisture content was 10% for full stream tailing. This also results in a tailing that is sufficiently moist that it will not be dust generating but dry enough to be immediately trafficable. BHOP proposes to naturally (wind and solar) dry the tailing on the surface of Blackwood Pit TSF2 transferring the dried tailing for permanent storage into Kintore Pit TSF3.

Preliminary test results have shown that the current moisture content of the settled tailing in Blackwood Pit TSF2 varies between 9% to 12.5% therefore, where near surface tailing is removed, the required moisture level can be attained with no additional drying. The moisture content of the waste rock is approximately 3%.

The process for harvesting is currently under review with several options currently being assessed by Golder as the TSF2 Dam Engineer. With the installation of the embankments Blackwood Pit TSF2 was classified as a Declared Dam under the NSW *Dam Safety Regulations 2019* and once the harvesting methodology is known, consultation will be undertaken with Dam Safety NSW in accordance with these Regulations.

Figure 3-1 Kintore Pit General Layout



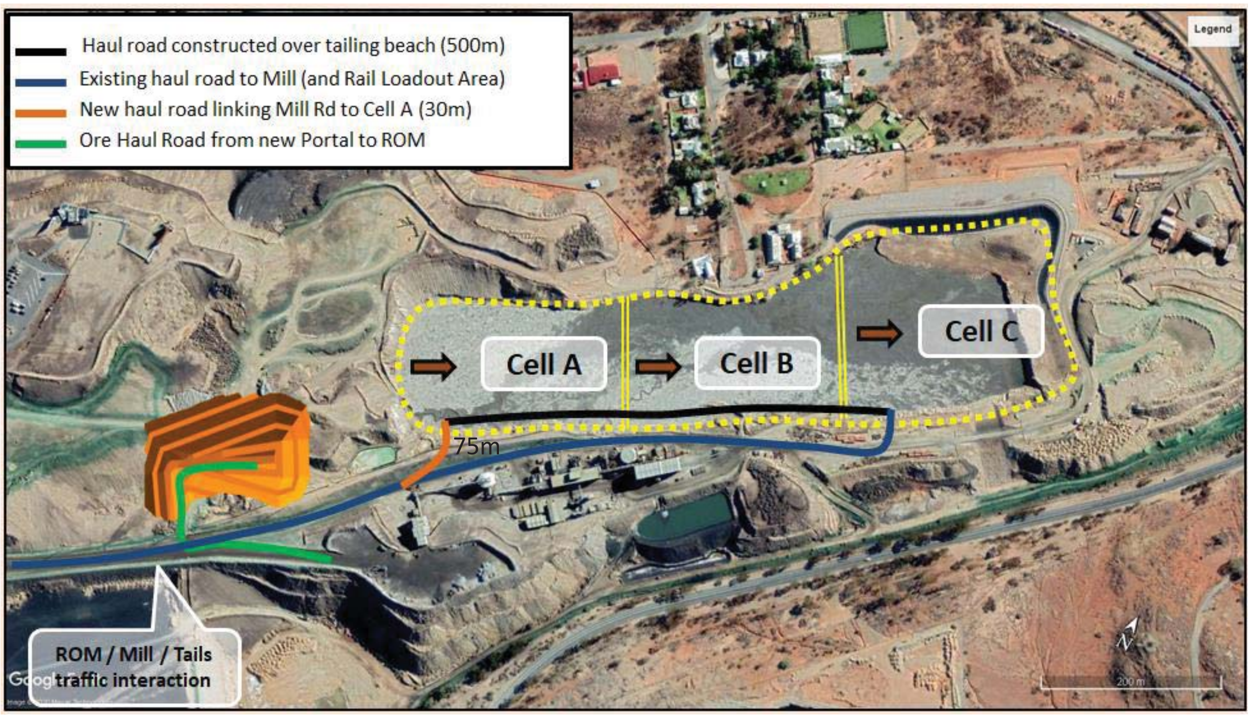
As a guide TSF2 would be divided into bays separated by bunding. Bunds will be constructed from waste rock material and are proposed to be approximately 1 m in height and 5 m wide to allow for access.

Figure 3-2 provides an indicative layout option for harvesting tailing. Tailing will be deposited alternatively between the bays keeping tailing beaching in the same direction without water pooling between the bays or tailing spilling from one bay to another. Any excess water will be directed (via natural gravity flow) to the northeast end of Blackwood Pit which will be kept to a minimum by pumping the water for reuse, in accordance with the current TSF Maintenance and Operations Manual.

Fresh tailing would continue to be placed in TSF2 and allowed to dry naturally (solar and wind), once sufficiently dried the tailing would be harvested and then transferred to Kintore Pit TSF3 continuing the cycle.

It is proposed to “shave” thin layers of the naturally dried tailing using specialised machinery such as a grader and dozers (D6) which will run along the length of a Bay scraping the tailing into windrows. These thinner layers are related to the drying time of hydraulically placed tailing allowing the layer to dry to the required moisture level.

Figure 3-2 Indicative Layout Option for Tailing Harvesting



Conceptual methodology proposes the use of two dozers to push the shaved tailing to the end of the Bay and form stockpiles in readiness for loading into trucks (60 t with 55 t payload) by an excavator and transferred to TSF3 or alternatively tailing may be pushed and directly loaded into trucks. Trucks would operate on an all-weather access track within TSF2 minimising the need for trucking directly on the tailing surface.

Tailing production within the mill operates 24 hours per day and may operate on a campaign basis or at current operating times (7 days per week). Tailing will be pumped to TSF2 as per normal methods with modified spigot locations. All other activities may occur on any day of the week, day shift only with operating hours 7 am to 6 pm Monday to Saturday and 8 am to 6 pm Sundays.

Under the current mine plan it is proposed to harvest a maximum of 480,000 tpa. **Table 3-1** indicates movements for the operation of mobile equipment for tailing harvesting activities and trucking to transfer tailing to TSF3.

Table 3-1 Indicative Mobile Equipment and Trucking Movements for Tailing Harvesting and Transfer

Equipment	Movements	
	Year	Day
2 D6 Dozers and 1 excavator	24,000	182
Trucks (55t payload)	8727	32

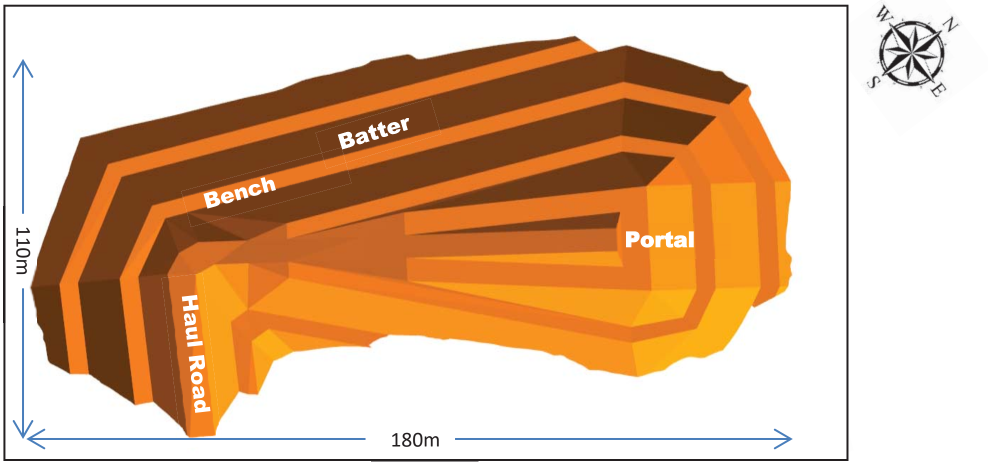
Full stream tailing will contains approximately 10% moisture and dusting is not expected however, a water spray system and water truck will be able to control any dust generation. In addition activities will be restricted to current site dust controls on windy days.

In addition the method for co-disposal of tailing with waste rock is currently under review by Golder.

3.3 New Boxcut, Portal and Decline Development

The construction of the proposed new underground access portal would require a boxcut constructed at a depth to reach competent hard rock material prior to the development of the new decline. The current design concept for the boxcut has been reduced, from that described in the previous Briefing Paper, to 180 m long and 110 m wide and up to 30 m deep at its lowest point prior to entry into the decline, **Figure 3-3**.

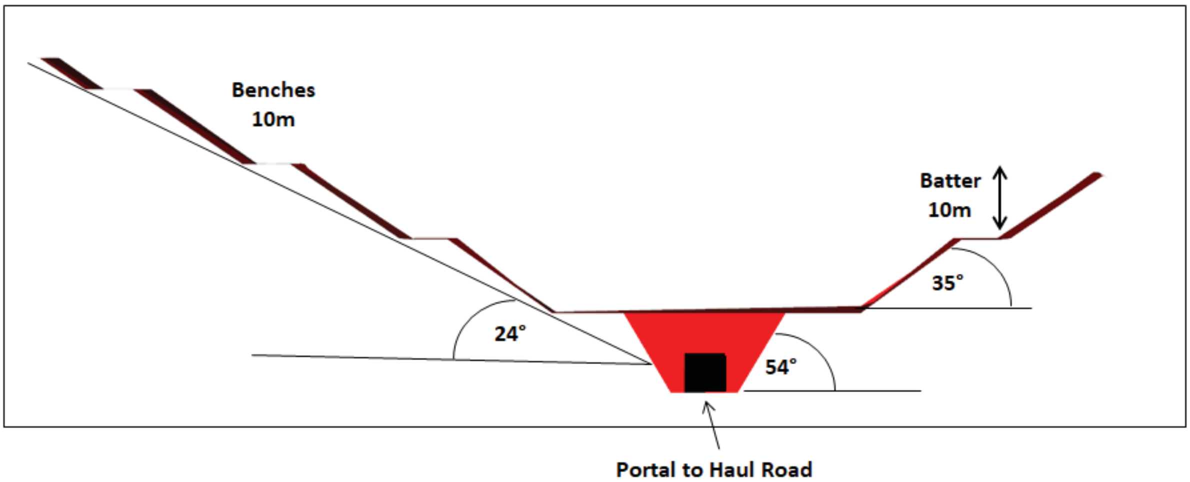
Figure 3-3 Indicative Proposed Boxcut and Portal



The overall slope angles for the boxcut would be 24^{o} with the Fill batter angle 35^{o} and the Rock batter angle 54^{o}, the benches would be 10 m wide and the batters 10 m high, **Figure 3-4**. This current design is the result of additional geotechnical information and improves geotechnical stability; the angle of the benches has been flattened, the benches have been made wider and the batters reduced in height and access has been moved slightly to the south to align better with the ROM Pad entry. The design may be further refined and this will be detailed in the EIS.

The boxcut will require the removal of approximately 440,000 t of material made up of predominately competent rock, waste and mixed rock fill, with small amounts of tailing (16,000 t) and slag (17,000 t). This waste material has been deemed >0,5%Pb as it is considered too difficult to separate out the lower Pb material. This material will be transferred to Little Kintore Pit and BHP Pit for permanent storage. On completion these Pits will be capped with material that has been tested and confirmed to be <0.5%Pb.

Figure 3-4 Cross-cut for Indicative Boxcut Design



A new decline will be installed from the proposed new portal and extend 400 m to meet existing and planned underground development. The total waste from this new section of decline is estimated as 40,000 t. The decline will be excavated from underground where possible with waste material placed in underground voids, once access is gained through the new portal, the material will be taken to BHP Pit for permanent storage. Conservatively all of this material has been deemed to go to BHP Pit for air and noise assessment modelling.

The proposed construction of the boxcut would be undertaken in three stages utilising a 65 t excavator, grader (12 m), 3 water carts (40,000 L), two D9 size dozers and up to six 43 t dump trucks. The 43 t trucks will be under-filled to 40 t to minimise spillage and dust exposure. The construction period will be approximately six months. This will require, over approximately 104 days, 10,889 truck movements taking waste material to in-pit storage areas (average 1,665 m distance). Using six 43 t trucks loaded to 40 t equates to approximately 11 truck movements per hour. This anticipates utilising shift times of 7 am to 6 pm, 6 days per week. It is proposed to undertake work on Sundays that will not adversely impact neighbours, particularly from machinery/truck generated noise, for example, maintenance activities.

The decline will be completed over an estimated period of three months, working normal mine shifts from underground over 24 hours per day 7 days per week and working 7 am to 6 pm 6 days per week from the surface, once access is gained through the new portal. Blasting methods will be designed by a mining specialist to minimise potential impact from vibration and overpressure, particularly in relation to the portal development. It is proposed where possible to mine the decline from underground to minimise surface impacts. Flyrock may be a potential risk with the development of the portal face and will be assessed as part of the EIS.

In operation there will be no change to the number and type of haul trucks used currently for transporting ore to the ROM Pad. The surface haulage distance to the ROM Pad will reduce from approximately 2 km to 200 m.

3.4 Periodic Crushing

Surface crushing of ore is undertaken in a fully enclosed crusher building under negative pressure venting to a baghouse. BHOP do not propose any changes to this activity.

Crushing of non-ore material (waste rock) is currently undertaken in Kintore Pit (EA) and BHP Pit (MOD7) and BHOP propose to continue these activities. Crushing is periodically conducted using a hired mobile crusher to produce material for road base (predominantly for underground roads), bunding and / or other site requirements.

Where waste rock material is proposed for use on the surface it is tested to confirm it contains <0.5%Pb prior to its placement. It is initially moisture conditioned with a water truck then stockpiled using a dozer. Moisture of the feed stockpile is maintained by use of a water truck equipped with sprays and high-pressure water cannon. An enclosed conveyor with water sprays is used to deliver crushed material to the stockpile. Following crushing the material is stockpiled for site use and dust is minimised using a water truck.

Crushing occurs periodically on a needs basis up to three times per year with the crushing activity occurring during day-time only, Monday to Friday, over a few days for each campaign.

3.5 Waste Rock Placement and Rehabilitation Capping

3.5.1 Waste Rock Characteristics

A waste rock study was undertaken in 2017 by Pacific Environment Ltd (PEL) for PA 07_0018 MOD4, Appendix K *Waste Rock Classification, March 2017*. PEL found that the bulk of the waste rock is composed of Garnet Pelite (GPE) and Psammopelite (PM), then Garnet Spotted Psammopelite (SPM) with very minor quantities of dolerite (DOL) and Garnet Quartzite (GQ) present. All of these rock types are described as hard and competent units with the exception of Garnet Pelite (GPE) 1 and 2, which is noted as a softer rock type that has been more susceptible to accommodating shearing. Conversely, DOL1 and DOL2 is rated as extremely hard rock with very high uniaxial compressive strength (UCS). An explanation of these geological rock description terms was contained within the report and will be described in the EA. The following discussion provides some highlights from the Report.

3.5.2 Particle size and moisture content

The waste rock composition was analysed for particle size and moisture content, and these results are presented in **Table 3-1**. PEL found that the moisture content of all samples was very low. Moisture content has a significant effect on rock strength, lower moisture contents are typically linked to increased rock strength which will impact how much weathering of the rock may occur over time.

PEL also found that the waste rock samples showed a consistent trend with a low proportion of small particle sizes. Laboratory reports showed that 4 of the 5 samples had 1% of the sample passing a 75 µm sieve; while one sample had 2% passing the 75 µm sieve. Significant volumes of dust are unlikely to be generated from particle sizes greater than 75 µm.

Table 3-2 Size and Moisture Characterisation

Sample ID	Moisture Content	Sieve sizes - Percentage Passing				
		75 mm	53 mm	19 mm	2.36 mm	75 µm (silt and clay)
1	3.1%	100%	52%	23%	8%	**2%**
2	1.6%	68%	49%	14%	3%	**1%**
3	3.1%	85%	47%	15%	5%	**1%**
4	3.4%	70%	47%	16%	5%	**1%**
5	3.4%	71%	49%	11%	3%	**1%**

Note - Results in **bold** represent particle sizes that are potentially ‘dust producing’

Furthermore PEL found that the greatest percentage of any sample passing a 2.36 mm sieve was only 8%, with 2.36 mm considered to be the geotechnical cut-off point for fine grained soils. Silt is classed as particles of less than 75 µm, but greater than 2 µm; particles of less than 2 µm are classed as clay. Therefore, the average silt content of the five samples is 1.2%, which may include some proportion of clay particles and may be dust generating.

PEL also commented that "*importantly, it is also noted that the proportion of small or fine grained material in the waste rock pile is likely strongly influenced by the method of mining (blasting) rather than being reflective of the rock's natural degradation and erosion (which will be slow).*"

3.5.3 Metals Content

It is known that the waste rock comprises a number of different rock types, in varying quantities. The waste rock samples were crushed prior to metals analysis being undertaken in order to homogenize the sample. This eliminated or reduced the possibility of preferentially sampling of the finer material, that may potentially introduce a bias to analytical results. Samples (six) were taken in August and September 2016.

The analytical results have been summarised in **Table 3-3** and the National Environment Protection Measure (NEPM) Health Investigation Level (HIL) guidelines are provided for comparison. PEL concluded that the "Recreational' guidelines would be the most relevant given potential future land use.

The concentrations of all metals analysed, with the exception of lead, are within the NEPM HIL-C (recreational) and HIL-D (industrial/commercial) guideline criteria. Four of the six samples exceed the NEPM HIL-C (recreational) criteria for lead in soil, and two of the samples (samples 3 and 5) exceed HIL-D (industrial/commercial) lead criteria. The mean lead concentration of all six samples was 2,371.5 mg/kg exceeding the NEPM HIL-C guideline value of 600 mg/kg and the HIL-D guideline value of 1,500 mg/kg.

Table 3-3 Summary of Laboratory Analysis Results, Moisture and Heavy Metals

Analyte	NEPM Guidelines			Sample ID (results in mg/kg)					
	HIL A (Residential)	HIL C (Recreational)	HIL D (Commercial)	Initial (Composite)	1	2	3	4	5
Arsenic	100	300	3,000	13	9	241	34	26	75
Barium	ND	ND	ND	40	30	30	30	30	20
Beryllium	60	90	500	<1	<1	<1	<1	<1	<1
Boron	4,500	20,000	300,000	<50	<50	<50	<50	<50	<50
Cadmium	20	90	900	6	<1	5	57	4	17
Chromium	100	300	3,600	17	22	13	10	20	17
Cobalt	100	300	4,000	8	9	16	14	10	11
Copper	6,000	17,000	240,000	93	15	55	240	45	141
Lead	300	600	1,500	543	57	**905**	**9010**	**684**	**3030**
Manganese	3,800	19,000	60,000	78	91	258	405	174	188
Nickel	400	1,200	6,000	12	18	18	12	19	18
Selenium	200	700	10,000	<5	<5	<5	<5	<5	<5
Vanadium	ND	ND	ND	15	22	18	14	28	22
Zinc	7,400	30,000	400,000	1780	222	1420	21500	973	4060
Mercury	10	13	180	<0.1	<0.1	<0.1	0.1	<0.1	<0.1
Moisture Content (%)	-	-	-	1.3	3.1	1.6	3.1	3.4	3.4

During the original Human Health Risk Assessment completed by Dr Roger Drew, Toxikos 2010, sampling was undertaken from various areas across the Mine and tested for lead content and its bioaccessibility. It was found that lead content alone did not determine how much was taken up into the human body and that the older more weathered material had the highest bioaccessibility, **Table 3-4**.

Table 3-4 Bioaccessibility of Lead in Surface Soils – Rasp Mine

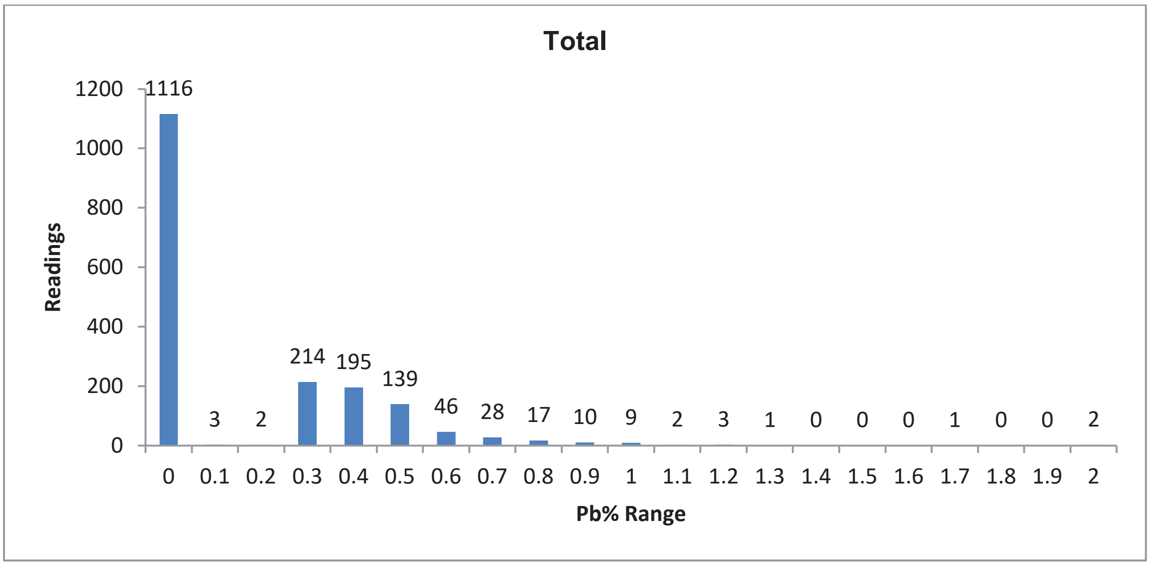
Sampling Point	Lead Concentration (mg/g)	Lead Concentration (mg/kg)	Lead Concentration (%)	Bioaccessibility (Bac) (%)
1	31	31,000	3.1	**14.6**
2	8.8	8,800	0.88	**3.6**
3	7.1	7,100	0.71	**8.5**
4	11.8	11,800	1.18	**6.1**
5	18.7	18,700	1.87	**3.7**

These lead concentration results are well above the levels found in waste rock sampling from the Kintore Pit Tipple with the exception of one sample (9,010 mg/kg) with the next closest result, 3,030 mg/kg. Therefore bioaccessibility of waste rock is expected to be low.

Figure 3-4 shows a summary of results of lead in waste rock from the Kintore Pit Tipple and the noise bund wall, undertaken for the Concrete Batching Plant. The results were obtained in-field using an XRF unit and maintaining a conservative approach by adopting the data at the highest end of the error margin. The number of readings taken was 1788 of which 1116 or 62.4% could not detect any lead, 93.3% (1669) of readings detected lead levels below 0.5% which is consistent with the findings by PEL of 0.237% lead content.

Broken Hill ore type is characterised for its very low pyrite content and the waste rock has even lower concentrations of pyrite, there is no visual evidence of acid drainage on the site. Some salts were evident in sampling and samples were high in calcium (major neutralising agent) however, there is insufficient information to draw any conclusions and further studies will be undertaken with the analysis reported in the EIS.

Figure 3-4 Waste Rock Sampling for Concrete Batching Plant



3.5.4 Waste Rock and Waste Material Placement

The material from the proposed new boxcut and decline is deemed to have a lead content greater than 0.5%. It is proposed that this material will be permanently stored in-pit within Little Kintore Pit and the in-fill area of BHP Pit. The volume of material is estimated at approximately 440,000 t from the boxcut and 40,000 t from the new decline (some of this material will be placed in underground voids prior to breakthrough and access is available to the surface via the new portal). The capacity of Little Kintore Pit has been estimated to hold 310,000 t and BHP Pit in-fill area 197,000 t.

It is also proposed to install waste rock with low lead content (<0.5%) as rehabilitation capping on the 'free areas' (non-active mine areas) of the site.

Location A – Kintore Pit TSF3

Location A Kintore Pit TSF3 has a capacity to hold approximately 9.4 Mt of tailing and it is proposed to co-deposit tailing with excess waste rock from underground mining.

No vegetation will be removed and there will be no addition to land disturbance.

Location B – Within BHP Pit, infill area only

BHP Pit is located centrally on the Lease near Delprats Mine and was in operation by BHP Pty Ltd in the 1890's through to the early 1900's, mining within the Pit ceased around 1907. No vegetation remains within the area and the area has been highly disturbed. Location B is approximately 717 m from the proposed new portal. There are a number of heritage items from the BHP era listed on the Broken Hill Local Environment Plan 2013, including building foundations, rock made wall, parts of an original headframe and a timber race, none of these items would be impacted. Barricades and signage are in place to separate activities currently undertaken in BHP Pit (ie waste rock storage, crushing and explosives storage) from heritage items.

