Ravensthorpe Gold Project

Environmental Review Document – Response to Submissions

Assessment No.2117

April 2020

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Approval for Release

Name	Position	File Reference
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Signature		
on behalf of P Bennett		

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1 Introduction

1.1 The Ravensthorpe Gold Project

The proposed Ravensthorpe Gold Project (the **Project** or **RGP**) is located approximately 550 kilometres (**km**) southeast of Perth and approximately 17 km southeast of Ravensthorpe in the Great Southern region of Western Australia (**WA**). The Project involves mining for gold and copper near the former town of Kundip.

The proposed Project occurs in an area with significant historical disturbance from previous mining activity dating back to the early 20th century. The current proposal includes a series of open pit operations, subsequent underground mining in some open pts, two waste rock landforms, a tailings storage facility and supporting infrastructure.

1.2 Assessment under the *Environmental Protection Act 1986*

An Environmental Review Document describing the proposal, the likely environmental impacts and the proposed management measures was realised released for public review on 1 October 2019. Submissions closed on 29 October 2019.

The purpose of this document is to assist the Environmental Protection Authority to assess the Project by providing responses to issues raised in submissions and to also provide the results of any additional investigations and/or information relevant to the assessment.

1.3 Submissions received

A total of 43 submissions was received. Submissions were received from:

- Seven State Government agencies;
- The Shire of Ravensthorpe; and
- Individuals, NGOs and other organisations based in the Ravensthorpe and Hopetoun areas.

2 EPA Services

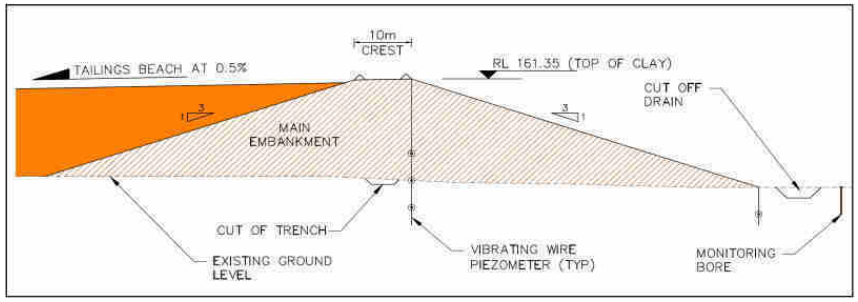
Item	Issue/Factor	Comment	Response
1.	Proposal	The proponent is advised to consider referring the proposal under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) to the Commonwealth Department of the Environment and Energy (DoEE) given the 14 year time frame since original referral, the change in scope and the presence of a number of threatened and vulnerable species.	An earlier version of the Project, the Phillips Rivers Project, was referred under the EPBC Act in 2005 (2005/2000). It was determined that it was "not a controlled action". ACH believes that the current proposal is substantially similar to the original proposal assessed under the EPBC Act in 2005. It contains key elements (mining and waste rock storage) within the same tenements which will be permanent features of the post-mining landscape. The addition of ore treatment and tailings storage in the current proposal adds to the Project footprint at Kundip. Conversely, the removal of the 17 km haul road traversing the Ravensthorpe Range from Kundip to RAV8, the removal of open pit mining and waste storage at Trilogy and the removal of the services corridor linking Trilogy to Kundip through the Kundip Nature Reserve collectively are significant reductions in the Project's environmental impact when compared to the Project that was determined to be "not a controlled action" in 2005. It is also noted that closure of the RAV8 site has been substantially advanced which would otherwise have not been the case had RAV8 been retained as the preferred ore treatment and tailings storage location for Kundip and Trilogy ores. The previous referral was supported by flora and fauna surveys that have been referenced in the current proposal and recorded substantially similar results to surveys undertaken on behalf of ACH.

Item	Issue/Factor	Comment	Response
2.			One species of Threatened Flora (listed under the WA *Wildlife Conservation Act 1950*) was recorded previously – this species is still present at the site but has since been removed from the Threatened species list and is now classified as a Priority species (P4). No flora listed under the EPBC Act has been recorded, either in surveys supporting the referral or in subsequent surveys. Fauna listed under the EPBC Act, including the malleefowl, Carnaby's black cockatoo and the western whipbird were recorded in surveys supporting the referral under the EPBC Act and the impact on these species was assessed at that time.
3.		The haulage route for water transport from RAV8 should be specified.	The haul route for carting of water from RAV8 to the RGP site will be along major public roads as shown in **Figure 1**.
4.	Terrestrial fauna	Please advise if the Heath Mouse *Pseudomys shortridgei* is or is not present at the site. Table 4-22 of the Environmental Review Document (ERD) states that it is present at the site yet Table 4-23 states that it is not.	Table 4-22 of the ERD is incorrect. The confusion arises from an incorrect field identification made in the initial fauna survey. The specimen was not vouchered. The survey company, APM, with the benefit of subsequent trapping efforts, determined that the specimen was likely to have been the much more common bush rat (*Rattus fuscipes*) and not the Heath Mouse (see p. 84 of Appendix C to the ERD). See also the response to item 51.