BHP Pit is 180 m by 340 m and houses the Rasp Mine explosives magazine and ANE storage. The area proposed for waste rock storage lies to the north where the Pit is deeper. This proposed infill area is approximately 80 m (w) by 80 m (l) and 14 m deep and has a capacity of approximately 197,000 t.

Location C – Within Little Kintore Pit

Little Kintore Pit is located adjacent and to the south-west of Kintore Pit. It is approximately 130 m in diameter and 17 m deep. It is 1,751 m from the proposed new portal. Little Kintore Pit contains an old shaft that will be capped prior to material placement. There are no heritage items within Little Kintore Pit and there is no vegetation. The land is already disturbed by previous mining.

BHOP proposes to place waste rock containing higher levels of lead within Little Kintore Pit and cover with waste rock containing lead levels less than 0.5%. The capacity for waste rock storage at Little Kintore Pit is 310,000 t.

Location D - Atop Mt Hebbard

Mt Hebbard is an historic tailing storage facility completed in the 1970s. It lies to the south of CML7 adjacent to residential housing located along Eyre Street. This area was identified as elevated in lead by the Human Health Risk Assessment in the original EA.

The area is approximately 320 m x 130 m and there are no vegetation or heritage items within the area.

Preparation works will be required to upgrade the road to Mt Hebbard to allow truck access. These activities are expected to be of short duration occurring during daytime hours only.

BHOP have engaged a consultant to design capping placement to provide a permanent solution to minimise dust from wind entrainment and address surface water management. This study will also confirm that the surface is suitable and trafficable for the waste rock placement activities.

3.6 Administrative Amendments

Requests for administrative changes are also included in this EIS.

Noise Criteria

BHOP propose to seek new noise criteria in line with the results of additional noise monitoring identified during completion of noise modelling for MOD6 and requirements outlined in the NSW EPA *Noise Policy for Industry (2017) (NPfI)*. The NPfI has increased the minimum day RBL from 30 dB to 35 dB and the noise modelling for MOD6 will be undertaken in accordance with the new requirements. In addition further attended monitoring has been undertaken and this will be used to inform noise criteria levels for MOD6.

Annual Review / Annual Environment Management Report – waiting for section from Devon

Currently BHOP are required to provide two separate reports detailing environmental management performance to the Department of Planning Industry and Environment (DPIE):

(1) PA07_0018 Schedule 4 Condition 3 requires submission to the DPIE Compliance Section of an Annual Review (AR), and
(2) CML7 Condition 3 requires submission to the DPIE Resource Regulator of an Environment Management Report annually (EMR).

The reports are similar in their content; the MER reports on activities in a calendar year and is due on March 1 each year, and the AR is required to be submitted by the end of June each year for the reporting period may to April. This requires considerable duplication of staff time for to both identify and collect information and produce the two separate reports.

BHOP propose to provide a consolidated report addressing all issues for the one reporting period and as current internal reporting requirements run from January to December efficiencies could be gained if these reports aligned. Therefore BHOP seek a change to the PA to require the submission of the Annual Review to be March 1 to align to the EMR.

4.0 PRELIIMINARY ENVIRONMENTAL REVIEW

4.1 Preliminary Risk Review

In April 2018, HMS Consultants Australia Pty Ltd (HMS) was engaged by BHOP to facilitate a risk assessment on the proposed conversion of Kintore Pit to a tailing storage facility. The objective of the Kintore Pit TSF risk review was to assist in determining a safe and suitable option for converting the Kintore Pit into a TSF. This was attended by relevant BHOP management and consultants covering the fields of metallurgy, tailing storage design, mining engineering, geotechnical engineering, environment and safety **Tables 4-1** and **4-2** identify the potential relevant matters and key issues identified in the preliminary environment assessment for the proposed Kintore Pit tailing storage, new portal and waste rock stockpiles.

A risk review was also conducted by SP Solutions Pty Ltd in January 2020 and a further review is scheduled in September 2020. These assessments will further inform the EIS.

In addition BHOP conducted consultation meetings with regulators to identify their requirements for the development of the Project. These are summarised in **Table 1-3** and are addressed in **Tables 4-1** (potential risks during construction) and **4-2** (potential risks during operations).

The proposed MOD6 has the potential to result in additional environmental impacts to noise (including vibration and overpressure), air quality and community health. There is also a potential additional risk to mine safety from inrush and pit wall collapse associated with the depositing tailing above current mine workings and decline. In addition with the construction of the proposed new portal there is a potential risk of flyrock. BHOP will engage specialist consultants to provide assessments of potential significant impacts and advise on recommended measures to control any risks and inform detailed design. A summary of their conclusions and recommendations will be provided in the EIS.

Table 4-1 Review of Relevant Matters - Construction

Issue	Relevance	Key Issue
KINTORE PIT TSF3 (Preparation Works)		
Noise	Noise will be generated by: - closing portal and installing cement plug. Not considered a key issue as this work will be undertaken at the bottom of the Pit (110 m deep). - transport of cement for concrete plug. Not considered a key issue as cement trucks already enter the mine 24 hours/day for shotcrete, consistent with current practice. - truck movements within the Pit transporting waste rock material from the Tipple to the floor of the Pit together with excavators and dozers. Given the depth of the Pit and the time duration for these activities noise was not considered a key issue. However construction noise within the Pit will be included in the noise modelling for operations as it is planned to be completed 7 days per week during daytime hours.	No No No
Dust	Dust will be generated by: - cement trucks to construct plug, not considered a key issue as there will be no increase in truck movements as haul trucks will cease from this location so no additional traffic in this area - excavation and truck movements from relocation of waste rock from Kintore Pit Tipple to Pit floor. Although the majority of dust will be contained within the Pit, it is considered a key risk given the volume to be relocated and the number of truck movements.	No Yes
Community Health	The extent of preparatory works required will involve earthworks and the relocation of waste rock within the Pit which will be dust generating and will be included in the air quality and health risk assessments.	Yes
Traffic & Transport	There will be some increased traffic on public roads due to delivery of supplies and equipment but these will not be discernable from current deliveries.	No
Water	Additional water will be used for: - cement to construct plug, not considered significant as recycled water is proposed to be use - dust suppression, not considered significant as recycled water is proposed to be used	No No
Heritage	No heritage items are located in the proposed project locations.	No
Fauna	The use of old adits or shafts within the Pit walls by fauna is not considered likely due to difficult access. There are no known fauna currently in these old workings and there is no safe access to inspect any openings.	No
Land Disturbance	No vegetation to be removed, no additional land disturbance will be required.	No
PORTAL & DECLINE (New Boxcut & Little Kintore Pit Preparation Works)		
Noise	Noise will be generated by: - earthworks using bulldozer and excavator to construct boxcut - Installing access ramp and filling / capping old shaft in Little Kintore Pit (impacts not considered material due to short duration of activities - surface blasting - truck movements removing waste material	Yes No Yes Yes
Vibration and Overpressure	Vibration and overpressure will be generated by: - blasting to construct the portal and decline - vibration impacts to TSF1 and/or TSf2 causes liquefaction of tailing	Yes Yes
Flyrock	Flyrock may be generated during surface blasting for the portal opening.	Yes
Dust	Dust will be generated by:	

Issue	Relevance	Key Issue
	- earthworks using bulldozer and excavator to construct boxcut - Installing access ramp and filling / capping old shaft in Little Kintore Pit (impacts not considered material due to short duration of activities - blasting activities for portal and decline - truck movements removing waste material	Yes No Yes Yes
Community Health	It has been assumed that the excavated/waste material will be >0.5%Pb and has been included in the air and health assessments.	Yes
Traffic & Transport	There will be some increased traffic on public roads due to delivery of supplies and equipment, it is not expected that these will be discernable from current deliveries. Increased traffic on internal roads will be addressed via the site's Construction Environment Management Plan.	No Yes
Water	Additional water will be used for: - cement for shotcrete at portal and decline not considered significant as recycled water is proposed to be used - dust suppression, not considered significant as recycled water is proposed to be use	 No No
Power	High voltage power line runs along the Haul Road adjacent to the proposed boxcut and portal access.	Yes
Heritage	No heritage items are located in the proposed project locations.	No
Land Disturbance	No vegetation to be removed, no additional land disturbance will be required.	No
TAILING HARVESTING TSF2 (Preparation works)		
Noise	Noise will be generated by: - earthworks using bulldozer and excavator to form dividing bund between bays and platform for harvested tailing stockpiles (if required) As these works will be conducted over one week it is not considered a key issue however noise will be included in the construction scenario for modelling.	 No
Dust	Dust will be generated by: - minor earthworks to form dividing bund between tailing drying areas and platform for harvested tailing stockpiles As these works will be conducted over one week it is not considered a key issue however dust will be included in the construction scenario for modelling.	 No
Community Health	Tailing contains very low Pb levels (average <0.3%) As these works will be conducted over one week it is not considered a key issue however results from the air modelling will include any dust generated from this activity and will be used for the human health risk assessment.	No
Traffic & Transport	There will be no increase in traffic movement due to these activities.	No
Water	Additional water will be used for: - dust suppression, not considered significant as recycled water is proposed to be use	 No
Heritage	No heritage items are located in the proposed project locations.	No
Land Disturbance	As these works will be completed within TSF2 on already disturbed land.	No
WASTE ROCK PLACEMENT & REHABILITATION CAPPING (Preparation works)		
Noise	Noise will be generated by earthworks using an excavator to upgrade the road to the top of Mt Hebbard to allow truck access. As it is expected that this will be of a short duration (less than 1 week) and conducted during daylight hours, it is not considered material to noise levels.	No
Dust	Dust will be generated by earthworks using an excavator to upgrade the road to the top of Mt Hebbard to allow truck access. As it is expected that this will be of a short duration (less than 1 week), it is not considered material to dust levels.	No
Land Disturbance	As these works will be completed within TSF2 on already disturbed land.	No

Table 4-2 Preliminary Risk Review - Operation

Issue	Relevance	Key Issue
KINTORE PIT TSF3 (Placement of tailing and waste rock)		
Inrush	Inrush could occur from: - moisture content of tailing, - tailing liquefaction from seismic event, mine blasting, subsidence of old workings, Pit wall failure - water migration along major fault lines, unknown connection from underground workings to TSF - seepage or perched water table accumulation - old workings that may provide a pathway for water flow - erosion of pit walls, particularly old tailing slope	Yes Yes Yes Yes Yes Yes
Ground Failure	Ground failure could occur from: - Pit wall failure - Fault zones and geological structures - Stress change during filling - Failure of ground support in current drives - Failure of Pit floor	Yes Yes Yes Yes Yes
Noise	Noise will be generated by: - earthmoving equipment spreading and compacting the tailing, primarily as tailing reaches closer to the surface - trucking of excess waste rock from underground mining	Yes Yes
Dust	Dust may be generated by: - earthmoving equipment spreading and compacting the tailing and waste rock primarily as material rises in the Pit - as the level of tailing rise closer to the surface and the tailing further dries out - trucking of excess waste rock from underground mining	Yes Yes Yes
Community Health	Dust, which may contain lead, may be generated from tailing and waste rock primarily as the surface of the material rises closer to the surface	Yes
Water	Water may collect in a sump within the Pit, particularly with rainfall events (this will be used for dust suppression within the Pit or recycled to the Mill as current practice) Tailing may impact groundwater water quality.	No Yes
Traffic & Transport	Transfer of harvested tailing from Blackwood Pit TSF2 to Kintore Pit TSF3 will be undertaken by trucks.	Yes
Waste Management	There are no wastes generated from the tailing deposition	No
Fauna	The use of old adits or shafts within the Pit walls by fauna is not considered likely due to difficult access. There are no known fauna currently in these old workings To address the potential for fauna habitats within old adits and shafts an inspection (when safe access is available) shall be undertaken. It is proposed that these inspections occur during the life of the facility as tailing levels rise and access to old voids/workings becomes available.	Yes
Land Disturbance	Activities will be undertaken on already disturbed land	No
Rehabilitation	Rehabilitation of the filled Kintore Pit will need to be considered	Yes
PORTAL & DECLINE		
Noise	Although the Haul Road will be shortened a new section of road will be used exiting from the boxcut to the Haul Road requiring noise modelling to be updated. Waste will be transferred from underground via the portal to Kintore Pit Tipple and Kintore Pit TSF3 by trucks. Vehicle movements for changeover will now be conducted in the Laydown Area adjacent the boxcut and not on Kintore Pit floor.	Yes Yes Yes
Dust	From new portal road to Haul Road. Waste will be transferred from underground via the portal to Kintore Pit Tipple and	Yes

Issue	Relevance	Key Issue
	Kintore Pit TSF3 by trucks. Vehicle movements for shift changeover will now be conducted in the Laydown Area adjacent the boxcut and not on Kintore Pit floor.	Yes Yes
Community Health	There will be no additional impacts to community health with reduced haulage route some reduction may occur. Waste will be transferred from underground via the portal to Kintore Pit Tipple and Kintore Pit TSF3 by trucks.	No Yes
Surface Water	There will be no additional water used, management of rainwater runoff and collection around the boxcut and portal will be addressed in the Site Water Management Plan.	Yes
Traffic & Transport	The surface Mine Haul Road taking ore to the ROM Pad will intersect with trucks from harvested tailing and traffic from the Mill and Rail Loadout area.	Yes
Waste Management	No additional waste generated	No
Land Disturbance	There will be no additional land disturbance	No
Rehabilitation	The boxcut will need to be rehabilitated	Yes
TAILING HARVESTING		
Noise	Will be generated by mobile equipment within Blackwood Pit TSF2 and truck movements transferring tailing to Kintore Pit TSF3.	Yes
Dust	Will be generated by excavator and dozers scraping and collecting the tailing and placing in stockpiles, truck loading and trucking movements transferring tailing to Kintore Pit TSF3.	Yes
Community Health	Tailing contains some lead (average 0.3%Pb).	Yes
Ground Failure	Impacts to the integrity of the embankment structures could occur from: - Vibration of mobile equipment and trucking activities - Activities within the Pit that undermine the foundations of the embankments - High rainfall events impact surface integrity resulting in loss or roll-over of mobile equipment or trucks	 Yes Yes
Vibration	Vibration from mobile equipment and trucks operating within TSF2 impact surface stability and may result in subsidence.	Yes
Surface Water	Water sprays will be used for dust suppression however will be limited and recycled water to be used.	No
Traffic & Transport	Internal traffic with interaction between ore haul trucks and tailing transfer trucks.	Yes
Waste Management	No additional waste generated	No
Land Disturbance	Activities will be undertaken on already disturbed land within Blackwood Pit TSF2.	No
Rehabilitation	Rehabilitation of Blackwood Pit TSF2 will be delayed. A conceptual rehabilitation plan was provided as a part of MOD4.	No
PERIODIC CRUSHING		
Noise	There will be some noise generated from increased traffic and crushing activities however due to the short duration of these activities, which are to be conducted during daytime only, it is not expected to have a material impact on noise levels.	No
Dust	There will be some dust generated by increased traffic, stockpiling, crushing and material collection and placement. However due to the short duration and low instance during the year for these activities it is not expected to have a material impact.	No
Community Health	There will be some dust generated by increased traffic, stockpiling, crushing and material collection and placement. However due to the short duration and low instance for these activities it is not expected to have a material impact on community health.	No
Water	There will be some additional water used for dust suppression in regards to stockpiled material and crushing activity, however due to the short duration and low instance for these activities water demands are not expected to impact current water supplies.	No

Issue	Relevance	Key Issue
Traffic & Transport	There will be some increase in internal traffic taking material to stockpiles for crushing and removing and placing crushed material. However as these activities are for short periods no impact to current traffic systems are expected.	No
Heritage	There are no listed heritage items located in Kintore Pit, the listed heritage items located in BHP Pit have been barricaded for protection from all mining activities and will not be affected.	No
Visual Amenity	Crushing activities will be conducted in-pit and will not be visible from residential areas of Broken Hill.	No
Land Disturbance	There will be no additional land disturbance as crushing activities will be conducted in disused mine open pits.	No
WASTE ROCK PLACEMENT & REHABILITATION CAPPING		
Noise	Noise will be generated by: - haul trucks delivering waste rock for rehabilitation capping - dumping of waste rock	 Yes Yes
Dust	Dust will be generated by: - haul trucks delivering waste rock - dumping of waste rock - stockpiling waste rock and loading into trucks on the Tipple, for rehabilitation capping	 Yes Yes Yes
Water	There may be some changes to surface water management and this will be addressed in the updated Site Water Management Plan - water may be used for dust suppression during dumping - management of rainwater runoff and collection around capped area	Yes
Community Health	Waste rock will be confirmed at <0.5%Pb which is a reduction on the content of the current surface materials. A reduction in current dust from wind entrainment is expected removing the need for the application of chemical dust suppressant. Transport of waste from the Kintore Pit Tipple to the capping area may result in dust with elevated Pb levels.	No Yes
Geotechnical and Geochemical Characteristics	Waste material to be paddocked dumped. Surface stability may be impacted by waste rock placement activities. Long term impacts of material are unknown and will be addressed in a Long Term Waste Rock Study.	Yes Yes Yes
Traffic & Transport	There will be no affects to off-site traffic or transport Some increase in internal traffic only from Kintore Pit Tipple to capping area and is not expected to impact.	No
Spontaneous Combustion	The waste rock has very low concentrations of pyrite and therefore the material is not considered to have a risk of spontaneous combustion	No
Heritage	There are some heritage items located in BHP Pit however these are separated with barricades from current mining operations and will not be impacted by the placement of waste rock. Confirmation will be sought to confirm if a controlled action under the EPBC Act. Details shall be outlined in the EIS	No
Visual Amenity	The rehabilitation capping will be offset from the edge of the capping area and will not be visible from the town and will be consistent with the current mining landscape.	No
Land Disturbance	There will be no additional land disturbance, capping areas have no vegetation.	No

4.2 Kintore Pit Tailing TSF3 – Discussion of Key Issues

The key potential issues identified for pit preparation works and the storage of tailing and waste rock in Kintore Pit are discussed in the following sections.

4.2.1 Dust

Potential key issue

Pit preparation works include the movement of approximately 300,000 t of material with truck movements within the Pit taking the majority of this material from the Kintore Pit Tipple to the floor of the Pit. Although most of the activities will be undertaken 100 m from the surface over a period of 3 months, given the volume of material and number of traffic movements it was considered to include this as a key issue.

Dust generation during the operation of the dozer / roller working on the tailing is unknown. It is anticipated that potential dust issues may only arise when the level of tailing / waste rock rises closer to the surface.

Proposed management measures and studies

- Pit preparation and construction works will be undertaken within the Pit and any dust generated will be managed through normal operating practices. Dust generated from these activities has been included in the dust modelling under the construction scenario.
- The dust modelling results will inform the human health risk assessment.
- Method for tailing deposition to minimise dust and will be addressed in the Golder design report.
- Air modelling consultants will also review any additional requirements for dust monitoring.
- As tailing rises closer to the surface instigate additional dust mitigation measures.
- Use of chemical dust suppressant, where required.
- Conduct air quality modelling and include potential for dust generation during construction and operation, include operations in the cumulative air quality assessment. Model the potential for lead bearing dust to lift off tailing storage facility.
- Update of the Air Quality Management Plan.

4.2.2 Community Health

Potential key issue

Dust, which may contain lead, may be generated as the tailing rises closer to the surface.

Proposed management measures and studies

- Conduct dust modelling and include potential for lead bearing dust generation in cumulative air quality assessment.
- Include the potential for lead bearing dust from tailing in Human Health Risk Assessment and predictions for Broken Hill community blood lead levels.
- Assess and determine dust monitoring requirements for Kintore Pit.
- As the tailing rises closer to the surface instigate additional dust mitigation measures.

4.2.3 Inrush

Potential key issue

BHOP operate a portal and decline from the base of Kintore Pit to access underground mine workings. The MLD runs beneath the Pit allowing access to both the south-west and north-west workings. Historic workings are also located beneath and around the Pit, not all of these historic mine areas are known and/or logged. Any crown pillars that may have been below the Pit have been removed by previous mining. The portal access and a number of exposed and unknown voids, shafts, adits and geological faults are within the Pit. Not all possible water pathways are known.

Inrush poses a credible risk to underground workings where water can find its way via various pathways:

- Tailing and waste rock contain water which may pose an inrush risk.

- Possible liquefaction of the tailing which may occur from a seismic event, mine blasting, subsidence of old workings or pit wall failure which can trigger the event.
- Water could also enter underground workings from migration along major fault lines, unknown connections between underground workings to the TSF, seepage or perched water table accumulation which suddenly releases and erosion of pit walls, particularly the old tailing slope.

Proposed management measures and studies

Measures to minimise the risk of inrush will be determined during the detailed design however the preliminary risk assessment has identified the following measures to be considered and studies to be undertaken:-

- Fill the MLD with waste rock and barricade to prevent access prior to disposal of tailing / wast rock into Kintore Pit TSF3.
- Dewatering of full stream tailing to achieve the optimal compaction using naturally dried tailing from Blackwood Pit – tailing harvesting methods study and in-situ compaction testing.
- Adequate tailing compaction within Kintore Pit (critical state moisture content assessment).
- Design of tailing placement in TSF3 to address drainage and potential for seepage and will be addressed in the Golder concept design report.
- Installation of an engineered plug seal to portal to be designed to withstand full hydrostatic head and possible dynamic loads and other plugs/barriers as determined by further investigations.
- Undertake a seismic study.
- Undertake a mine water pathway study and assessment for further barriers if required.
- Sealing adits and old mine workings in the Pit walls where required (with waste rock) compacted tailing / waste rock will provide a base from which to treat these openings.
- Underground drive seepage water management.
- Surface water management - collect and pump excess water from the Pit and recycle to the Mill.
- Update the Tailing Maintenance and Management Plan.

4.2.4 Ground Failure

Potential key issue

The MLD is located beneath the Pit. The material above the MLD to the Pit floor is approximately 10 m to 15 m and crown pillars have already been removed.

Proposed management measures and studies

With the completion of current mining plans there access along this Drive will no longer be required, It is proposed to fill the Drive with waste rock and install barricades to stop access. BHOP will engage a suitably qualified consultant to confirm the methodology and provide safety assurance.

4.2.5 Noise

Potential key issue

Construction works will be undertaken within the Pit and any noise generated will be managed through normal operating practices. Although noise was not considered a key potential issue for pit preparation works, given the current level of truck movements within the Pit, as activities 7 days per week (during day time hours) BHOP has included noise generation in the noise modelling for operations.

During operations a dozer will be used within the Pit to spread materials and a roller to compact the tailing, the potential for noise to be an issue will only be evident when the tailing reaches closer to the surface.

Proposed management measures and studies

- Conduct noise modelling for pit preparation works as part of operations noise assessment.
- Incorporate truck and mobile equipment movements in noise assessment.

- Conduct cumulative assessment for post MOD6 operations.
- Update of the Noise Management Plan.

4.2.6 Water Assessment and Management

Potential key issue

There may be some mixing of water from tailing with groundwater which may impact groundwater quality.

Proposed management measures and studies

- Provide groundwater assessment following tailing placement in Kintore Pit and the potential impact on groundwater quality.
- Provide seepage analysis for Kintore Pit, including water expression through the Pit walls.
- Provide details of water management including seepage management and stormwater management in the Pit.
- Provide underground drive seepage water management.
- Update the Tailing Maintenance and Management Plan.

4.2.7 Rehabilitation

The rehabilitation of Kintore Pit will be required and needs to be developed in consultation with DRG, BHCC and the inter-government group reviewing closure and rehabilitation options for the whole of the Line of Lode. A preliminary closure concept shall be provided in the EIS for both Kintore Pit and Blackwood Pit tailing storage facilities. The following items will be addressed:

- Details of rehabilitation plans and methods to ensure minimum dust emissions from the site.
- An assessment of slumping of tailing in Kintore Pit at closure.
- Justification for the use of waste rock armouring against other dust mitigation measures.
- Details for monitoring – air, water, slumping or subsidence post closure.
- Assessment of alternatives for rehabilitation (for dust suppression).
- Description of the final landform (subject to advice received from DRG and the inter-government group).

4.3 Boxcut, Portal & Decline – Discussion of Key Issues

The key issues identified during the construction and operations of the new portal are discussed in the following sections.

4.3.1 Noise

Potential key issue

A number of potential key issues for noise were identified during the preliminary risk review resulting from construction activities including noise from earthworks using bulldozer and excavator to construct boxcut, trucking of material to Little Kintore and BHP Pits and surface blasting.