Item	Issue/Factor	Comment	Response
5.	Inland waters	<u>Water Balance</u> The water balance provided in Figure 4-36 does not provide any indicative volumes or information on water quality. The balance needs to be updated to include this information.	With regard to water volumes, feasibility studies are still underway and it is not possible to provide detailed water balance data (volumes) at this point. However, the initial water balance showed a potential shortfall in available water in the initial stages of the Project – thus, the potential requirement to import water from the RAV8 open pit. As the Project progresses, management of the site water balance will be undertaken via abstraction from RAV8 when in shortfall and potentially discharge to RAV8 and storage in the water storage facility (with discharge via evaporation) (see Figure 2-1 of ERD) when in excess. With regard to groundwater quality, Table 4-40 from the ERD summarises groundwater quality within the Project Area. This table has been updated to include more monitoring data collected since the release of the ERD and is included here as **Table 1**. Water quality data for RAV8 is also included here as **Table 2**. Water quality from both locations is comparable with a total dissolved solids content of approximately 20-30,000 mg/L.
6.		<u>Background Water Quality Monitoring</u> There has been insufficient background water monitoring for both surface and groundwater. Further sampling needs to be undertaken pre mining to be able to ensure adequate knowledge of background water quality and thus the impact of the operation. Much of the sampling undertaken to date is over 10 years old and may no longer reflect the current condition of the proposal area and surrounding environment. For example:	<u>Surface water quality</u> Local surface waters collected in dams directly over the Project Area provide background data on surface waters. These locations continue to be monitored and have most recently been monitored in September 2019. The results of water monitoring undertaken since the release of the ERD have been incorporated into **Table 1** (an update of ERD Table 4-39). Historical monitoring of water quality in both the Jerdacuttup and Steere Rivers has been limited. All available data has been presented in the ERD. Given that there has been no significant changes in land use in recent years, there is no reason to conclude that water quality will now be substantially different. ACH's ability to collect surface water samples has been hindered by low rainfall over a number of years. ACH has identified background surface water data

<table>
<tr><th>Item</th><th>Issue/Factor</th><th>Comment</th><th>Response</th></tr>
<tr><td></td><td></td><td>Water monitoring for Jerdacuttup River was collected in 2001-2002 and is unlikely to reflect the current condition of the streams in the area.
There is no background groundwater or surface water monitoring being undertaken in the Tailings Storage Facility (TSF) area. Without this information the potential impact of seepage from the TSF will not be able to be determined.</td><td>collection points that target the Steere and Jerdacuttup Rivers directly upstream and downstream of the Project Area. These points were outlined in the indicative surface water and groundwater monitoring program (see Figure 4-38 of the ERD and Table 3, Figure 2 which are updates of Table 4-43, Figure 4-39 of the ERD). The surface water and groundwater monitoring program has since been updated to address the various submissions received. Photo monitoring points P1 and P2 have also been converted to surface water sampling locations.
The surface water monitoring points are only able to be sampled opportunistically after rainfall event sufficient to generate stream flows. There has been no surface water flow and therefore no samples analysed since the submission of the ERD. ACH notes that only 9 days across the previous 2 years (2018/2019) have recorded over 10 mm of rain, none of which were over 25 mm. Monthly rainfall data across 2018 and 2019 showing generally low rainfall (~30 -40 % below yearly mean/median) is shown below (measured in mm).
<table>
<tr><th>Statistic</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th></tr>
<tr><td>Mean</td><td>24.6</td><td>26.4</td><td>32.6</td><td>32.5</td><td>43.7</td><td>43.3</td></tr>
<tr><td>Median</td><td>12.1</td><td>12.8</td><td>21.1</td><td>23.0</td><td>35.4</td><td>39.0</td></tr>
<tr><td>2018</td><td>12.4</td><td>36.5</td><td>16.7</td><td>13.4</td><td>8.0</td><td>22.4</td></tr>
<tr><td>2019</td><td>4.6</td><td>5.3</td><td>21.5</td><td>11.4</td><td>34.5</td><td>26.3</td></tr>
</table>
<table>
<tr><th>Statistic</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th><th>Annual</th></tr>
<tr><td>Mean</td><td>47.1</td><td>45.3</td><td>41.8</td><td>38.1</td><td>30.4</td><td>23.9</td><td>429.6</td></tr>
<tr><td>Median</td><td>43.2</td><td>41.6</td><td>37.0</td><td>31.4</td><td>24.2</td><td>15.3</td><td>432.1</td></tr>
<tr><td>2018</td><td>28.4</td><td>48.3</td><td>8.2</td><td>54.3</td><td>37.2</td><td>13.9</td><td>299.7</td></tr>
<tr><td>2019</td><td>(25.7)</td><td>69.2</td><td>12.1</td><td>29.6</td><td>9.3</td><td>6.7</td><td>(256.2)</td></tr>
</table>
ACH's surface water monitoring program in place now is activated on the basis of events rather than regular intervals. The program will respond to significant rainfall events which have the potential to lead to stream flows which in turn</td></tr>
</table>

Item	Issue/Factor	Comment	Response
			provide an opportunity for a representative and guideline compliant sample to be collected. Surface and groundwater monitoring at the TSF footprint There are no potential surface water sampling points (streams, dams) within the TSF footprint. While ACH acknowledge there is no groundwater monitoring data over the TSF footprint, ACH believe there is sufficient groundwater data for a baseline that is representative of the aquifers present within the TSF footprint. Consider the two aquifers occurring within the TSF area as shown in **Figure 3**. ACH has at least one bore in each of these aquifers and their distribution has been mapped. Groundwater monitoring bores are proposed for the TSF so additional data will be available prior to the commencement of operations.
7.		In Section 4.6.5.1 the impact of a breach of the TSF on surface water quality has been understated. Given the saline nature of the tailings, the sediment load and Potential Acid Forming (PAF) material, a breach of the TSF would be a significant impact and should be considered as such with management options in place to reduce likelihood of this event. This risk is increased as there are currently no seepage controls proposed for the facility.	A failure of the embankment (as it is designed) will only be a result of either the embankment saturating (as a result of poor operating practices) or as a result of liquefaction. Liquefaction will be negated by good operational and deposition practices (i.e. water is not to be stored on the TSF and not allowed to pond after storm events). This will be achieved in the detailed design (sufficient stormwater capacity) and also by adhering to the Operating Manual that will be implemented as part of the construction of the TSF. The risk is further negated over the life of the facility due to the fact that there is no proposed upstream raise over the life of the TSF. The starting embankments will be constructed at full width/capacity from the beginning of operations. As such it will only be for a very short period that the TSF will near its maximum operating pond storage capacity (840 mm freeboard), which would still provide 500 mm freeboard after a 1:100 year 72 hour event. This

Item	Issue/Factor	Comment	Response
			minimum 840 mm freeboard will only occur as the mine and tailings production approaches closure. It is also worth noting that these values were modelled using very conservative assumptions (i.e. runoff coefficient, C=1.0). The location of the proposed TSF has been optimised to provide the required storage capacity whilst minimising the catchment runoff that reports to the facility i.e. seepage is minimised by minimising TSF inflow. Specific design elements that relate to seepage have been included in the updated design report which has been attached in **Appendix A**. This design report includes significantly more detail in relation to the design, operation and closure of the tailings storage than the preliminary documentation provided with the ERD. The design elements to be incorporated include underdrainage, cut-off drains and cut-off trenches (under the embankment). These can be seen in plan view in **Figure 4**, taken from **Appendix A**. A cross section of the cut-off trench and cut-off drain is shown below. 

Item	Issue/Factor	Comment	Response
8.		Section 4.6.5.3 refers to seepage monitoring and a groundwater monitoring network and reference with baseline data. There is currently no baseline data for the TSF area. The proposed seepage monitoring bores are a considerable way downstream from the TSF and outside the project area, making early detection of seepage impossible. By the time seepage reaches the proposed locations a significant impact may have already occurred. The TSF design should be updated to include seepage controls and improved seepage monitoring at the toe of the facility and downstream.	While ACH acknowledges there is no groundwater monitoring data within or immediately adjacent to the proposed TSF footprint, ACH believe there is sufficient baseline groundwater data as the same aquifers are present across the project generally – see also response to item 5. The updated design report (**Appendix A**) includes a network of Vibrating Wire Piezometers and monitoring bores downstream of the TSF (see **Appendix A**). Monitoring bores will be installed around the TSF as part of the detailed design and construction (see **Figure 2**). The additional monitoring bores have been proposed closer to the TSF to align with those of the TSF design and to allow for earlier detection of seepage. Data from these bores and the piezometers will be used to correlate any rises in water level around the facility with deposition or increased rainfall. It is important to note that, given the geology of the TSF site, the monitoring bores will only intercept seepage through the alluvial soils – of which there are very little. The TSF site is underlain by siltstone and sandstone at surface. The seepage controls and the clay lined floor design of the TSF will restrict seepage.
9.		Information on the likely chemical composition of the tailings should be provided in order to better assess the likely impacts.	Appendix N of the ERD considered the geochemistry of both oxide and primary ore ('fresh rock') tailings and the information was summarised in section 4.4.3.4 of the ERD. Briefly, oxide tailings are likely to be NAF (not acid-forming) and tailings derived from fresh rock are likely to be PAF (potentially acid-forming). Elevated concentrations of some elements, compared with average crustal abundance, were noted. These included arsenic, selenium and copper.