There were no key issues identified during operations as the surface Haul Road taking ore to the ROM Pad for processing will be shortened. A new section of road (50 m to 100 m) will be installed exiting from the proposed portal to the Haul Road, the current Haul Road will then be crossed to gain access to the ROM Pad. Noise modelling will be updated to include these changes.

Proposed management measures and studies

Measures to minimise noise will be determined following noise modelling as part of the EIS, however the following will be considered:-

- Construction of boxcut and portal to be during daytime hours only, with plans to identify what equipment will be in use and its location over the weekly period.
- Schedule of works to minimise potential noise impacts to surrounding neighbours on Sundays.
- Identification and assessment of all feasible and reasonable mitigation measures that can be implemented.
- Use of ‘squawker’ type reverse alarms on vehicles used on site.
- Timing of surface blasting to minimise impacts to surrounding neighbours.
- Development of Construction Environment Management Plan – New Portal.
- Modelling of noise for construction and operations, including cumulative noise levels with operations.
- Update of the Noise Management Plan.

4.3.2 Vibration and Overpressure

Potential key issue

Vibration and overpressure will be generated during construction from blasting to create the portal and decline. There were no potential key issues identified for vibration and overpressure during operations.

The new portal and decline will be located close to TSF1 and / or TSF2. During construction blasting activity or truck movements may have the potential to impact these facilities causing liquefaction. The propensity for historic tailing material (TSF1 and TSF2) to liquefy as a result of the development of the decline and mining activities is unknown.

Proposed management measures and studies

- Design of blasting methods, parameters, blast size and during and the timing of blasts.
- Review monitoring requirements for blasting.
- Vibration and overpressure modelling will be undertaken to predict potential impacts for portal and decline development.
- Assess the potential vibration and overpressure impacts to surrounding residential and sensitive receptors.
- Assess the potential for liquefaction of TSF1 or TSF2 from blasting activities and in the case of TSF2, surface truck movements.
- Update the Technical Blasting Management Plan.

4.3.3 Flyrock

Potential key issue

Flyrock may be generated during the construction of the portal.

Proposed management measures and studies

The blast plans shall assess and indicate an exclusion zone which will be signed off by a competent person. The establishment and management of the exclusion zone shall be conducted via a formal procedure which explains the boundaries, evacuation, clearance checking methods, and requirements for removing the exclusion zone.

Summary details will be outlined in the Construction Environment Management Plan – New Portal.

4.3.4 Dust

Potential key issue

During the construction phase dust will be generated by earthworks using dozers and excavators to construct the boxcut, and truck movements to remove waste material. Increase in traffic with heavy and light vehicles using the Haul Road during construction of the boxcut and new portal.

During operations dust will be generated by haul trucks taking ore to the ROM Pad, however, this is not identified as a key issue as the shorter Haul Road will reduce dust levels from truck movements.

During operations dust will also be generated by truck movements transporting waste rock to Kintore Pit TSF3 for co-disposal with tailing. Waste rock will also be taken to Kintore Pit Tipple and/or BHP Pit for testing of its Pb content prior for use as rehabilitation capping (expected average one truck per day, Monday to Friday only).

In addition vehicles entering the Laydown Area at shift change may also generate some dust.

These activities will be included in proposed dust modelling which will include a cumulative assessment.

Proposed management measures and studies

- During construction water sprays and water trucks will be used to minimise dust. Dust management will be outlined in the Construction Environment Management Plan – New Portal.
- Management of potential dust generating activities on windy days will be addressed via current procedures which include suspension of works if required (where winds exceed 50 kph).
- Use of chemical dust suppressant, if required.
- The majority of the route transporting waste material will be on sealed roads.
- The section of the new road from the portal to the Haul Road shall be sealed.
- Conduct safety assessment for vehicle interactions on the Haul Road, including identification of control measures.
- Formulate Traffic Management Plan for Construction.
- An air quality assessment will be undertaken by a specialist and will include modelling to identify other areas for dust mitigation measures including a cumulative assessment with proposed operations.
- Update of the Air Quality Management Plan.

4.3.5 Community Health

Potential key issue

Dust, which may contain lead, may be generated with removal of materials for the boxcut, portal and decline and transport of these materials to storage areas.

Proposed management measures and studies

- Undertake analysis of the chemical properties of waste materials.
- Assess the potential for lead bearing dust from material removal and ongoing waste rock placement and assess the bioaccessibility of these materials.
- Identify and describe the air quality control measures used to ensure there is no net increase in blood lead levels.
- Review dust monitoring requirements for construction of the boxcut and portal, and road transport of this material, including ongoing waste rock removal via the portal to waste stockpiles.
- Determine dust suppression measures including the use of water sprays, misting and water truck or other as identified.
- Complete a Human Health Risk Assessment (including a cumulative assessment with current operations).

4.3.6 Power

A high voltage power line (22kV) runs along the ore Haul and Mill Roads. An assessment will be conducted to determine safety risks associated with the interaction of both construction vehicles and operations traffic and determine any required control measures.

4.3.7 Rehabilitation

At the time of mine closure the boxcut and portal will require rehabilitation. This will require some reshaping of the batters around the portal and backfill of the portal. A conceptual closure landform will be proposed in the EIS.

4.4 Tailing Harvesting - Discussion of Key Issues

There were no key issues identified for preparation works for tailing harvesting. The following key issues were identified for operation of the tailing harvesting.

4.4.1 Noise

Potential key issue

Noise will be generated by mobile equipment operating within Blackwood Pit TSF2 and truck movements transferring harvested tailing to Kintore Pit TSF3.

Proposed management measures and studies

Noise modelling undertaken for MOD6 will include noise generated by tailing harvesting activities and trucking of tailing to Kintore Pit TSF3.

4.4.2 Dust

Potential key issue

Dust will be generated by excavator and dozers scraping and (trucks) collecting the tailing and placing in stockpiles, truck loading and trucking movements transferring tailing to Kintore Pit TSF3.

Proposed management measures and studies

Surface tailing has a moisture content of approximately 12% and is not expected to be dusty. Normal operating practices such as the use of a water truck and chemical suppressants will be applied to minimise dust emissions during operations. The water spray system will also assist to further minimise dust.

Dust modelling undertaken for MOD6 will include dust generated by all tailing harvesting activities including trucking of tailing to Kintore Pit. All relevant metals have been included in this modelling which will form the basis for the Human Health Risk Assessment.

4.4.3 Community Health

Potential key issue

The tailing has a smaller particle size than waste rock and contains an average of 0.3% Pb.

Proposed management measures and studies

- Dust generated from tailing harvesting will be included in the dust modelling which will form the basis for the Human Health Risk Assessment.

4.4.4 Ground Failure and Vibration

Potential key issue

There is potential for the integrity of the embankments to be impacted by the vibration of mobile equipment and trucks operating within Blackwood Pit TSF2 and harvesting activities that could undermine the embankments particularly at EMB1 and EMB3 which are located on the tailing surface. High rainfall events may impact surface integrity resulting in loss or roll-over of mobile equipment or trucks.

Proposed management measures and studies

Golder, the nominated Design Engineer for Blackwood Pit TSF2, have been engaged to provide a methodology for tailing harvesting and will address these risks in their design report. In addition BHOP will consult with Dam Safety NSW regarding the harvesting process methodology and the potential to impact embankment integrity.

4.4.5 Traffic & Transport

Potential key issue

BHOP has identified a potential risk for internal traffic with interactions between ore haul trucks and tailing transfer trucks and both of these trucks with light vehicles.

Proposed management measures and studies

- An assessment will be undertaken by BHOP to determine controls and from the outcome of this investigation the Traffic Management Plan will be updated.

4.5 Waste Rock Placement and Rehabilitation Capping - Discussion of Key Issues

The key issues identified for waste rock placement and rehabilitation capping are discussed in the following sections.

4.5.1 Noise

Potential key issue

Noise will be generated by:

- During construction, by waste material being transferred from the boxcut to Little Kintore Pit (LKP) and BHP Pit.
- During operations, by haul trucks delivering waste rock to Kintore Pit TSF3 for co-disposal with tailing, and Kintore Pit Tipple and BHP Pit for testing and use as rehabilitation capping once Pb content is confirmed to be <0.5%Pb.
- Paddock dumping of waste rock at the rehabilitation capping area.

Proposed management measures and studies

Measures to minimise noise will be determined following noise modelling as part of the EIS, however the following will be considered:-

- Identification and assessment of all feasible and reasonable mitigation measures that can be implemented.
- Placement activities to occur during daylight hours only.
- Use of ‘squawker’ type reverse alarms on vehicles used on site.
- Modelling of noise, including cumulative noise levels with current operations.
- Update of the Noise Management Plan.

4.5.2 Dust

Potential key issue

Dust during the operation of waste rock stockpiles will be generated by:

- Haul trucks delivering waste rock to the stockpiles in Kintore Pit tipple and BHP Pit.
- Truck loading and dumping of waste rock in pits and at rehabilitation capping areas.

Proposed management measures and studies

Measures to minimise dust will be determined following air quality modelling as part of the EIS, however the following will be considered:-

- Use of a water truck and water sprays.
- Management of potential dust generating activities on windy days including suspension of works if required (winds exceed 50 kph).
- An air quality assessment will be undertaken by a specialist and will include modelling to identify other areas for dust mitigation measures including a cumulative assessment with operations.
- Update of the Air Quality Management Plan.

4.5.3 Community Health

The waste rock will contain low levels of lead and there is the potential, where dust is generated, to impact community health. BHOP will engage a suitably qualified specialist to assess any potential for health impacts and will provide the findings and recommendations in the EIS.

4.5.4 Geotechnical and Geochemical Characteristics

The design of rehabilitation capping will be completed by an experience engineer to provide the most appropriate structure and dumping method to minimise dust generation over time and address storm water management and acid mine drainage. In addition an assessment of the waste rock materials will be undertaken to provide a design that is safe, stable and non-polluting. Confirmation of the surface suitability and trafficability for the proposed waste rock placement activities will also be assessed.

Proposed Studies

- Assessment of long term geochemical degradation ie 100 to 500 years of waste rock used on surface coverings.
- Rehabilitation design report.

4.5.5 Rehabilitation

The waste material placement within LKP and BHP Pit will be capped with material containing <0.5% Pb and be shaped to align with the surrounding landform. Conceptual rehabilitation designs will be included in the EIS which will also address:

- Measures to minimise dust emissions from the site.
- Justification for the use of waste rock armouring against other dust mitigation measures.
- Details for monitoring – air, water, slumping or subsidence (post closure).
- An assessment of alternatives for rehabilitation (for dust suppression).
- Description of final landform.

4.6 Cumulative Environmental Impacts

The potential for cumulative impacts, that is impacts from construction and new operations with current operations, will be considered in the EIS, particularly in relation to potential noise and dust impacts.

It is also intended to hold a presentation event for the community of Broken Hill prior to finalisation of the EIS and details of this consultation will be included in the final EIS report.

5.0 BENEFITS OF THE MODIFICATION

The proposed modification would:

- Permit mining at the Rasp Mine to continue post 2022 with additional storage of tailing;
- Significantly reduce the surface distance of hauling ore from underground to the ROM Pad;
- Ensure continued employment of 186 full-time employees, 32 full-time contractors and indirectly over 200 casual contractors that provide specialist services when required;
- Engagement of approximately 20 contractors during construction and an additional 6 full time employees for operations
- Allows the filling of legacy open pits.
- Allow the resource to be fully utilised, and
- Allow BHOP to continue to support the sustainability and economy of Broken Hill.

It is considered that the proposed modification could be implemented with appropriate management of the increased risk of noise and dust generated primarily during the short construction period.

Placing tailing on the Lease in a disused pit results in no additional land disturbance, no interruption to local land use and farmers, no dust and noise that would result from off-site road traffic (from an off-site location) reduced costs for design, construction and operation.

Without approval of the MOD6 the Rasp Mine will cease operation in 2022 when current capacity for tailing storage is attained.

6.0 APPROVAL REQUIREMENTS

In addition to the application to the Department of Planning, Industry and Environment to modify the Project Approval 07_0018, BHOP will also seek to modify its Mining Operations Plan and will consult with the EPA to determine if any variation to its Environment Protection License 12559 is required.

7.0 ADDITIONAL INFORMATION

For additional information please contact:
Gwen Wilson
Group Manager – Safety health Environment Community
CBH Resources Ltd
Broken Hill Operations Pty Ltd
M: 0431 483 825

8.0 ACRONYMS

AR	Annual Review required under PA07_0018
BHCC	Broken Hill City Council
BHOP	Broken Hill Operations Pty Ltd
CBH	CBH Resources Ltd
CML7	Consolidated Mine Lease 7
DOL	Dolerite
DPIE	NSW Department of Planning Industry and Environment
EA	Original Project Environment Assessment Report
EIS	Environment Impact Statement
EMR	Environment Management Report required annually under CML7
EP&A Act	NSW *Environment Planning & Assessment Act 1979*
EPA	NSW Environment Protection Authority
g	grams
Golder	Golder Associates Pty Ltd
GPE	Garnet pelite
GQ	Garnet quartzite
GRES	GR Engineering Services Ltd
Ha	hectare
HIL	Health Investigation Level
HMS	HMS Consulting Consultants Australia Pty Ltd
kg	kilogram
km	kilometres
kph	kilometres per hour
kW	kilowatts
kV	kilovolts
(l)	Long
L	litre
LEP	BHCC Local Environment Plan 2013
LKP	Little Kintore Pit
m	metres
M	million
m^3	cubic metres
mg	milligram
MOD1	Relocation of the main ventilation shaft
MOD2	Crushing of ore permitted to occur at any time
MOD3	Extend underground mining into Block 7 (includes the Zinc Lodes)

MOD4	BHOP Modification for the erection of a Concrete Batching Plant and the construction of embankments to extend the life of TSF2
MOD5	Proposed modification for a Stores Warehouse extension, installation of a cement silo and adjustments to air quality monitoring requirements.
MOD6	Proposed modification to the PA for placing tailing in Kintore Pit and relocation of the mine access portal and waste rock stockpiles
MOP	Mining Operations Plan
NEPM	National Environment Protection Measure
Normandy	Normandy Mining Investments
NSW	New South Wales
PA	Project Approval 07_0018
Pb	lead
PEL	Pacific Environment Ltd
Perilya	Perilya Broken Hill Operations Pty Ltd
the Pit	Kintore Pit
PA	Project Approval 07_0018
PM	Psammopelitic
PM10	Particulate matter with equivalent aerodynamic diameter of 10 micrometres
RR	NSW Division of Resources Regulator
Rasp Mine	the Mine
ROM Pad	Run of Mine Pad (for ore storage prior to crushing)
SEPP	NSW State Environment Planning Policy
SPM	Garnet spotted psammopelite
SSD	State Significant Development
t	tonnes
tpa	tonnes per annum
tph	tonnes per hour
TSF1	Historic tailing storage facility
TSF2	Blackwood Pit tailing storage facility
TSF3	Proposed Kintore Pit tailing storage facility
UCS	Uniaxial Compressive Strength (measure of rock strength)
U/G	Underground
µg	microgram
µm	micrometre
(w)	Width
XRF	X-Ray Fluorescence Analyzer
Zn	zinc

APPENDIX N

Ground Control Engineering Report G0202 Geotechnical Assessment of the Rasp Mine Box Cut, dated 17 December 2020.

GROUND CONTROL ENGINEERING Pty Ltd
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GEOTECHNICAL AND MINING ENGINEERING SERVICES
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17 December 2020

Giorgio Dall'armi

General Manager

Broken Hill Operations (BHOP) – Rasp Mine

GEOTECHNICAL ASSESSMENT OF THE RASP MINE BOX CUT

Dear Giorgio,

Please find Ground Control Engineering's (GCE) report presenting a geotechnical assessment and slope design parameters for a proposed box cut for the Rasp Mine, Broken Hill NSW.

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

Cameron Tucker

Principal Geotechnical Engineer

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Executive summary

Ground Control Engineering Pty Ltd (GCE) was commissioned by Broken Hill Operations (BHOP) to undertake a geotechnical assessment of a proposed box cut to replace the current access to the Rasp underground mine, currently situated at the base of the Kintore open pit.

GCE have completed a geotechnical assessment to develop slope design parameters for the box cut and provided preliminary ground support design requirements for the portal batter and upper sections of the decline linking the boxcut with the current Rasp underground workings.

The location for the boxcut was selected by BHOP based on operational factors. The location sites the boxcut excavation in historic surface waste rock and backfill material placed during the mining of the nearby historic BHP and Blackwood open pits. The boxcut location is also near historic underground, sand-filled workings., The location of the old workings has been estimated using original survey mining plans. The preferred location for the boxcut does not intersect the known underground workings apart from the Wilson and Darling Shafts located on what will be the western wall of the boxcut. These shafts originally connected the underground workings to the surface; however, it is understood these shafts were filled after abandonment. A known limitation with the underground historic data is accuracy and completeness of the available records. Investigative methods including probe hole drilling in the vicinity of the shafts and review of historic information is required.

Box cut slope design

Four geotechnical units (FILL, WEATHERED, TRANSITION and FRESH) were defined from geotechnical logging, and slope design parameters determined by empirical design and numerical modelling methods.

The upper portion of the box cut will be excavated in the FILL unit deposited as waste rock and backfill material from previous mining. The strength of this material is defined by its level of compaction, drainage characteristics and angle of repose. There are no records regarding the composition of the FILL unit and is assumed to be homogenous with respect to material properties for the purpose of this assessment.

The lower portion of the boxcut will be excavated in weathered rock (WEATHERED unit). The WEATHERED unit describes rock in a state of weathering ranging from extremely weathered to highly weathered with pervasive fracturing. The strength of the WEATHERED unit is variable, ranging from very low strength to low strength rock.

Slope design parameters for the box cut slopes are provided in the table below.

Bench Number	Geotechnical Unit	Maximum Batter Angle	Maximum Batter Height in Material	Bench Width	Maximum Slope Angle in Material	Maximum Slope Height
1	FILL	35°	10 m	8m	29°	18m
2	FILL / WEATHERED CONTACT	40°	10 m	10m	NA	10m
3	WEATHERED	54°	11 m	10m	34°	16.5m

Surface erosion

The annual rainfall in Broken Hill is less than 250mm per annum. Long term erosion of the boxcut batters and berms is not expected to compromise the stability of the boxcut slopes apart from minor narrowing of the berms and the forming of erosion channels on the batter slopes in FILL unit. Broken Hill occasionally experiences high intensity rainfall events which may result in increased boxcut slope erosion. Measures to control long term erosion should be adopted by Rasp and access to the benches in the FILL unit should be maintained if remedial works are required. The boxcut design incorporates wide berms to account for potential erosion of the berm crests over the longer term, however, erosion protection is recommended for permanently exposed boxcut slopes and benches.

Seismic loading

The Rasp Mine experiences irregular, low level seismic activity in part due to historic and current mining activity in the area. A preliminary assessment of seismic loading on the boxcut slopes was undertaken during this analysis. A peak ground acceleration (PGA) value of 0.15 was applied to the analysis according to the Geoscience Australia NSHA18 hazard map, the map depicts the mean PGA for a 10% probability of exceedance in 50 years. The results of the analysis predict stable boxcut slopes when a seismic coefficient of 0.15g is applied to the model. Such an event is unlikely to trigger failure of the de-watered slopes but should warrant a detailed inspection for possible remediation. Any TARP that is developed for ground conditions for the boxcut should include seismic activity.

Portal batter design

The portal face is expected to be excavated in the WEATHERED unit. Ground conditions are expected to be “Very Poor’ to ‘Poor’. GCE recommend that the final portal ground support design and initial decline support design is finalised once the portal batter is established.

Decline design and ground conditions

The decline will commence in the WEATHERED or TRANSITION rock unit, the expected ground conditions for the initial decline development are expected to be “Very Poor’ to ‘Poor’, consistent with the assessment of the rock units in this report. Ground conditions are expected to improve as the decline progresses towards less weathered rock units. An improved level of data pertaining to ground conditions along the decline path is recommended to refine the rock mass characterisation information which will facilitate the prediction of ground conditions ahead of the decline face.

The ground conditions for the decline will be managed according to the requirements of the Rasp Principal Hazard Management Plan (PHMP) – Ground or Strata Failure. Adverse ground conditions that fall outside the scope of the PHMP will be managed by exception.

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1 Introduction

Ground Control Engineering Pty Ltd (GCE) was commissioned by Broken Hill Operations (BHOP) to undertake a geotechnical assessment and provide slope design parameters for a proposed box cut to replace the current access to the Rasp underground mine, currently situated at the base of the Kintore open pit.

The proposed location for the boxcut sites the excavation in historic surface waste rock and backfill material placed during the mining of the nearby BHP and Blackwood open pits. The boxcut location is also near historic underground, sand-filled workings. The location of the old workings has been estimated using historic survey mining plans. The location for the boxcut does not intersect the known underground workings apart from the Wilson and Darling Shafts located on what will be the western wall of the boxcut. These shafts originally connected the underground workings to the surface; however, it is believed that these shafts were filled after abandonment. A known limitation with the underground historic data is accuracy and completeness of the available records. Investigative methods including probe hole drilling in the vicinity of the shafts and review of historic information is required.

2 Scope of Work

The scope of work for this report was based on discussions between GCE and Rasp Mine technical management and comprised the following items:

1. Produce a conceptual boxcut design based on the BHOP preferred location.
2. Assess the condition of the slopes in the nearby areas to the proposed boxcut location.
3. Review of drill core from the geotechnical drilling programs to identify the base of the historic fill material and rock units.
4. Geotechnical analyses to define the site geotechnical conditions, determine slope design parameters and provide a ground support guidance for the decline portal.

The results of the 2018 and 2019 geotechnical logging and testing has formed the basis of the following assessment methods undertaken for this report:

1. Empirical analysis of overall wall angles (derived from Rock Mass Rating (RMR) values), from the geotechnical logging of drill holes from the 2018 and 2019 box cut drilling programs.
2. Two-dimensional limit equilibrium modelling to assess the Factor of Safety (FOS) of design slope configurations.
3. Empirical assessment of anticipated ground conditions for the upper sections of the proposed decline to determine preliminary ground support requirements.

2.1 Project description

Broken Hill Operations (BHOP) operate the Rasp Mine in Broken Hill NSW. The mine is an underground operation situated approximately in the centre of the Broken Hill Line of Lode. The access to the underground mine is via a portal constructed in the base of the Kintore open pit which was completed in the 1991. BHOP plan to convert the Kintore Pit into a tailings facility which will require an alternative access to the underground workings.

Figure 1 shows the location of the current portal location and proposed boxcut excavation

Figure 1 Kintore pit and box cut design outline within existing topography.

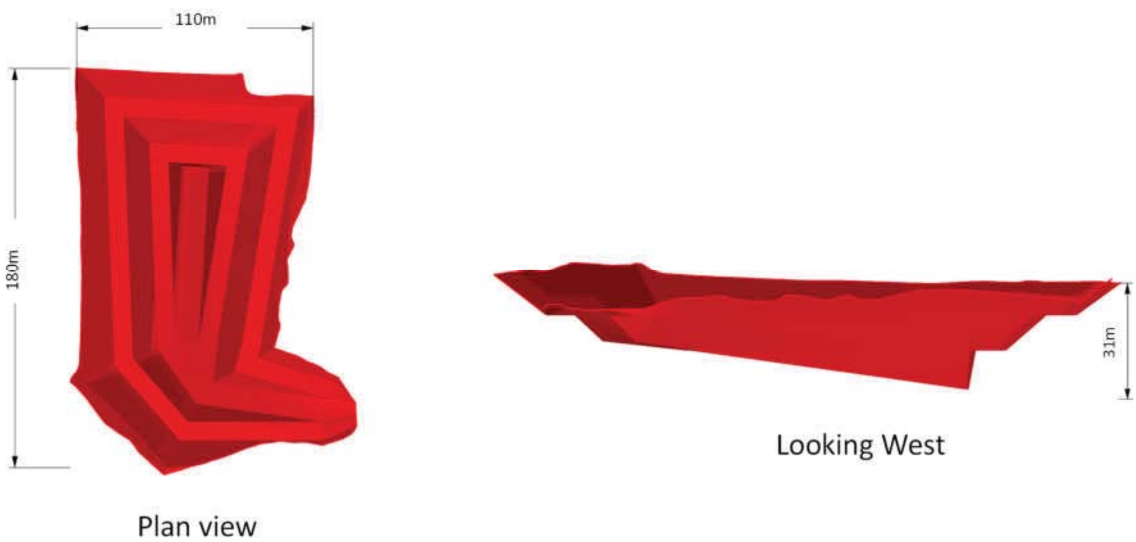
2.2 Boxcut dimensions

The proposed boxcut design dimensions are shown in Table 1 and Figure 2. The width of the box cut is constrained by the location of Rasp mine infrastructure on the eastern side of the boxcut and the mine boundary

Table 1 Boxcut design dimensions

Boxcut dimension	Unit	No
Length	m	180
Width	m	110
Maximum depth	m	31
Excavation voluime	m^3	181,000

Figure 2 Boxcut design dimensions, plan view and looking west.



2.3 Information sources

The following reports and data were provided to GCE for this assessment:

<u>Geotechnical logging and testing</u>

- BHOP Geotechnical logs and core photographs from the 2018 and 2019 box cut drilling programs:
  - 2018 Program
    - MLDD 3873
    - MLDD 3874
    - MLDD 3875
    - MLDD 3876
    - MLDD 3877
    - MLDD 3878
    - MLDD 3879

- 2019 Program
  - MLDD4132
  - MLDD4133
  - MLDD4134
  - MLDD4135
  - MLDD4136
  - MLDD4137
  - MLDD4138
  - MLDD4139
  - MLDD4140
- Trilab, 2018, 4 triaxial test results (3 consolidated-undrained (CU) triaxial tests).

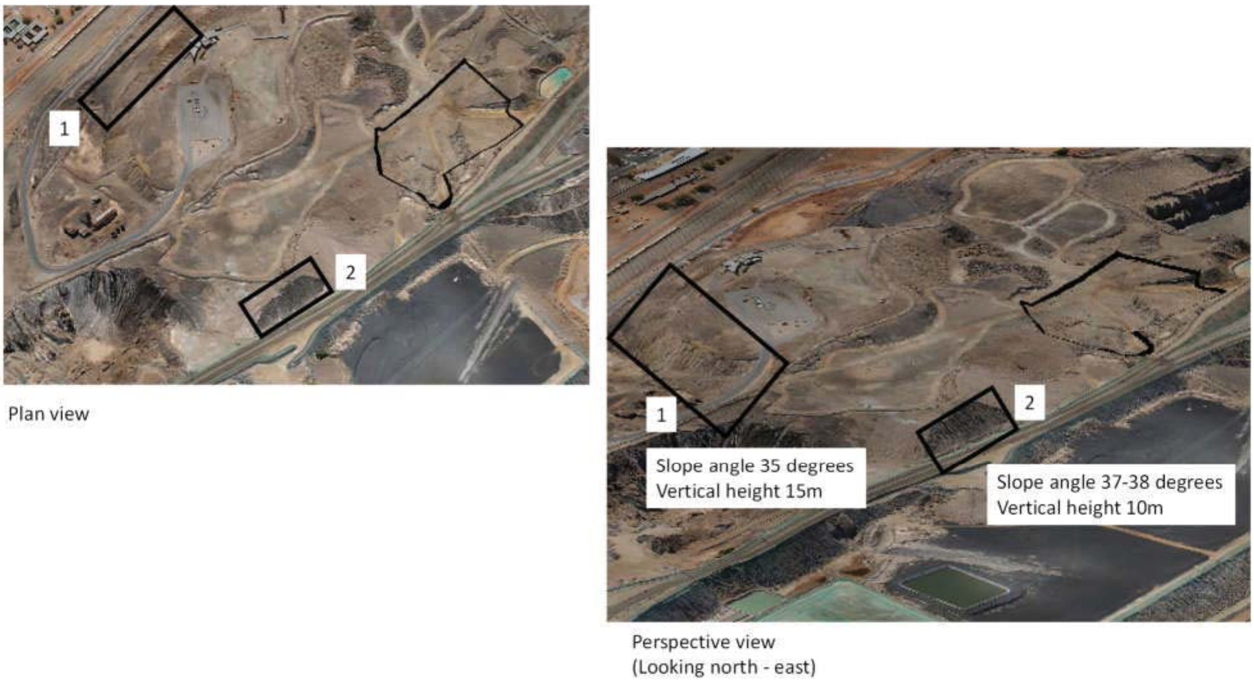
Models and surfaces provided by BHOP

- Surpac files showing location of historic underground workings
- Aerial survey data of the mine lease.

Back analysis of existing slopes in the area

There are several historically stable slopes in the immediate area of the boxcut that were constructed using waste rock and fill material during the mining of the Blackwood Pit Figure 3 shows the location of the fill slopes in relation to the proposed boxcut location.

Figure 3 Existing fill slopes in the boxcut area



2.4 Limitations

The geotechnical data collected from the drilling programs was analysed to define the boundaries between fill material, weathered rock, and fresh rock and to determine the insitu strength properties of the rock units.

Insitu strength testing of the fill material was considered, however due to the depth of the material and the variable nature of deposition, insitu strength testing was considered an unsuitable method for determining the material properties of the fill material. The material properties adopted for assessing the fill material have been derived from GCE's experience with waste rock and sandfill material behaviours, from back-analyses of the performance of historic fill sites on site.

Access restrictions and depth of fill cover limited the extent of the drilling program in the western area of the boxcut area. Several holes were drilled in this area without definitively intersecting rock due to the depth of fill cover.

The location of the old workings in the vicinity of the proposed boxcut location were digitised from historic mining plans by BHOP. The accuracy of this information cannot be verified or guaranteed without probe drilling or accessing the workings.

The location for the boxcut does not intersect known underground workings apart from the Wilson and Darling Shafts located on what will be the western wall of the boxcut. These shafts originally connected the underground workings to the surface; however, it is believed that these shafts were filled after abandonment. The location of the Wilson and Darling Shafts is shown in Figure 4.

Figure 4 Wilson and Darling Shaft locations – plan view

3 Geotechnical data collection

3.1 2018 and 2019 Geotechnical drilling programs

Seven diamond drill holes were completed in 2018, followed by 9 diamond drill holes in 2019, spaced over the boxcut surface area. The purpose of the drilling was to locate the base of the historic fill material that overlies the surface of the intended boxcut location and to characterise the weathering profile of the rock below the historic fill material. The details of the drill holes are provided in Table 2. The information gained from the geotechnical logging also formed the basis of the empirical analyses that was used in the determination of the portal batter and initial decline ground support design. a plan view of the hole locations is shown in Figure 5.

Table 2: 2018 /2019 Geotechnical drilling program – drill hole details

Hole ID	Depth (m)	Dip	Easting (m)	Northing (m)	RL (m)
MLDD3873	45.0	-90.0	9888.6	2351.0	10334.6
MLDD3874	36.0	-90.0	9989.4	2333.6	10325.0
MLDD3875	42.6	-90.0	9985.0	2177.8	10324.6
MLDD3876	44.4	-90.0	9935.2	2085.4	10335.5
MLDD3877	53.6	-90.0	9802.2	2259.7	10354.0
MLDD3878	42.0	-90.0	9771.0	2365.0	10352.0
MLDD3879	42.0	-90.0	9782.4	2426.0	10344.8
MLDD4132	41.0	-90.0	9842.4	2526.1	10343.3
MLDD4133	40.9	-90.0	9806.8	2524.2	10343.0
MLDD4134	40.1	-90.0	9807.2	2499.1	10343.2
MLDD4135	40.0	-90.0	9806.3	2477.5	10343.0
MLDD4136	40.1	-90.0	9806.9	2524.7	10342.9
MLDD4137	40.3	-90.0	9844.6	2500.1	10340.7
MLDD4138	41.0	-90.0	9876.1	2485.0	10342.1
MLDD4139	40.3	-90.0	9879.8	2501.7	10341.8
MLDD4140	40.9	-90.0	9886.0	2548.7	10335.8

Figure 5 Plan view of diamond drill investigation holes

Laboratory testing – Rock samples

Seven representative samples from the WEATHERED zone were taken from three of the drill holes and submitted for unconfined compressive strength (UCS) and triaxial testing. The results are summarised in Table 3 and Table 4 and presented in Appendix A

Table 3: UCS test results from 2018 geotechnical drilling

Hole ID	Sample Interval		UCS (MPa)	Failure mode
	From (m)	To (m)		
MLDD3874	24.7	24.9	16.0	Shear on bedding plane
MLDD3875	30	33.0	13.4	Multiple fracturing
MLDD3876	21	21.25	24.3	Fracture along core axis
MLDD3876	30	30.2	16.5	Shear on bedding plane

Table 4 Triaxial test results from 2018 geotechnical drilling

Hole ID	Sample Interval		Friction angle (°)	Cohesion (KPa)
	From (m)	To (m)		
MLDD3874	18.7	19.0	49.7	270.9
MLDD3876	31.4	31.6	32.2	92.4
MLDD3877	48.6	48.8	51.4	240.1

4 Geotechnical model

Based on the information obtained from the geotechnical core logging and review of digital models, GCE have divided the rock mass into geotechnical units. Four geotechnical units have been defined and slope design parameters determined based on the orientation of the box cut walls and geotechnical characterisation of the rock mass. By using this approach, zones of the rock mass with similar geotechnical properties and anticipated slope performance can be grouped together.

Table 5 lists the geotechnical units and their prevalence in the geotechnical drill holes.

Table 5: Geotechnical units as logged in the drill holes

Geotechnical Unit	Metres Logged
FILL	118
WEATHERED unit - Extremely Weathered to Highly Weathered rock	238.46
TRANSITION unit - Highly Weathered to Moderately Weathered rock	160
FRESH rock	15.9

4.1 Rock mass quality

The box cut will be excavated in slopes comprising material from the FILL and WEATHERED units with the upper batter (approximately 15m) excavated predominantly in the FILL unit and the lower batter and portal face excavated in the WEATHERED unit. The boxcut is not expected to intersect the TRANSITION or FRESH rock units.

The boundaries of the units were defined using information from the recent drilling programs. The spatial distribution of the drilling data was limited by access to the area where the western wall and end wall of the boxcut is planned to be excavated. For this assessment, the material properties for the east, west and end wall of the boxcut are considered homogenous.

Further characteristics to note include:

- The upper batter will be excavated entirely in the FILL unit deposited from previous mining. The strength of this material is defined by its level of compaction, drainage characteristics and angle of repose. The FILL unit is assumed to be homogenous with respect to material properties.
- The WEATHERED unit is characterised by material affected by ground water and oxidation. The unit is of very low to low strength.
- Several fragmented and highly fractured zones were intersected in all the drill holes in each of the (natural) units. These zones were characterised by sheared, low strength material in various states of weathering.

4.2 Ground water and surface water

The geotechnical drilling program intersected several intervals where ground water was present indicated by saturated material in the core. These areas were located at the interface between the FILL unit and WEATHERED units. It is likely the saturated layer was the product of a perched water table rather than a natural water table.

The perched water table is not expected to adversely affect slope stability as the ground water in the area drains through the old workings and is collected in the current Rasp underground workings. However, provisions for dewatering infrastructure (e.g. dewatering bores and depressurisation holes) should be made to manage groundwater and surface water flows during excavation of the boxcut and to reduce deterioration and weakening of the slopes due to water ingress.

This assessment does not consider surface water flows or flood bunding around the box cut. A hydrological assessment of inflows (both groundwater and storm water) into the box cut is recommended to accurately assess drainage requirements and manage water flowing into the decline.

As a minimum, good drainage infrastructure that prevents surface water running over slopes and pooling on berms will be required.

5 Geotechnical design

5.1 Design criteria

Mine slope design is essentially governed by two factors:

1. The consequences of failure; and
2. The degree of inherent uncertainty.

To accommodate these two design factors, it is common practice to apply an appropriate Factor of Safety (FOS) and/or Probability of Failure (POF) to the design geometry of mine slopes. An example of FOS and POF design criteria is provided in Table 6. These design criteria have been developed from a combination of Western Australian, Department of Mines, Industry Regulation and Safety.

Table 6: Examples of design criteria for open pit walls

Wall Class	Consequence of Failure	Design FOS	Design POF	Pit Wall Examples
1	Not serious	Not applicable		Walls not carrying major infrastructure) where all potential failures can be contained within containment structures

2	Moderately serious	1.2	10%	Walls not carrying major infrastructure
3	Serious	1.5	1%	Walls carrying major mine infrastructure (e.g. treatment plant, ROM pad, tailings structures)
4	Serious	2.0	0.30%	Permanent pit walls near public infrastructure and adjoining leases

For this analysis, a FOS of 1.5 was applied to reflect that the boxcut will be life of mine, permanent infrastructure.

5.2 Empirical assessment

Rock mass rating (RMR)

GCE have completed an empirical assessment of the rock mass comprising the WEATHERED and TRANSITION units using the geotechnical logging data processed into Rock Mass Rating (RMR), then Mining Rock Mass Rating (MRMR), to determine general slope angles. This approach is based on rock mass quality and assesses the likelihood of shear failure through the rock (rather than along structures). This has proven to be a highly effective approach for small to intermediate pit slopes where the method is based on numerous similar case studies.

Table 7 Core logged based on RMR

and

Table 8 show RMR values determined from assessment of the logging data.

Table 7 Core logged based on RMR

RMR Range	Description	Metres logged
< 20	Very Poor Rock	35
21 to 40	Poor Rock	86
41 to 60	Fair Rock	58.3
61 to 80	Good Rock	39.3
81 to 100	Very Good Rock	3

Table 8: RMR statistical data for each geotechnical unit

Geotech Unit	RMR				
	Minimum	25% Quartile	Median	75% Quartile	Maximum
WEATHERED	0	39	50	58	79
TRANSITION	0	56	65	73	83

Mining rock mass rating (MRMR)

MRMR values were derived for the WEATHERED and TRANSITION units and used to guide the determination of inter-ramp slope angles (IRSA) for the lower pit walls comprising the WEATHERED and TRANSITION units using the method of Haines and Terbrugge (1991). Median data was used to assess the design to account for the small number of data points available for the assessment (Table 9).

Table 9: MRMR statistical data

Geotechnical Unit	MRMR				
	Minimum	25% Quartile	Median	75% Quartile	Maximum
WEATHERED	0	11.3	23.5	40.0	34.4
TRANSITION	0	11.7	24.8	57.2	57.2

The Haines and Terbrugge design chart utilise MRMR to determine inter ramp slope angles (IRSAs) based on a number of case studies comprising pit slopes in rock. For this case, the Haines and Terbrugge design chart is applied to the bottom 10m bench which will be excavated in the WEATHERED unit. Overall stope stability will be addressed in Section 5.3

IRSAs for Factor of Safety 1.5, using the median value MRMR are shown in Table 10.

Table 10: IRSA using Haines and Terbrugge design chart

Geotechnical Unit	MRMR Median	Slope Height (m)	IRSA (Haines & Terbrugge)
WEATHERED	23.9	16	42°

5.3 Slope stability modelling

Representative sections were modelled using "Slide" 2D limit equilibrium software by Rocscience to identify slope design configurations that met or exceeded the FOS criteria.

The material properties for all units remained fixed for all slope configurations (Table 11). The Bishop simplified and GLE/Morgenstern-Price methods were used to assess for circular failure. Results are presented in Appendix B

Table 11: Material properties for Slide modelling

Geotechnical Unit	Strength Type	Unit Weight (kN/m^3)	Strength Parameters	
			Cohesion (kPa)	Friction Angle
FILL	M-C	20	5.0	36°
WEATHERED	M-C	24	92	32°
TRANSITION	M-C	24	270	50°

Notes: M-C – Mohr-Coulomb

Figure 6 show the overall model geometry for permanent slopes and Figure 7 shows detailed model geometry for the east wall of the boxcut.

Figure 6 Slide model configuration for permanent slopes

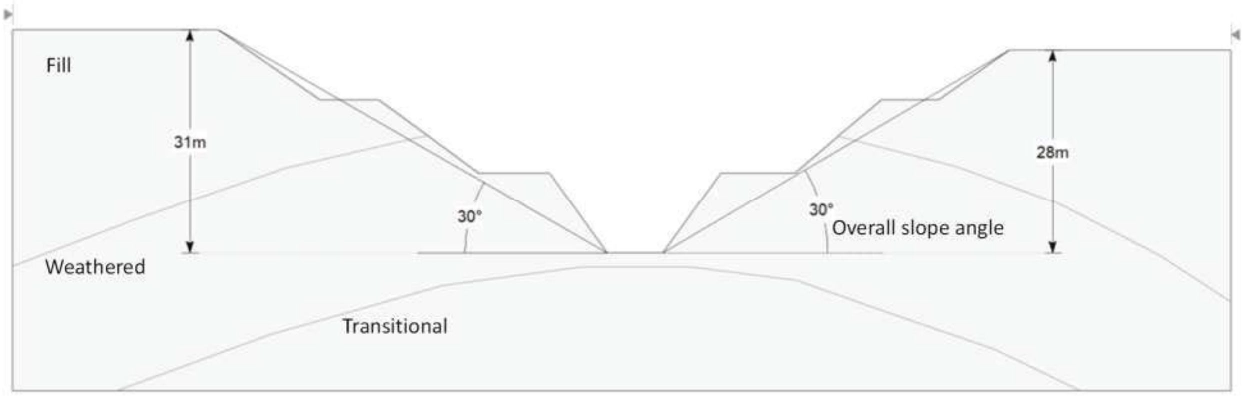
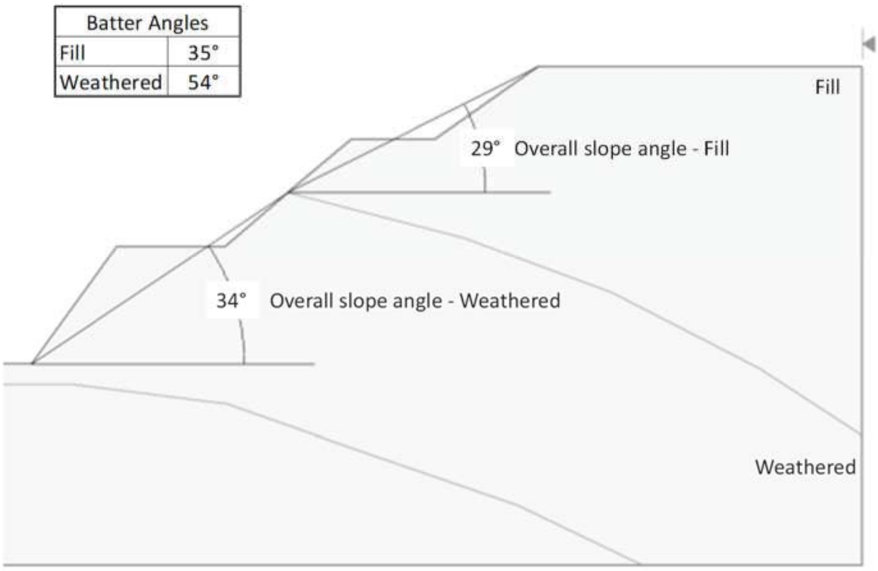


Figure 7 Detailed model geometry



<u>Discussion on modelling results;</u>

The results of the modelling indicate an overall slope angle of 30 degrees or less meets or exceeds the Factor of Safety criteria of 1.5

<u>Slopes in the FILL unit</u>

Based on the assumed geotechnical conditions, the modelling indicates stable slopes in the FILL unit at the proposed slope configuration.

<u>Slopes in combination of FILL and WEATHERED units</u>

Slopes constructed in both the FILL and WEATHERED units are expected to be stable at the proposed slope configuration.

<u>Slopes in the WEATHERED unit</u>

The results of the modelling indicate the slopes in the WEATHERED unit are expected to be stable at the proposed slope configuration.

<u>Portal batter face</u>

It is expected that the portal batter will be excavated in the WEATHERED unit. The stability of the portal batter may be compromised if FILL unit is present above the crown of the portal. Further detailed geotechnical assessment and a specific ground support design corresponding to the ground conditions encountered, will be required for the portal and portal batter face once it is exposed. It is important to note that the depth and overall shape of TRANSITION and WEATHERED units is based on limited information.

Two-dimensional modelling cannot account for confinement of slopes from the side walls (by the end wall) and the end wall (by the side walls). As such, it could be considered that the FOS results may be slightly higher if this confinement of abutting walls are incorporated into the modelling.

The model results are presented in Appendix B.

Seismic loading

The Rasp Mine experiences irregular, low level seismic activity in part due to mining activity in the area. A preliminary assessment of seismic loading on the boxcut slopes was undertaken during this analysis. A peak ground acceleration (PGA) value of 0.15 was applied to the analysis according to the Geoscience Australia NSHA18 hazard map, the map depicts the mean PGA for a 10% probability of exceedance in 50 years. The results of the analysis predict stable boxcut slopes when a seismic coefficient of 0.15g is applied to the model. Such an event is unlikely to trigger failure of the de-watered slopes but should warrant a detailed inspection for possible remediation. Any TARP that is developed for ground conditions for the boxcut should include seismic activity.

Surface erosion

The annual rainfall in Broken Hill is less than 250mm per annum. Long term erosion of the boxcut batters and berms is not expected to compromise the stability of the boxcut slopes apart from minor narrowing of the berms and the forming of erosion channels on the batter slopes in FILL unit. Broken Hill occasionally experiences high intensity rainfall events which may result in increased boxcut slope erosion. Measures to control long term erosion should be adopted by Rasp and access to the benches in the FILL unit should be maintained if remedial works are required. The boxcut design incorporates wide berms to account for potential erosion of the berm crests over the longer term, however, erosion protection is recommended for permanently exposed boxcut slopes and benches.

6 Portal batter design

The portal face is expected to be excavated in the WEATHERED unit. Ground conditions are expected to be "Very Poor' to 'Poor' GCE recommend that the final portal ground support design and initial decline support design is finalised once the portal face is established and ground support is installed. Due to expected poor ground conditions, controlled perimeter blasting is recommended to avoid damaging the drive profile during the construction of the portal.

For 'Very Poor' ground conditions (Q<1), the portal face and wall should be supported with the following elements:

- 75 mm FRS (fibre reinforced shotcrete), strength UCS 40 MPa after 28 days over mesh. The FRS should cover the entire portal face and wrap over the portal bench by at least 2m and a minimum of 10m of wall coverage back from the face.
- The portal face should be cable bolted using 10m length, twin strand cable bolts at 2m centres. Cable bolts may be drilled slightly upwards at less than 5 degrees from the horizontal.
- Install 9m long spiling bars at approximately 300mm centres around the portal arch. Overlap 1.5m between spiling rounds.
- Ground improvement techniques including soil nailing and pressure grouting may be required for the portal batter if very poor ground conditions are encountered. This work should be undertaken before establishing the ramp to the portal batter face.

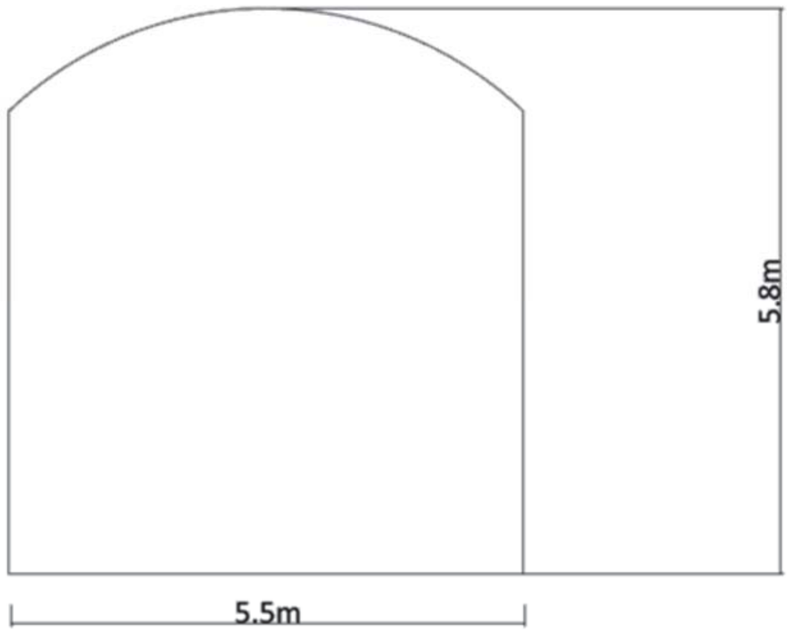
The proposed portal face design is shown in Appendix C. The support guidelines should be re-evaluated once the portal face is established.

7 Initial decline design

7.1 Decline ground conditions

The decline will be excavated using the same ached profile that is in use for the Western Min decline, the dimensions of the decline are shown in Figure 8.

Figure 8 Decline excavation profile for the decline



The decline will commence in the WEATHERED unit, the expected ground conditions for the initial decline development are expected to be "very poor" to "poor", consistent with the assessment of the rock unit in this report. Ground conditions are expected to improve as the decline progresses through the TRANSITION and FRESH rock units. An improved level of data pertaining to ground conditions along the decline path is recommended to refine the rock mass characterisation information for the decline path which will facilitate the prediction of ground conditions ahead of the decline face.

7.2 Decline ground support

Rasp have a comprehensive system for managing ground conditions during development which is detailed in the Principal Hazard Management Plan – Ground or Strata Failure. It is expected that the procedures for managing ground conditions and ground support methodology will be applied to the decline. unexpected changes in ground conditions will be managed by exception which may require, specific ground support design.

The ground support configurations that will be applied to the decline are shown in Appendix D.

8 Summary of findings

8.1 Box cut slope design parameters

The recommended slope design parameters for the box cut slopes are presented in Table 12 and are to be read in conjunction with the comments that follow the table. They have been reached using a combination of geotechnically derived results from the following methods:

- Empirical assessment
- 2D slope stability modelling

Table 12 Summary of slope design parameters

Bench Number	Geotechnical Unit	Maximum Batter Angle	Maximum Batter Height in Material	Bench Width	Maximum Slope Angle in Material	Maximum Slope Height
1	FILL	35°	10 m	8m	29°	18m
2	FILL / WEATHERED CONTACT	40°	10 m	10m	NA	10m
3	WEATHERED	54°	11 m	10m	34°	16.5m

The following comments are critical to application of the slope design parameters presented above:

- Dewatered slopes are recommended to ensure the long-term stability of the box cut. Provision for depressurised walls (de-watering holes may be required) and surface drainage should be made.
- The slope design parameters are appropriate for good final wall blasting techniques (i.e. pre-split and/or trim blasted) and good slope management (e.g. scaling walls). Note: pre-split blasting may not be the best method in the weathered, low strength ground due to the damage potential from explosive energy directly against the final walls.
- Routine geotechnical inspections of batters and berms, and the commissioning of a slope movement monitoring system (i.e. a system of prisms set up along berm crests and routinely surveyed by mine surveyors).
- A preliminary seismic loading analysis indicates stable boxcut slopes when a seismic coefficient of 0.15g is applied to the model. Such an event is unlikely to trigger failure of the de-watered slopes but should warrant a detailed inspection for possible remediation. Any TARP that is developed for ground conditions for the boxcut should include seismic activity.
- Long term erosion of the boxcut batters and berms is not expected to compromise the stability of the boxcut slopes apart from minor narrowing of the berms and the formation of erosion channels on the batter slopes in FILL unit. Broken Hill occasionally experiences high intensity rainfall events which may result in increased boxcut slope erosion. Measures to control long term erosion should be adopted by Rasp and access to the benches in FILL unit should be maintained if remedial works are required.
- Erosion protection is recommended for the portal batter and bench to prevent damage to the portal batter surface support.

8.2 Portal face design

- The portal face will be excavated in the WEATHERED unit. Ground conditions are expected to be ‘Very Poor’ to ‘Poor’. GCE recommends that the final portal ground support design and initial decline support design is finalised once the portal face is established.
- Preliminary ground support requirements for ‘Very Poor’ and ‘Poor’ to ‘Fair’ rock mass quality are provided in Section 5.

8.3 Decline design and ground conditions

The decline will commence in the WEATHERED or TRANSITION rock unit, the expected ground conditions for the initial decline development are expected to be “Very Poor’ to ‘Poor’, consistent with the assessment of the rock units in this report. Ground conditions are expected to improve as the decline progresses towards less weathered rock units. An improved level of data pertaining to ground conditions along the decline path is recommended to refine the rock mass characterisation information which will facilitate the prediction of ground conditions ahead of the decline face.

The ground conditions for the decline will be managed according to the requirements of the Rasp Principal Hazard Management Plan (PHMP) – Ground or Strata Failure. Adverse ground conditions that fall outside the scope of the PHMP will be managed by exception.

Appendix A Laboratory test results

Trilab
Soil Rock Calibration

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UNIAXIAL COMPRESSIVE STRENGTH TEST REPORT

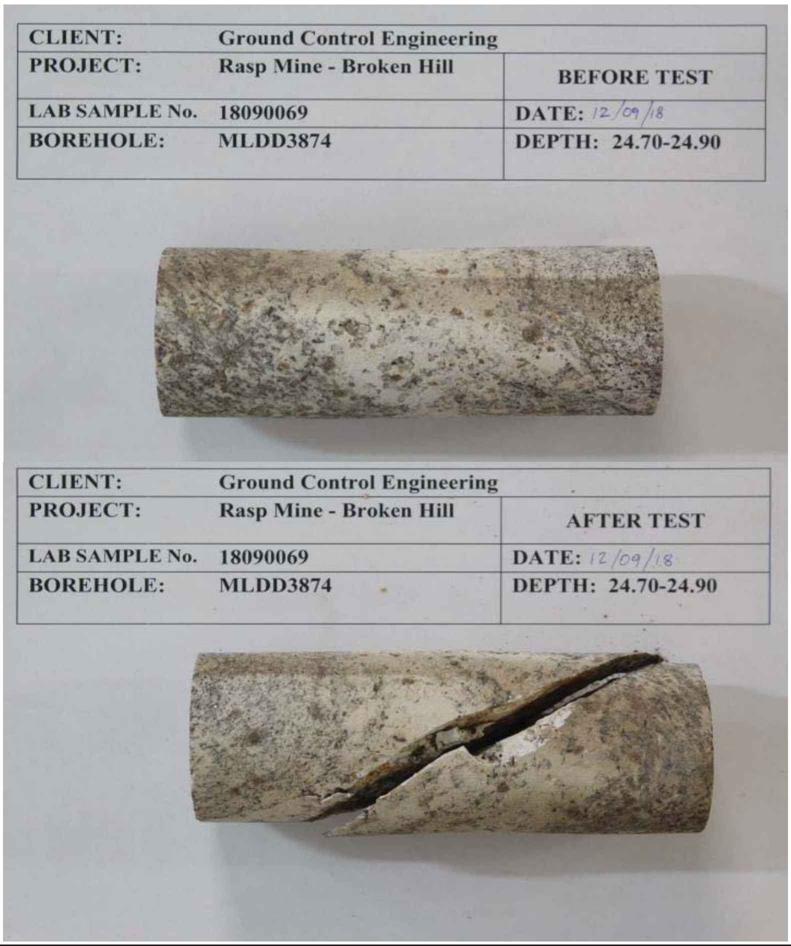
Test Method: AS 4133.4.2.1 & AS 4133.1.1.1

Client	Ground Control Engineering	**Report No.**	18090069-UCS
		Workorder No.	0004803
Address	16 Farmer Street, Edmonton QLD 4869	**Test Date**	12/09/2018
		Report Date	13/09/2018
Project	Rasp Mine - Broken Hill		
Client ID	MLDD3874	**Depth (m)**	24.70-24.90
Description	-		
Sample Type	Single Individual Rock Core Specimen		

TEST DETAILS

Average Sample Diameter (mm)	60.5	Moisture Content (%)	0.2
Sample Height (mm)	159.9	Wet Density (t/m^3)	2.76
Duration of Test (min)	5:23	Dry Density (t/m^3)	2.75
Rate of Loading (MPa/min)	2.97	Bedding (°)	60
Mode of Failure	Shear	Test Apparatus	Kelba 1000 kN Load Cell
Rupture Angle (°)	65		
UCS (MPa)	**16.0**		

Before and After Testing Photo's



NOTES/REMARKS:
Stored and tested as received
Sample/s supplied by the client

Photo's not to scale

Accredited for compliance with ISO/IEC 17025 - Testing.
The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.

Tested at Trilab Brisbane Laboratory.

Authorised Signatory
N. Maddison

NATA ACCREDITED FOR TECHNICAL COMPETENCE
Laboratory No. 9926

Trilab
Soil Rock Calibration

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UNIAXIAL COMPRESSIVE STRENGTH TEST REPORT

Test Method: AS 4133.4.2.2 & AS 4133.1.1.1

Client	Ground Control Engineering	**Report No.**	18090070-UCS
		Workorder No.	0004803
Address	16 Farmer Street, Edmonton QLD 4869	**Test Date**	12/09/2018
		Report Date	13/09/2018
Project	Rasp Mine - Broken Hill		
Client ID	MLDD3875	**Depth (m)**	21.00-21.25
Description	-		
Sample Type	Single Individual Rock Core Specimen		

TEST DETAILS

Average Sample Diameter (mm)	60.9	Moisture Content (%)	0.2
Sample Height (mm)	164.4	Wet Density (t/m^3)	2.85
Duration of Test (min)	25:05	Dry Density (t/m^3)	2.84
Rate of Displacement (mm/min)	0.10	Bedding (°)	80
Mode of Failure	Shear	Test Apparatus	100 kN Load Cell in Compression Machine
Rupture Angle (°)	80		
UCS (MPa)	**24.3**		

Before and After Photo's

NOTES/REMARKS:
Stored and tested as received
Sample/s supplied by the client

Photo's not to scale

Accredited for compliance with ISO/IEC 17025 - Testing.
The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.

Tested at Trilab Brisbane Laboratory.

Authorised Signatory
N. Maddison

NATA
ACCREDITED FOR TECHNICAL COMPETENCE
Laboratory No. 9926

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UNIAXIAL COMPRESSIVE STRENGTH TEST REPORT

Test Method: AS 4133.4.2.2 & AS 4133.1.1.1

Client	Ground Control Engineering	**Report No.**	18090071-UCS
		Workorder No.	0004803
Address	16 Farmer Street, Edmonton QLD 4869	**Test Date**	12/09/2018
		Report Date	13/09/2018
Project	Rasp Mine - Broken Hill		
Client ID	MLDD3875	**Depth (m)**	32.80-33.00
Description	-		
Sample Type	Single Individual Rock Core Specimen		

TEST DETAILS

Average Sample Diameter (mm)	61.0	Moisture Content (%)	0.3
Sample Height (mm)	153.8	Wet Density (t/m^3)	2.69
Duration of Test (min)	19:53	Dry Density (t/m^3)	2.68
Rate of Displacement (mm/min)	0.10	Bedding (°)	70
Mode of Failure	Shear	Test Apparatus	Kelba 1000 kN Load Cell
Rupture Angle (°)	70		
	UCS (MPa)	**13.4**	

Before and After Photo's

NOTES/REMARKS:
Stored and tested as received
Sample/s supplied by the client

Photo's not to scale

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Tested at Trilab Brisbane Laboratory.

Authorised Signatory
N. Maddison

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UNIAXIAL COMPRESSIVE STRENGTH TEST REPORT

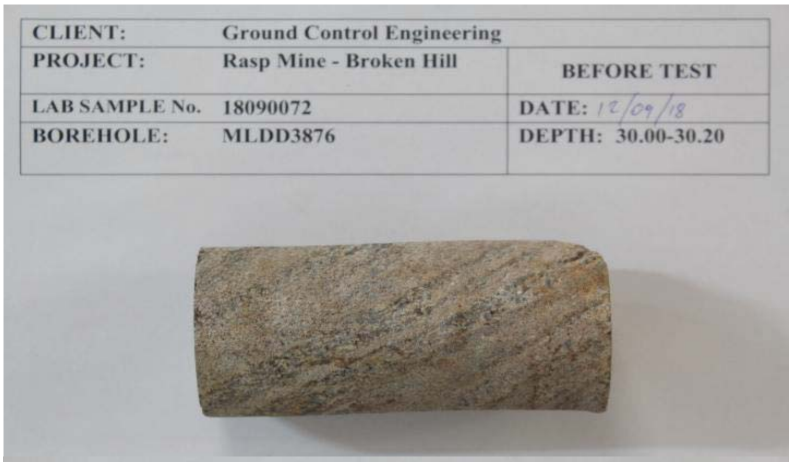
Test Method: AS 4133.4.2.2 & AS 4133.1.1.1

Client	Ground Control Engineering	**Report No.**	18090072-UCS
		Workorder No.	0004803
Address	16 Farmer Street, Edmonton QLD 4869	**Test Date**	12/09/2018
		Report Date	13/09/2018
Project	Rasp Mine - Broken Hill		
Client ID	MLDD3876	**Depth (m)**	30.00-30.20
Description	-		
Sample Type	Single Individual Rock Core Specimen		

TEST DETAILS

Average Sample Diameter (mm)	60.8	Moisture Content (%)	0.3
Sample Height (mm)	131.6	Wet Density (t/m^3)	2.69
Duration of Test (min)	21:21	Dry Density (t/m^3)	2.68
Rate of Displacement (mm/min)	0.10	Bedding (°)	70
Mode of Failure	Shear	Test Apparatus	100 kN Load Cell in Compression Machine
Rupture Angle (°)	70		
	UCS (MPa)	**16.5**	

Before and After Photo's



NOTES/REMARKS:
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Sample/s supplied by the client

* Length to diameter ratio less than 2.5:1

Photo's not to scale

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TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

Client:	Ground Control Engineering	**Report No.:**	18090073 - CU
		Workorder No.	0004803
Address	16 Farmer Street, Edmonton QLD 4869	**Test Date:**	28/09/2018
		Report Date:	12/10/2018
Project:	Rasp Mine - Broken Hill		
Client Id.:	MLDD3874	**Depth (m):**	18.70-19.00
Description:			

SAMPLE & TEST DETAILS

Initial Height:	128.5	mm	Initial Moisture Content:	3.1	%	Rate of Strain:	0.007	%/min
Initial Diameter:	60.7	mm	Final Moisture Content:	9.8	%	B Response:	98	%
L/D Ratio:	2.1 : 1		Wet Density:	2.34	t/m^3			
			Dry Density:	2.27	t/m^3			

Sample Type: Single Individual Undisturbed Specimen

TEST RESULTS

FAILURE DETAILS

Effective Pressure	Confining Pressure	Back Pressure	Initial Pore	Failure Pore	*Principal Effective Stresses* σ'_1	σ'_3	σ'_1 / σ'_3	*Deviator Stress*	*Strain*
120 kPa	624 kPa	504 kPa	504 kPa	591 kPa	1628 kPa	33 kPa	49.774	1595 kPa	1.15 %
243 kPa	747 kPa	504 kPa	504 kPa	606 kPa	2665 kPa	141 kPa	18.917	2525 kPa	1.58 %
494 kPa	1000 kPa	506 kPa	506 kPa	584 kPa	4516 kPa	416 kPa	10.864	4100 kPa	2.21 %

FAILURE ENVELOPES

Interpretation between stages :	**1 to 2**	**2 to 3**	**1 to 3**
Cohesion C' (kPa) :	**212.1**	**330.7**	**270.9**
Angle of Shear Resistance Φ' (Degrees) :	**54.2**	**47.9**	**49.7**
Failure Criteria:	Peak Principal Stress Ratio		

Remarks: Tested as Received

Sample/s supplied by the client

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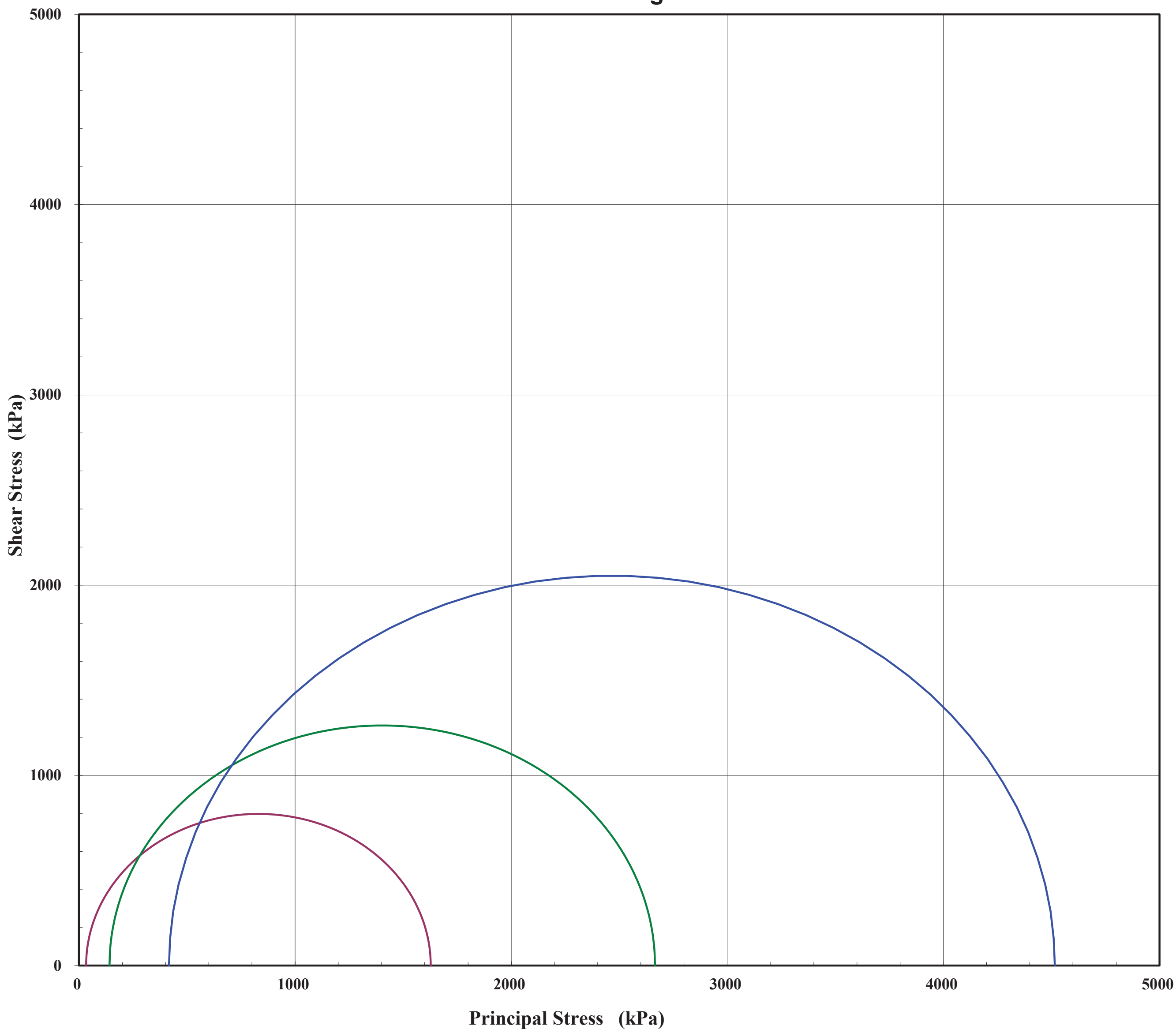
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

Client: Ground Control Engineering

Report No.: 18090073 - CU

Mohr Circle Diagram



Interpretation between stages :	1 to 2	2 to 3	1 to 3
Cohesion C' (kPa) :	212.1	330.7	270.9
Angle of Shear Resistance Φ' (Degrees) :	54.2	47.9	49.7
Failure Criteria:	Peak Principal Stress Ratio		

Remarks: Tested as Received

Sample/s supplied by the client

Note: Graph not to scale

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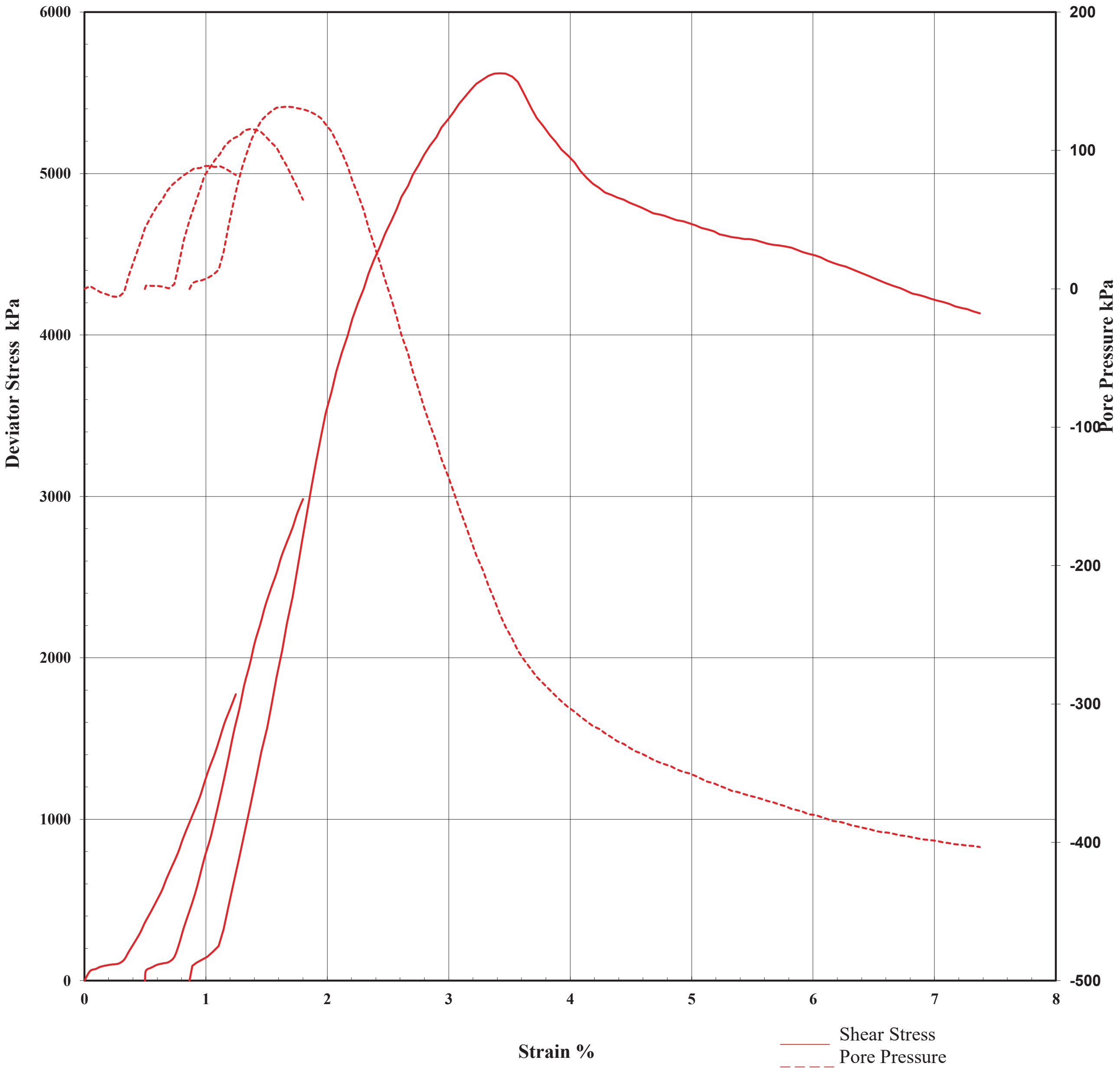
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

Client: Ground Control Engineering	**Report No.:** 18090073 - CU

Stress/Strain & Pore Pressure/Strain Diagram



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Note: Graph not to scale

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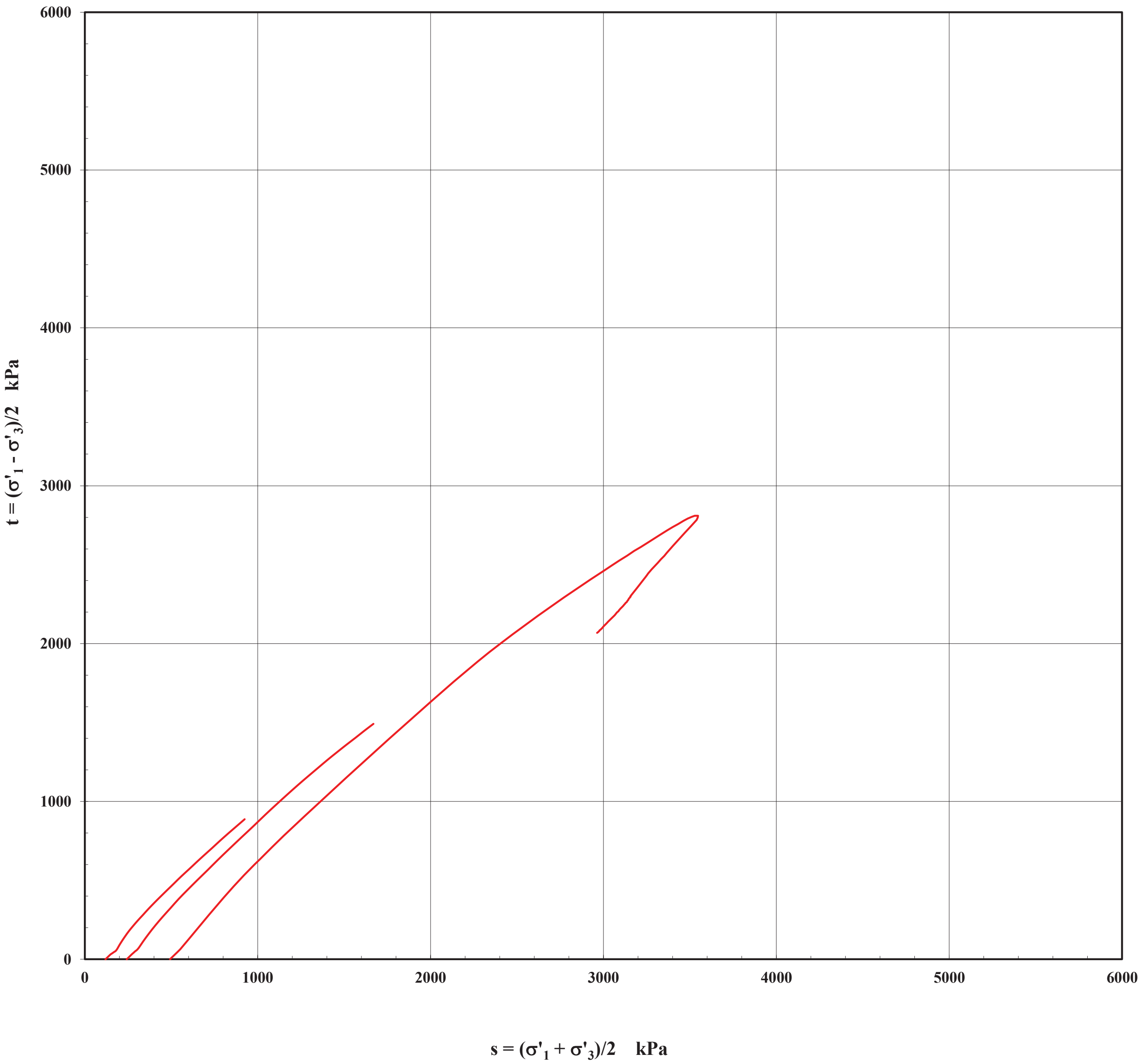
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

Client: Ground Control Engineering

Report No.: 18090073 - CU

MIT Method - Effective Stress Path



Remarks: Tested as Received

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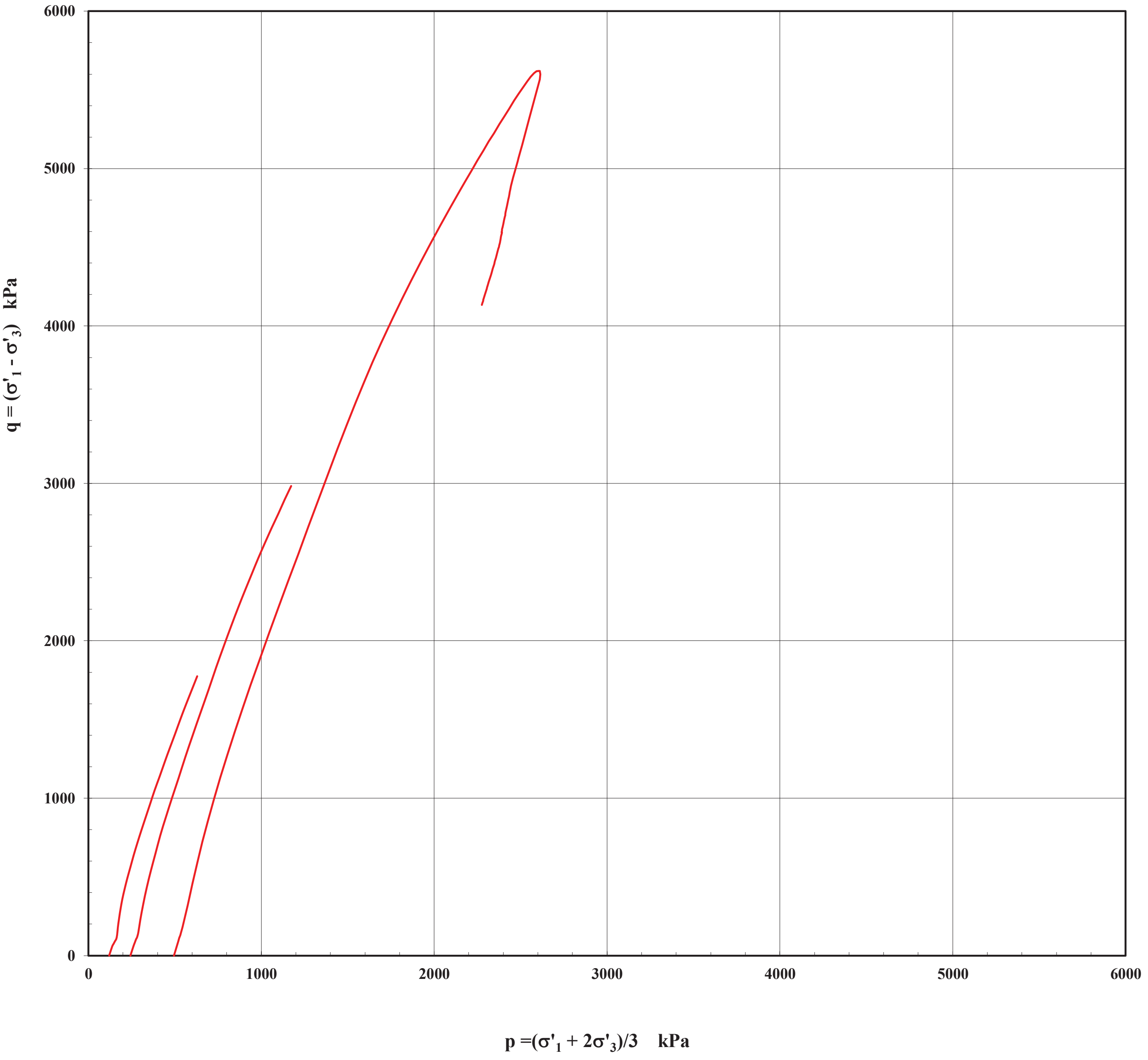
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

Client: Ground Control Engineering	**Report No.:** 18090073 - CU

Cambridge Method - Effective Stress Path



Remarks: Tested as Received

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TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

Client: Ground Control Engineering	**Report No.:** 18090073 - CU

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TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

Client:	Ground Control Engineering	**Report No.:**	18090074 - CU
		Workorder No.	0004803
Address	16 Farmer Street, Edmonton QLD 4869	**Test Date:**	26/09/2018
		Report Date:	10/10/2018
Project:	Rasp Mine - Broken Hill		
Client Id.:	MLDD3876	**Depth (m):**	31.40-31.60
Description:			

SAMPLE & TEST DETAILS

Initial Height:	125.6	mm	Initial Moisture Content:	1.1	%	Rate of Strain:	0.007	%/min
Initial Diameter:	60.7	mm	Final Moisture Content:	8.3	%	B Response:	99	%
L/D Ratio:	2.1 : 1		Wet Density:	2.23	t/m^3			
			Dry Density:	2.21	t/m^3			

Sample Type: Single Individual Undisturbed Specimen

TEST RESULTS

FAILURE DETAILS

Effective Pressure	Confining Pressure	Back Pressure	Initial Pore	Failure Pore	*Principal Effective Stresses*			*Deviator Stress*	*Strain*
					σ'_1	σ'_3	σ'_1 / σ'_3		
128 kPa	627 kPa	499 kPa	499 kPa	559 kPa	531 kPa	68 kPa	7.802	463 kPa	0.83 %
253 kPa	751 kPa	498 kPa	498 kPa	574 kPa	968 kPa	177 kPa	5.466	791 kPa	1.58 %
503 kPa	904 kPa	401 kPa	401 kPa	488 kPa	1688 kPa	416 kPa	4.054	1272 kPa	2.38 %

FAILURE ENVELOPES

Interpretation between stages :	**1 to 2**	**2 to 3**	**1 to 3**
Cohesion C' (kPa) :	**64.6**	**125.4**	**93.4**
Angle of Shear Resistance Φ' (Degrees) :	**36.9**	**30.1**	**32.2**
Failure Criteria:	Peak Principal Stress Ratio		

Remarks: Tested as Received

Sample/s supplied by the client

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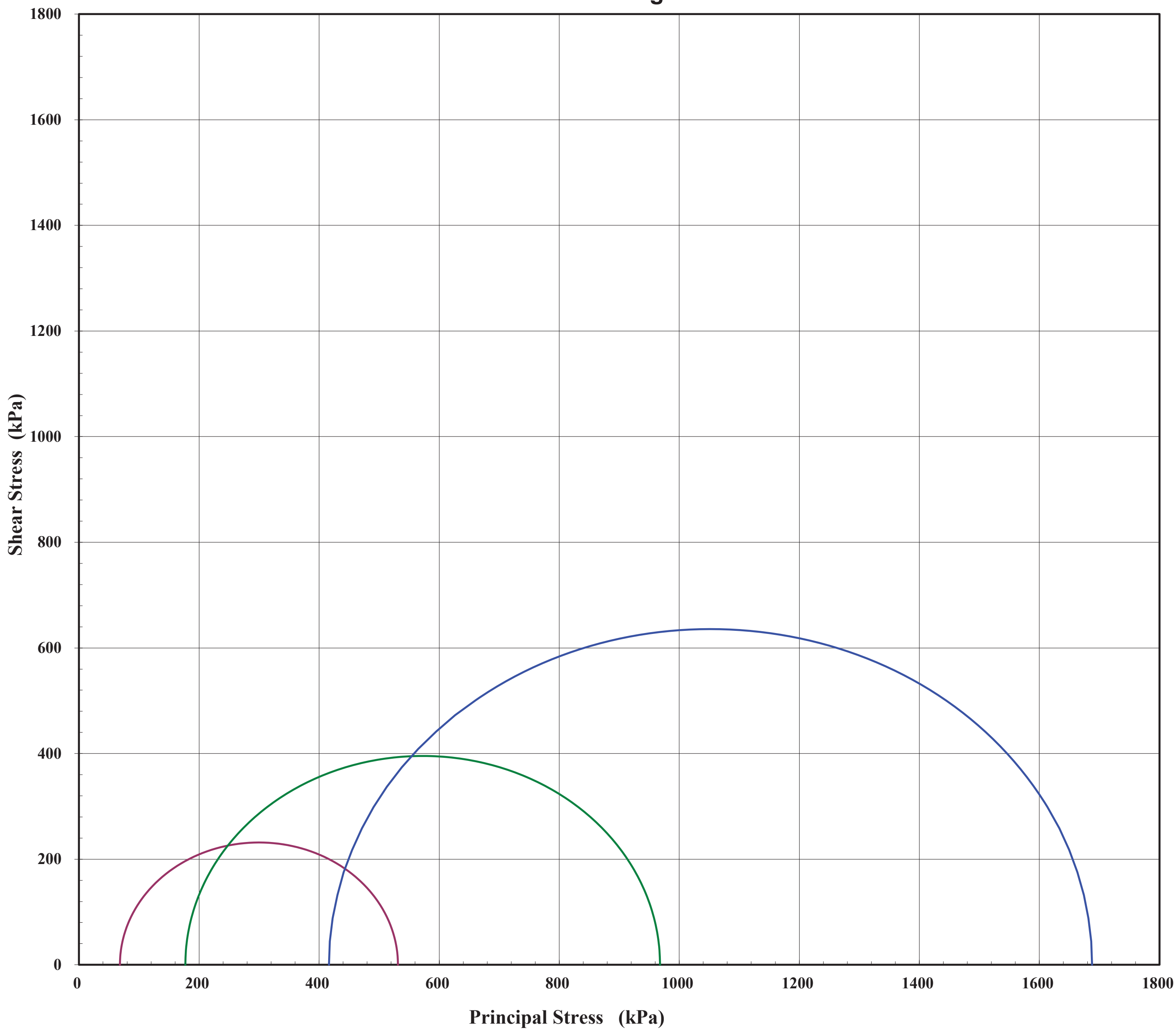
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

Client: Ground Control Engineering

Report No.: 18090074 - CU

Mohr Circle Diagram



Interpretation between stages :	1 to 2	2 to 3	1 to 3
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Angle of Shear Resistance Φ' (Degrees) :	36.9	30.1	32.2
Failure Criteria:	Peak Principal Stress Ratio		

Remarks: Tested as Received

Sample/s supplied by the client

Note: Graph not to scale

REP03001

Authorised Signatory

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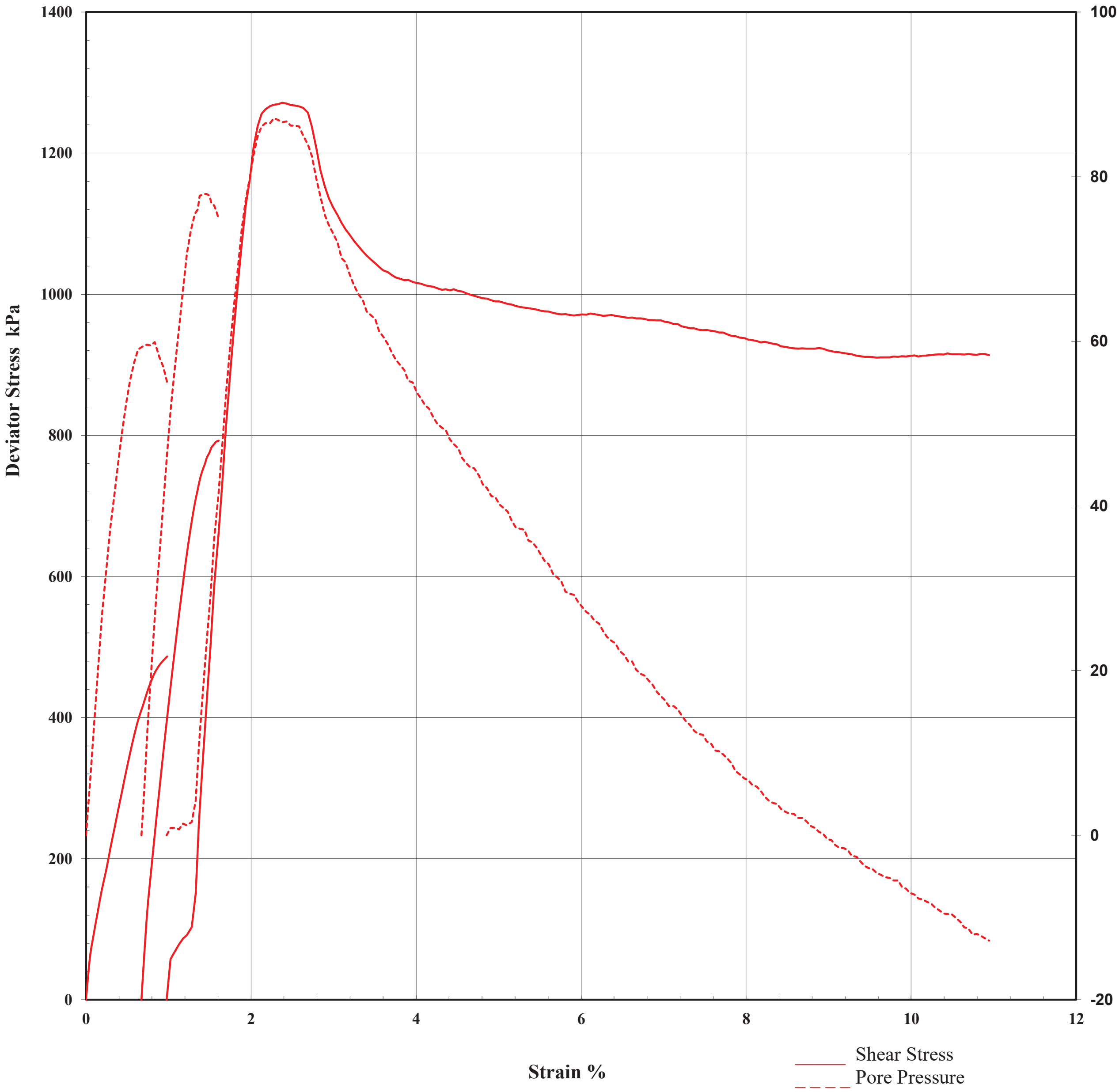
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

Client: Ground Control Engineering	**Report No.:** 18090074 - CU

Stress/Strain & Pore Pressure/Strain Diagram



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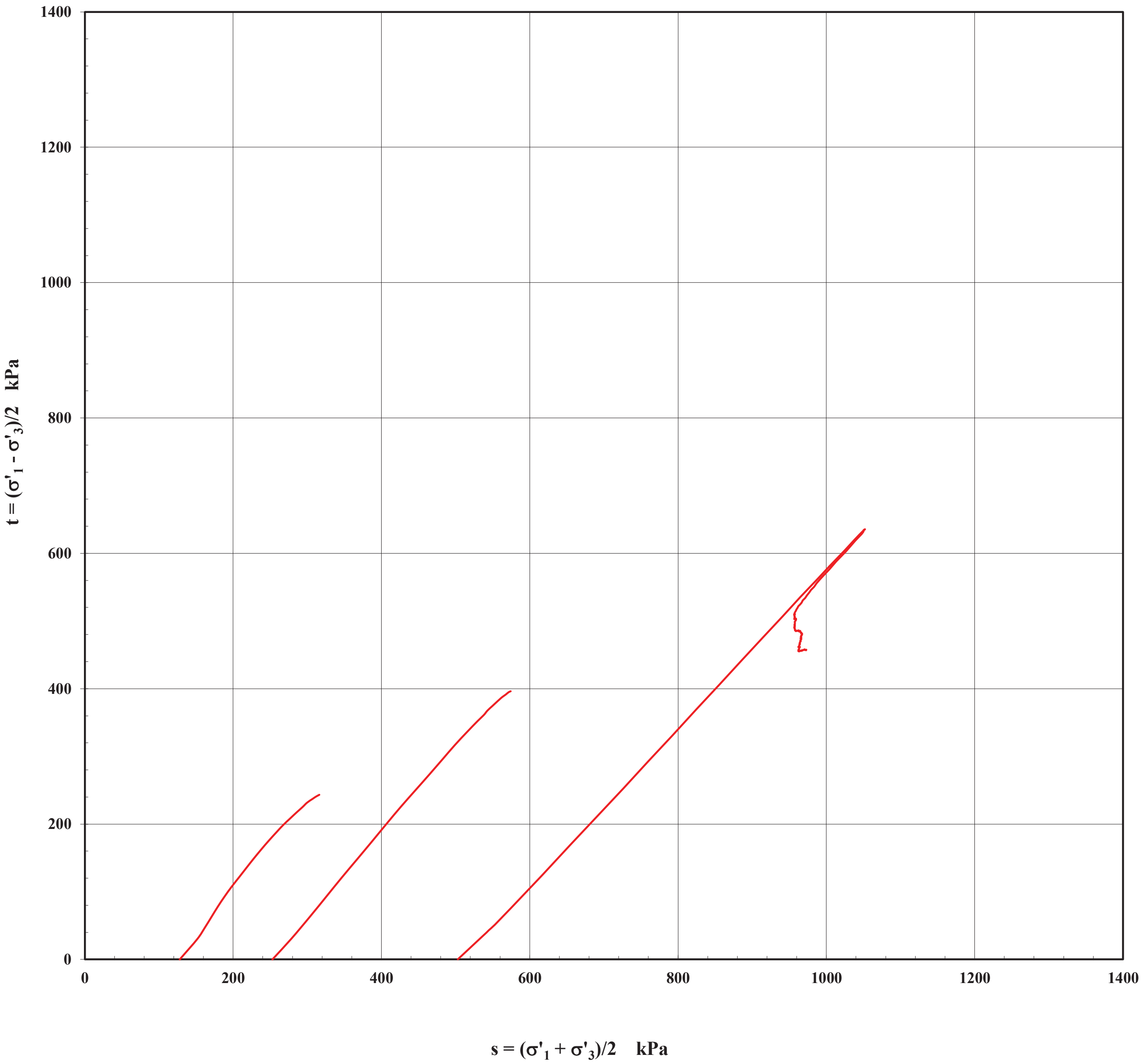
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

Client: Ground Control Engineering

Report No.: 18090074 - CU

MIT Method - Effective Stress Path



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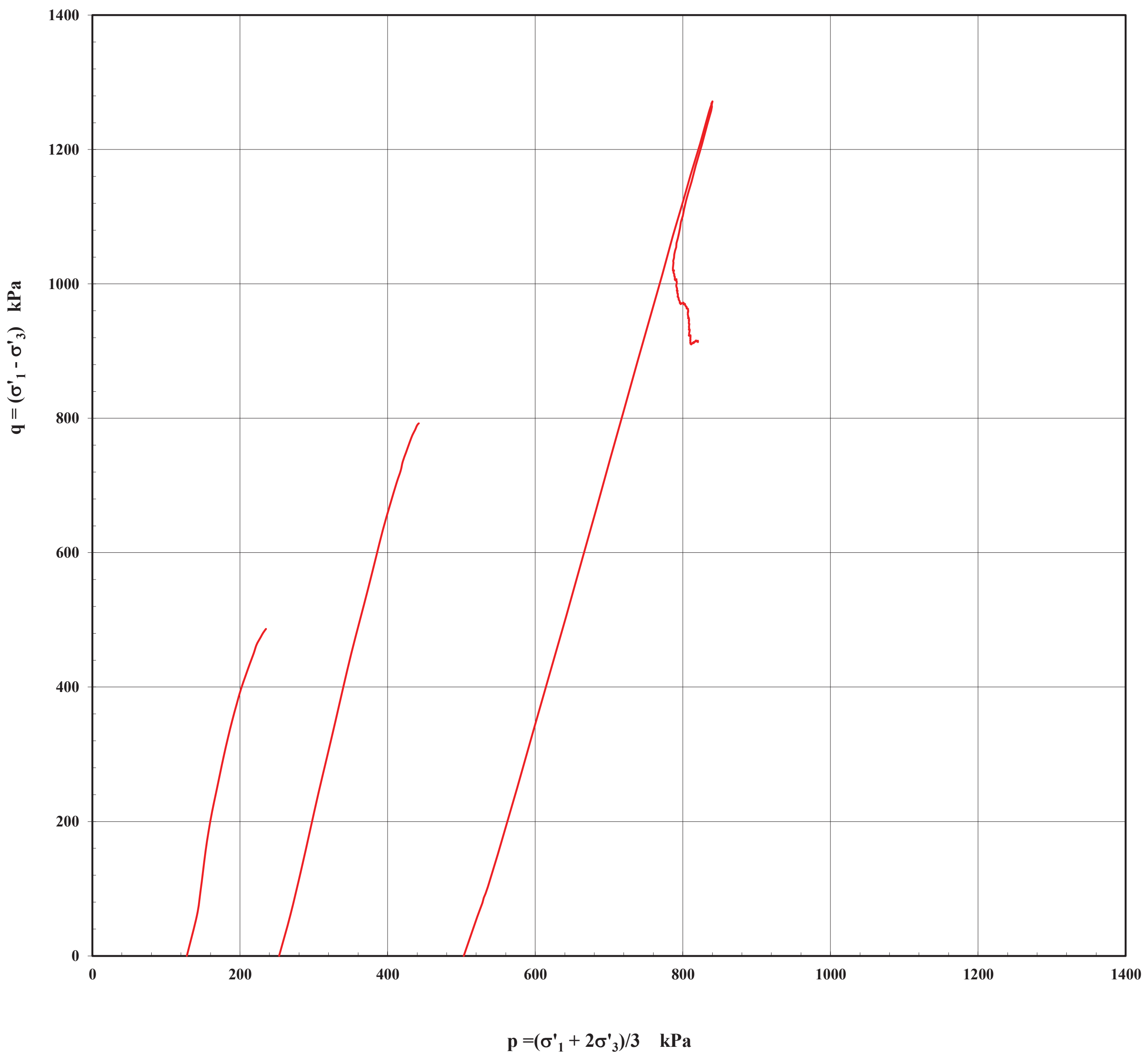
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

Client: Ground Control Engineering	**Report No.:** 18090074 - CU

Cambridge Method - Effective Stress Path



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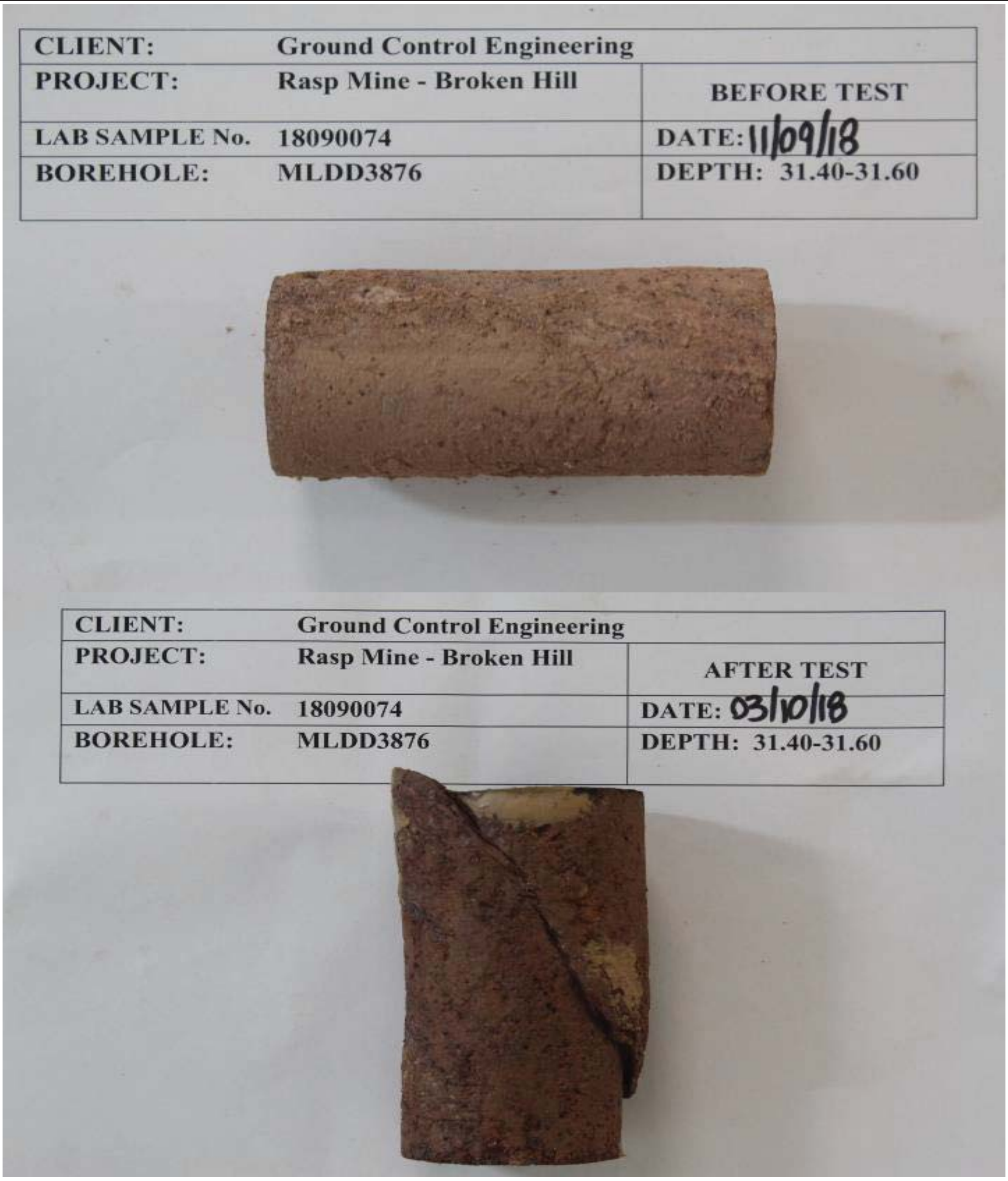
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

Client: Ground Control Engineering	**Report No.:** 18090074 - CU



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TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

Client:	Ground Control Engineering	**Report No.:**	18090075 - CU
		Workorder No.	0004803
Address	16 Farmer Street, Edmonton QLD 4869	**Test Date:**	25/09/2018
		Report Date:	12/10/2018
Project:	Rasp Mine - Broken Hill		
Client Id.:	MLDD3877	**Depth (m):**	48.60-48.80
Description:			

SAMPLE & TEST DETAILS

Initial Height:	126.0	mm	Initial Moisture Content:	3.1	%	Rate of Strain:	0.007	%/min
Initial Diameter:	61.3	mm	Final Moisture Content:	6.6	%	B Response:	99	%
L/D Ratio:	2.1 : 1		Wet Density:	2.47	t/m^3			
			Dry Density:	2.40	t/m^3			

Sample Type: Single Individual Undisturbed Specimen

TEST RESULTS

FAILURE DETAILS

Effective Pressure	Confining Pressure	Back Pressure	Initial Pore	Failure Pore	*Principal Effective Stresses*			*Deviator Stress*	*Strain*
					σ'_1	σ'_3	σ'_1 / σ'_3		
127 kPa	624 kPa	497 kPa	497 kPa	517 kPa	2084 kPa	107 kPa	19.480	1977 kPa	1.14 %
252 kPa	750 kPa	498 kPa	498 kPa	466 kPa	4044 kPa	284 kPa	14.240	3760 kPa	1.61 %
505 kPa	1001 kPa	496 kPa	496 kPa	471 kPa	5490 kPa	530 kPa	10.358	4960 kPa	1.86 %

FAILURE ENVELOPES

Interpretation between stages :	**1 to 2**	**2 to 3**	**1 to 3**
Cohesion C' (kPa) :	**135.2**	**489.9**	**240.1**
Angle of Shear Resistance Φ' (Degrees) :	**56.5**	**45.2**	**51.4**
Failure Criteria:	Peak Principal Stress Ratio		

Remarks: Tested as Received

Sample/s supplied by the client

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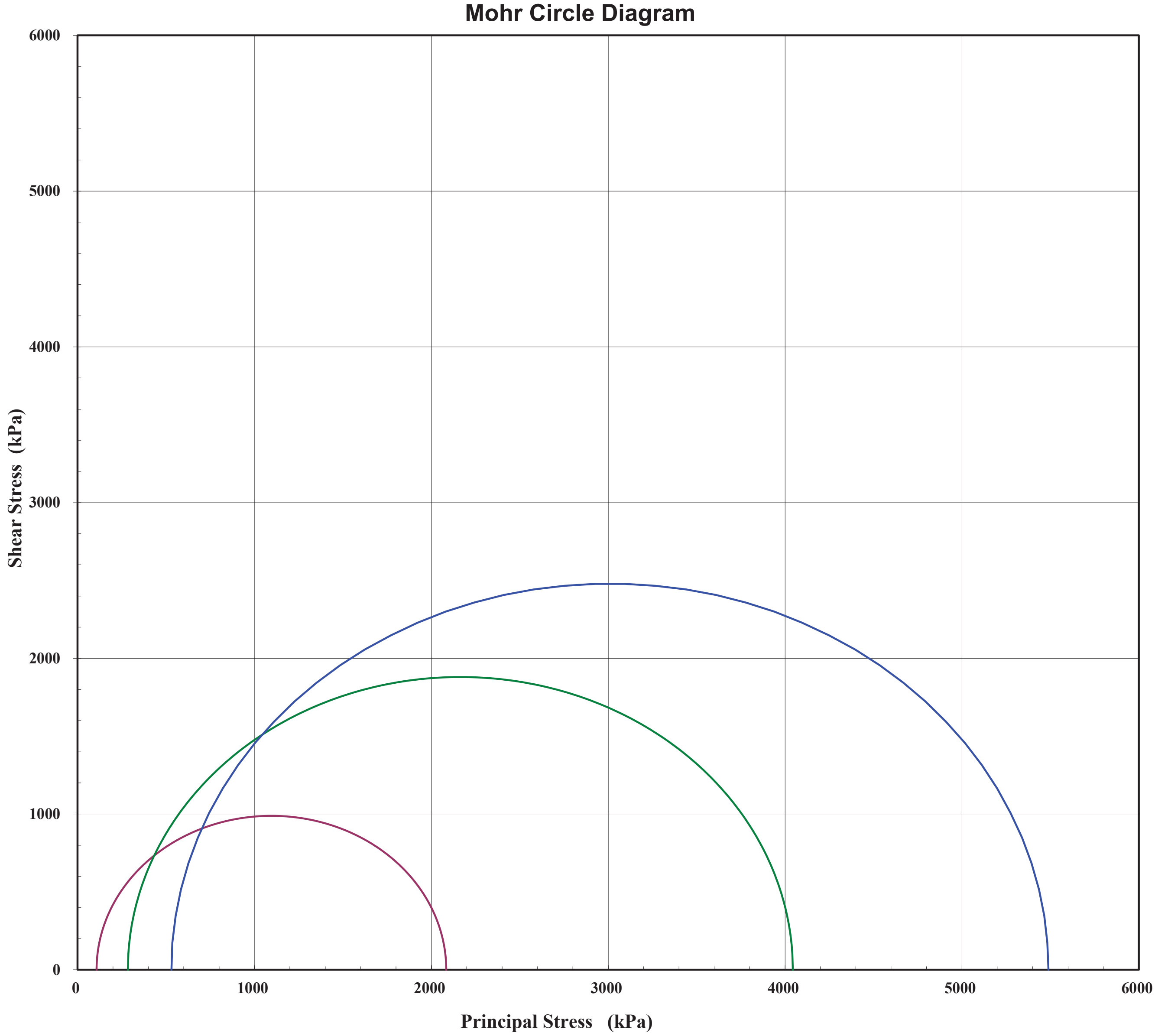
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

Client: Ground Control Engineering	**Report No.:** 18090075 - CU

Mohr Circle Diagram



Interpretation between stages :	1 to 2	2 to 3	1 to 3
Cohesion C' (kPa) :	135.2	489.9	240.1
Angle of Shear Resistance Φ' (Degrees) :	56.5	45.2	51.4
Failure Criteria:	Peak Principal Stress Ratio		

Remarks: Tested as Received

Sample/s supplied by the client

Note: Graph not to scale

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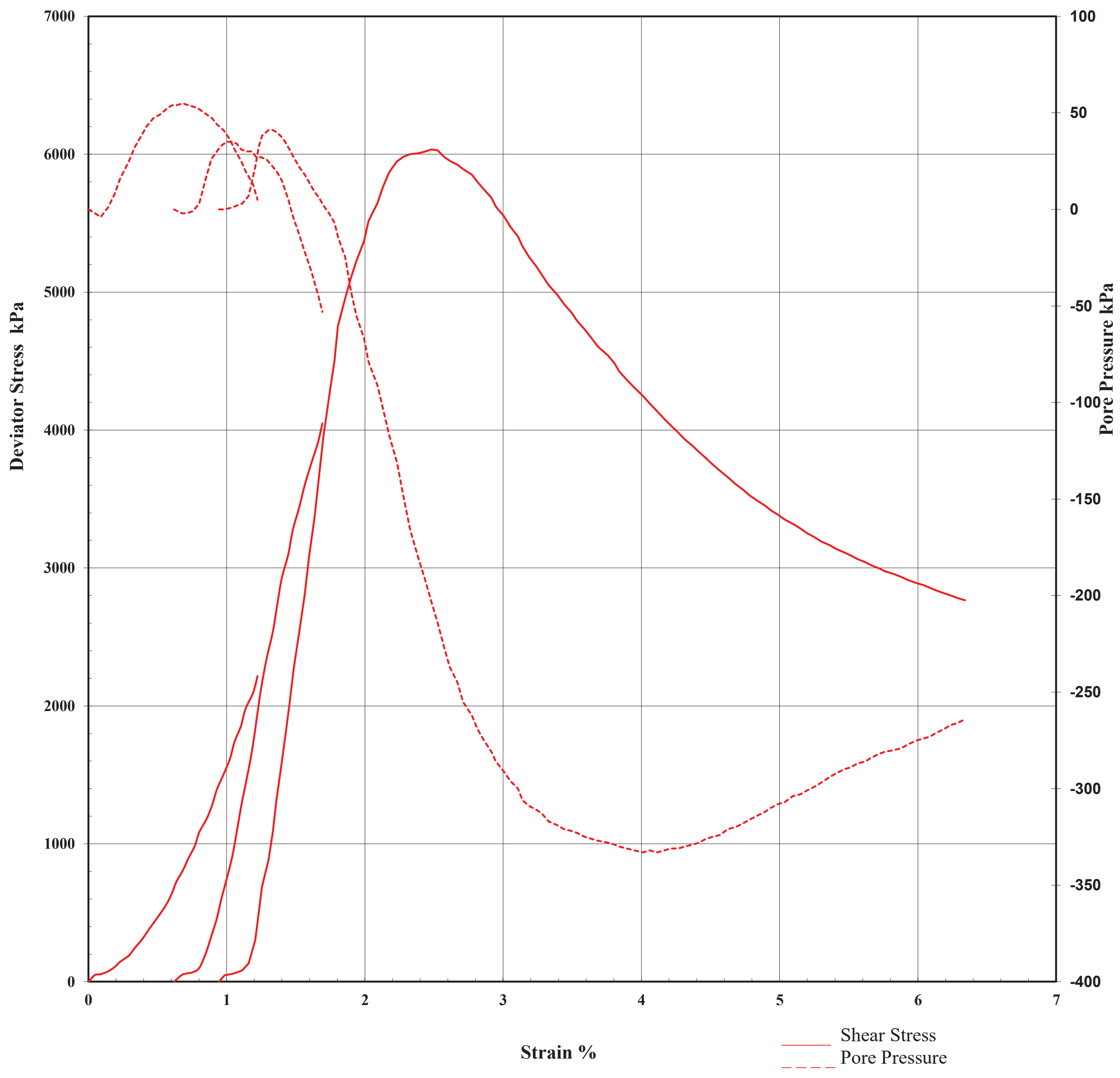
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

Client: Ground Control Engineering	**Report No.:** 18090075 - CU

Stress/Strain & Pore Pressure/Strain Diagram



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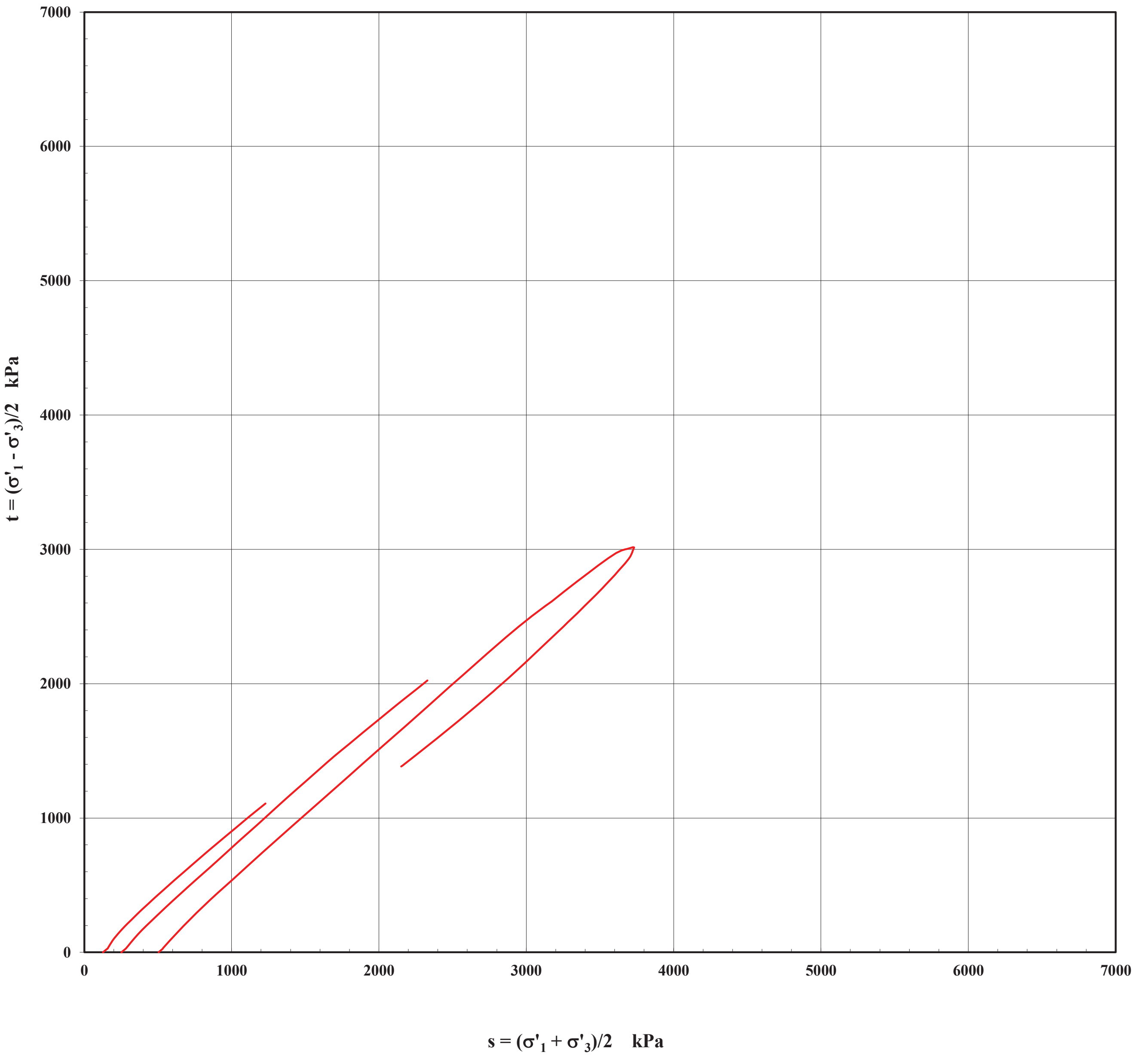
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

Client: Ground Control Engineering	**Report No.:** 18090075 - CU

MIT Method - Effective Stress Path



Remarks: Tested as Received

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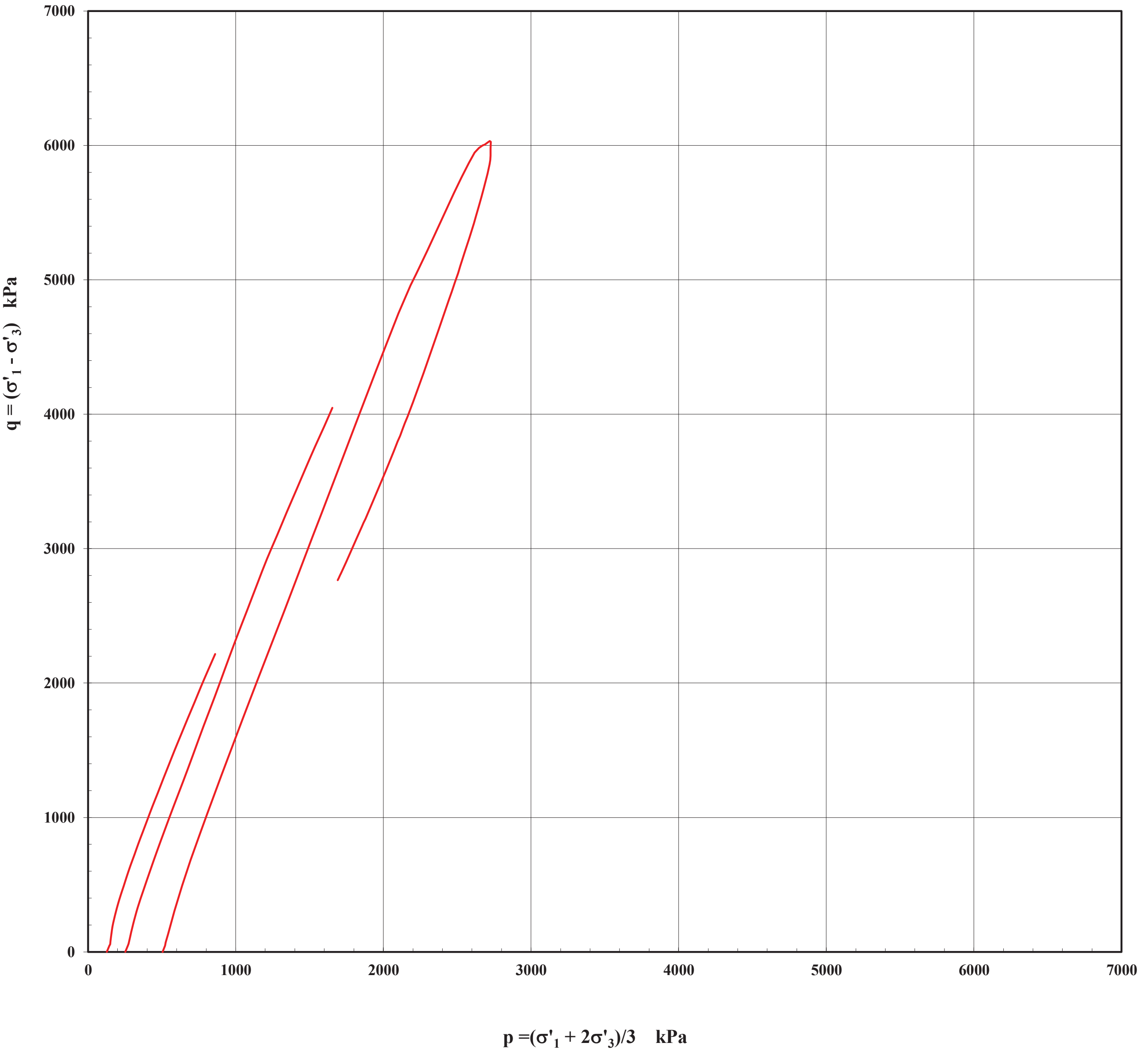
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

Client: Ground Control Engineering

Report No.: 18090075 - CU

Cambridge Method - Effective Stress Path



Remarks: Tested as Received

Sample/s supplied by the client

Note: Graph not to scale

Accredited for compliance with ISO/IEC 17025 - Testing.
The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.

Tested at Trilab Brisbane Laboratory.

Authorised Signatory

C. Channon

NATA
ACCREDITED FOR TECHNICAL COMPETENCE

Laboratory Number 9926

Trilab
Soil Rock Calibration

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TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

Client: Ground Control Engineering	**Report No.:** 18090075 - CU

Remarks: Tested as Received

Sample/s supplied by the client

Note: Photo not to scale

REP03001

Accredited for compliance with ISO/IEC 17025 - Testing.
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Tested at Trilab Brisbane Laboratory.

Authorised Signatory

C. Channon

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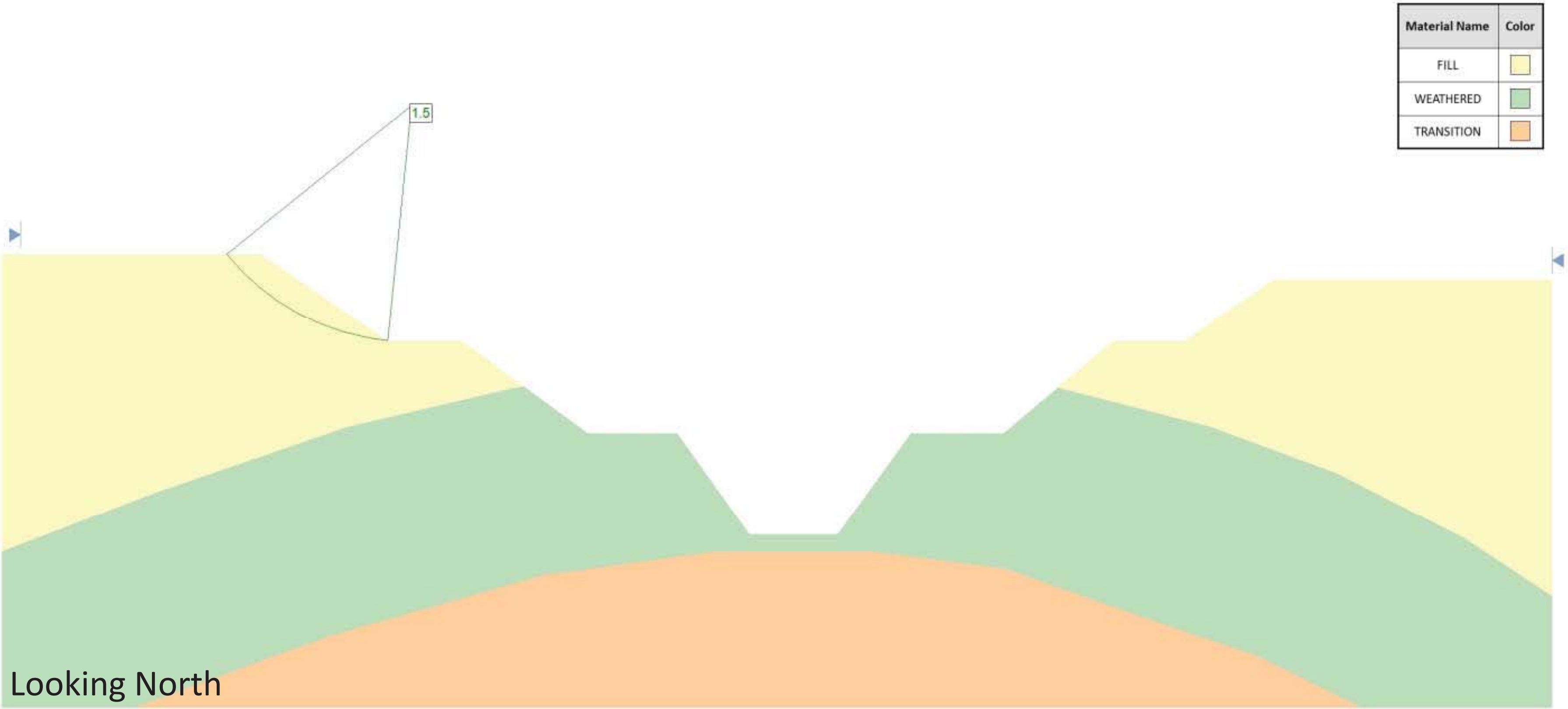
ACCREDITED FOR TECHNICAL COMPETENCE

Laboratory Number
9926

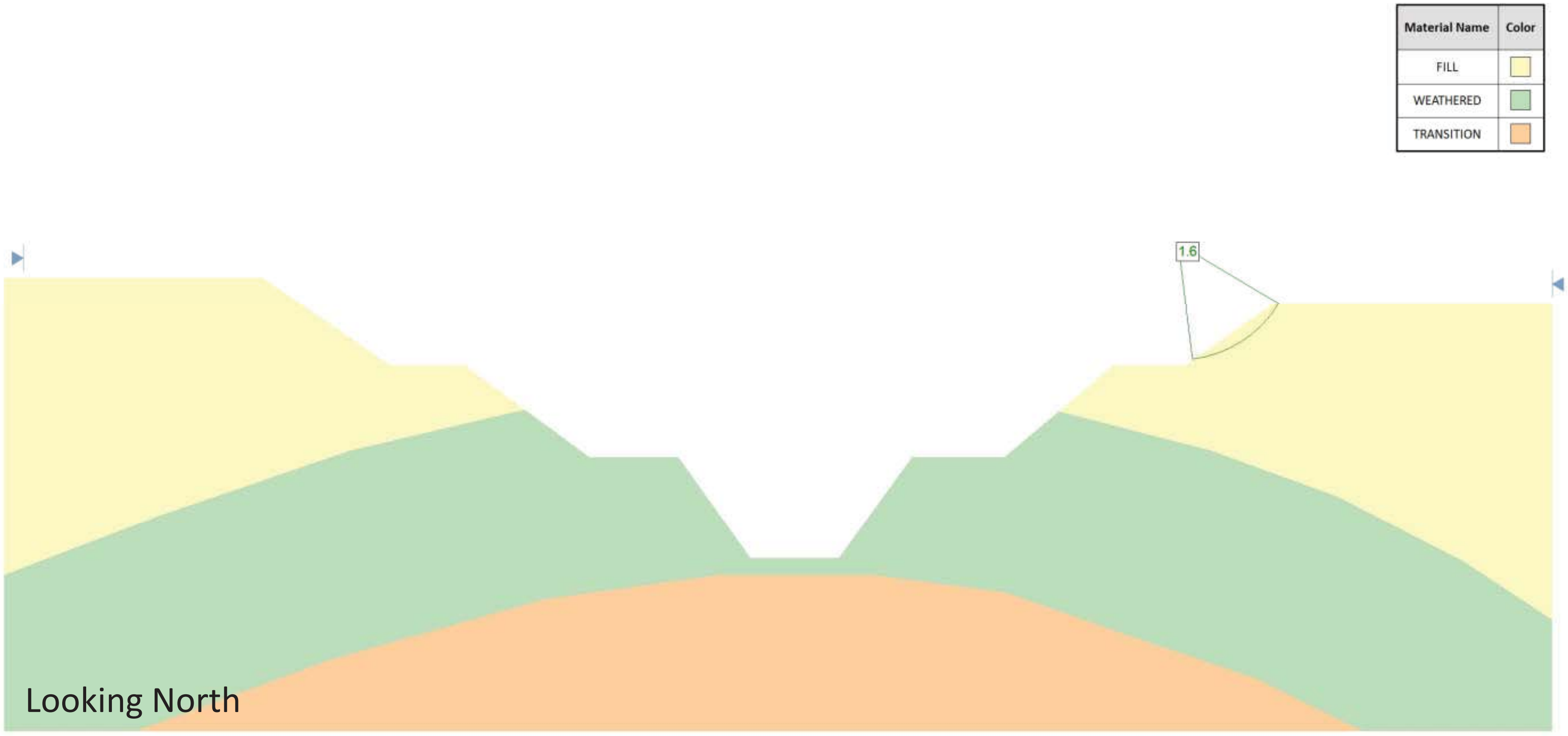
Appendix B Slide Model Results

West Wall

Model Results - Factor of Safety

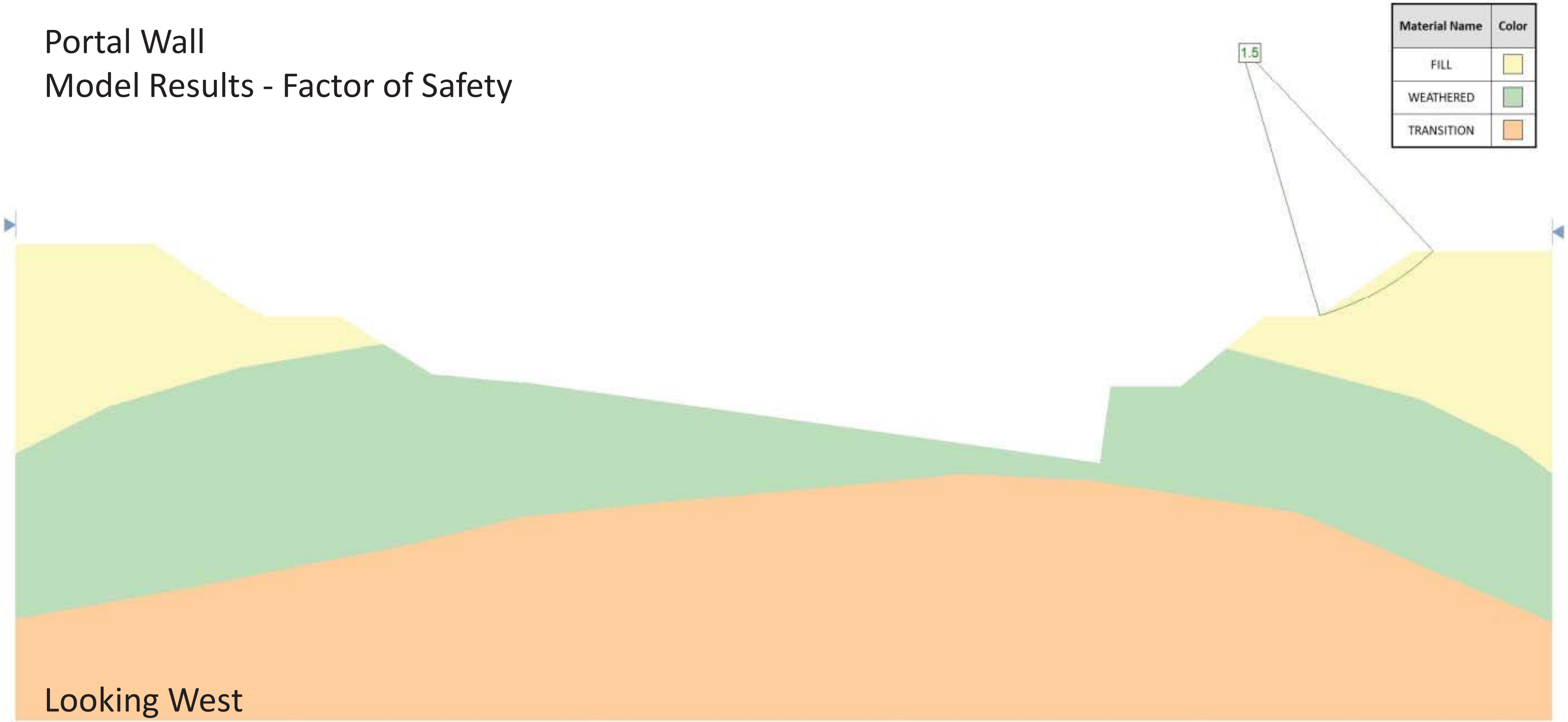


East Wall
Model Results - Factor of Safety

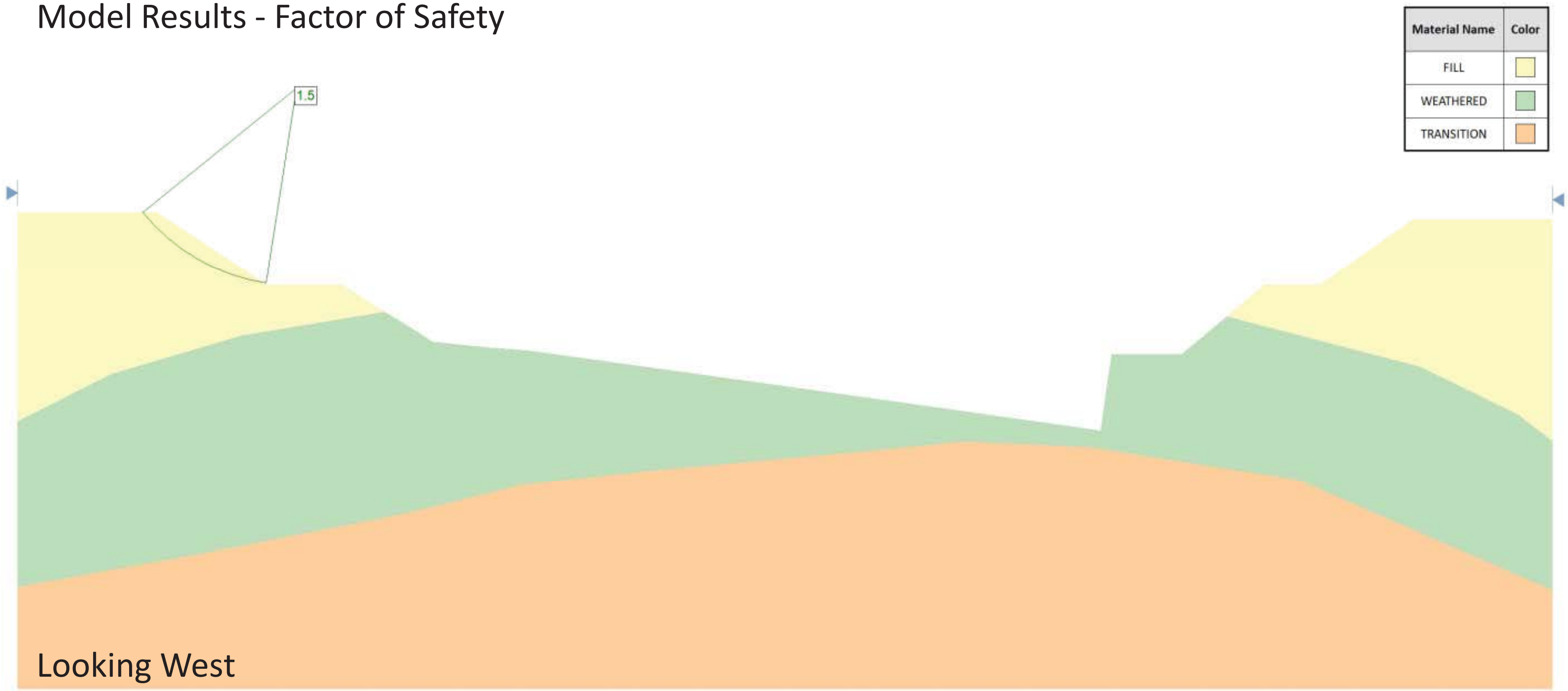


Portal Wall

Model Results - Factor of Safety



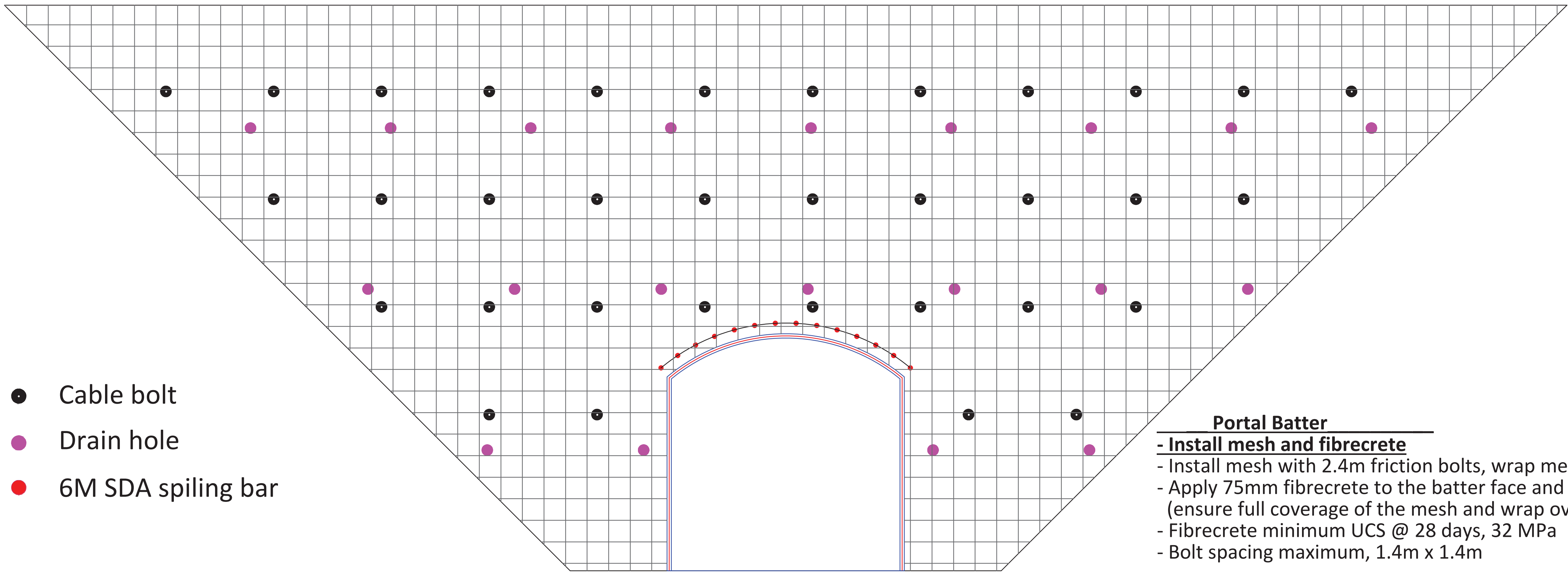
End Wall
Model Results - Factor of Safety

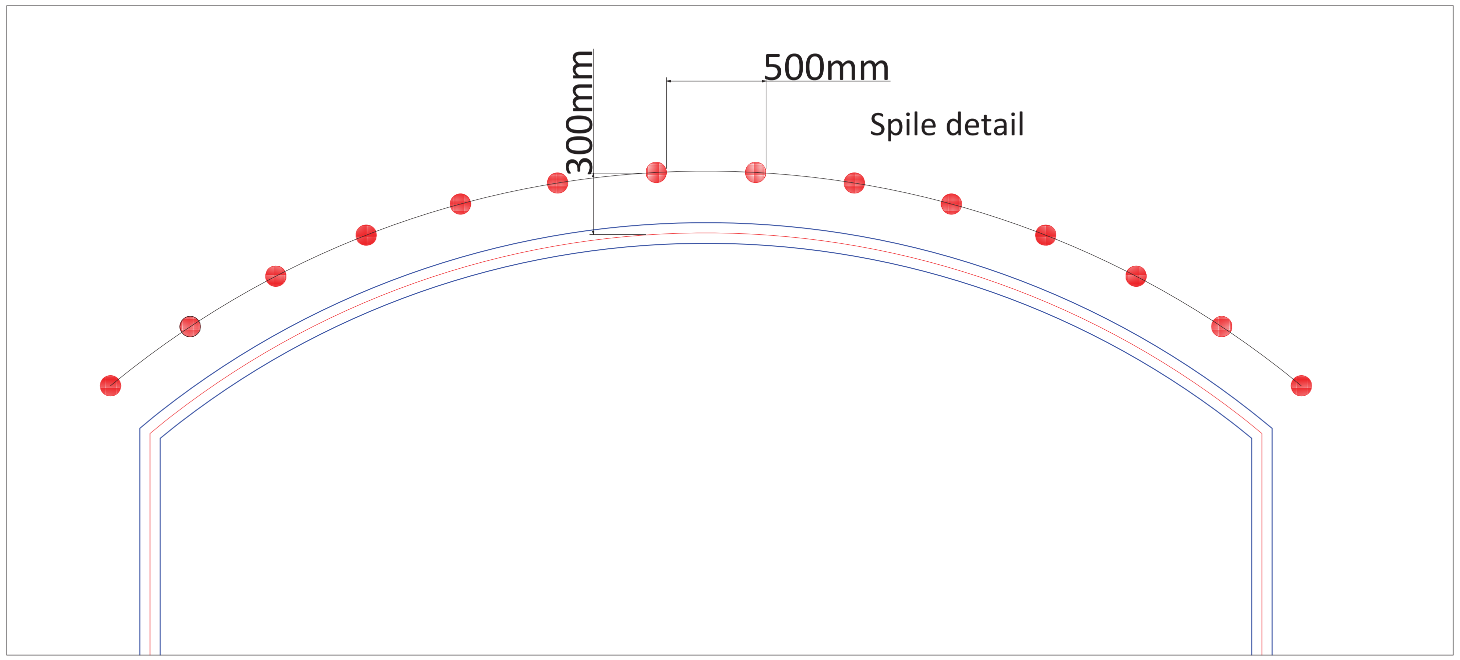


Looking West

Appendix C Portal Batter Ground Support Design

PORTAL FACE GROUND SUPPORT REQUIREMENTS





Portal Batter

- Install mesh and fibrecrete
- Install mesh with 2.4m friction bolts, wrap mesh 0.5m over crest
- Apply 75mm fibrecrete to the batter face and 0.5m over crest (ensure full coverage of the mesh and wrap over crest)
- Fibrecrete minimum UCS @ 28 days, 32 MPa
- Bolt spacing maximum, 1.4m x 1.4m

- Install cable bolts
- Twin strand, 25T per strand, w:c ratio 0.35 to 0.4 (full column)
- Plate and jack 1 cable to 4T
- Length, 10m
- Spacing maximum, 2.5m x 2.5m
- Crest to top row of cable bolts, 2.0m

- Install spiling bars
- Install prior to firing decline face
- 9m long, (2 x 3m coupled R32N bars)
- Overlap between spiles - 2.0m
- Drill holes 5 degrees up.
- Grout spiles with OPC with w:c ratio 0.35 to 0.4 (full column)

- Drain holes
- Drill drain holes to 6.0m depth, drain hole diameter 45mm
- Drill drain holes 5 degrees up
- Spacing - 3.5m x 3.5m
- Top row to crest - 2.8m

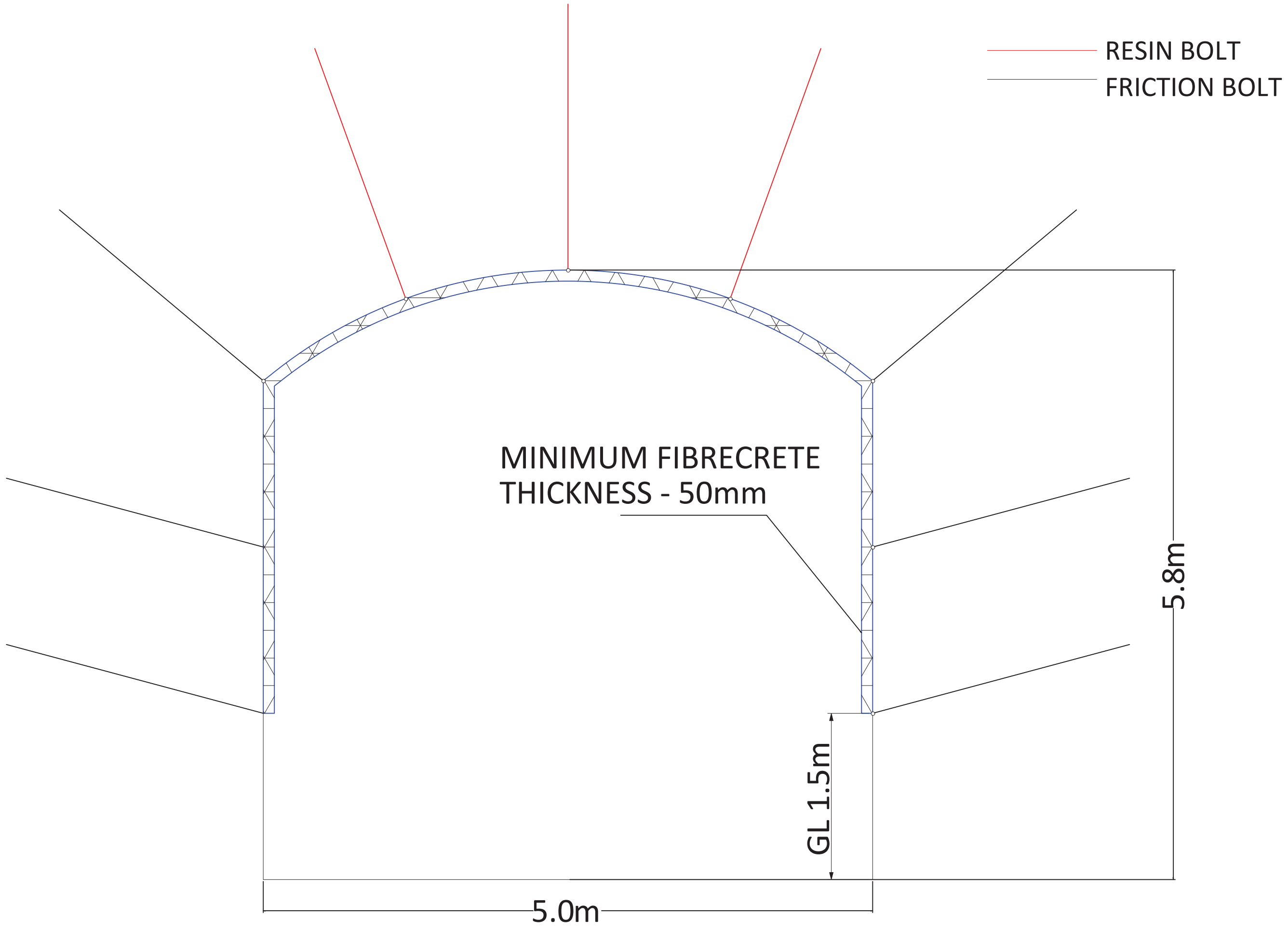
Side walls
- Mesh sidewalls with 2.4m friction bolts,wrap mesh 0.5m over crest.
- Spacing maximum, 1.4m x 1.4m
- Apply minimum 75mm fibrecrete to mesh (ensure full coverage of the mesh and wrap over crest)
- Minimum extent of sidewall coverage - 6.0m back from portal entrance.

Appendix D Decline Ground Support Designs

CBH Resources Limited

RASP MINE

PROFILE A
GROUND SUPPORT STANDARD F1



PROFILE: 5.8mH x 5.0mW ARCH
MINIMUM GROUND SUPPORT REQUIREMENTS
FOR GOOD GROUND CONDITIONS

REFER TO TARP FOR POOR GROUND CONDITIONS
IF GROUND CONDITIONS ARE POOR (PTO)

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

NOT TO SCALE

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