Item	Issue/Factor	Comment	Response
10.		Given Bore KMB3 appears to be the only source of fresh water in the proposal area, are any specific controls planned by ACH Minerals to protect the water quality in this area?	Figures 4-30 and 4-31 of the ERD show that KMB3 sits on a localised fissured aquifer described as "fissured aquifer, locally fractured and jointed - moderate supplies from fracture zones, minor groundwater resource" (see **Figure 3**). This geological feature passes through the southern portion of the Project Area and is likely a location where a greater percentage of rainfall recharges to groundwater based on salinity and groundwater levels which is not typical of the remainder of the Project Area. At closure the water in Flag West pit (near KMB3) is likely to become moderately acidic because of oxidation of sulphides in the pit walls, causing copper, iron and aluminium to occur at multi-mg/L levels in the pit lake. Iron and aluminium concentrations might be reduced by the presence of silicates in the wall. However, the change in water quality at Flag West Pit / KMB3 will remain localised to the pit as there will be no movement of water from the pit into the surrounding rocks due to the pit acting as a groundwater sink at closure. The impact to groundwater quality will be localised to the Flag West Pit (refer to Appendix R from the ERD). It is for this reason that ACH believe that the water source around KMB3 / Flag West Pit area is adequately protected from significant water quality impacts.
11.		A revised monitoring programme (Table 4-43) is required to include seepage monitoring at the toe of the TSF. It is recommended that a comprehensive water management plan be developed, including more detailed groundwater monitoring of TSF and seepage from Waste Rock Formation (WRF).	See responses to items 6 and 7 in relation to seepage from the TSF. Seepage from waste rock landforms (WRL) is not anticipated to occur in any material sense. The design for WRLs describe in the ERD (as shown in Figure 4-25) includes: • A basal blanket of selected NAF waste rock, 1 m in thickness will be progressively placed and machine compacted over the footprint of the WRL;

Item	Issue/Factor	Comment	Response
			• The outer portion of the initial 10 m layer of waste rock will be constructed from NAF waste rock; • A low permeability barrier will be constructed from selected NAF waste rock near the downstream extent of the WRL; and • A clay barrier will be placed over co-mingled NAF-PAFLC-PAF waste rock. On the subject of a water management plan, ACH agrees a plan covering surface and groundwater monitoring and management would be beneficial and would accept a Ministerial condition in this regard.

Item	Issue/Factor	Comment	Response
12.		Section 4.6.5.6 refers to impacts to sensitive receptors as being only downstream users of the water. Sensitive receptors also include aspects of the environment, for example use of expressed groundwater to supplement stream flows and supporting vegetation. These sensitive receptors should also be considered.	It is implicit in the assessment that water quality in the Steere River is an important consideration. Impacts on downstream users and the environment will not occur without some degradation of water quality along the course of the river. With regard to groundwater in particular, the assessment does note that: • Groundwater can be recharged from stream flows but there is some potential for discharge of groundwater into stream sediments when stream levels are very low (section 4.5.3.4 of the ERD). In other words, expressed groundwater is not an established feature in the Steere River and flows are as likely or more likely to move from stream sediments into local aquifers; • Surveys did not record any obligate phreatophytes (plants dependent on groundwater) (section 4.2.3.4 of the ERD); and • Groundwater flows are very slow - the effect of any groundwater level changes would be undetectable at more than 300 m – 500 m down-gradient of the pits, due to the low permeability of rocks in the area as assessed by Rockwater (Appendix R of the ERD). There are potential impacts from the discharge of surface water from the site. Measures to manage this potential impact are discussed in the response to item 47.

Item	Issue/Factor	Comment	Response
13.	Terrestrial environmental quality	Section 4.4.5.1 - The management of PAF waste rock requires more detailed explanation. It is advised that a management plan for PAF and Waste Rock landform development should be developed. This should include, as ACH minerals have stated, ongoing monitoring of geochemistry as the pit develops to ensure PAF is identified and handled appropriately.	The relative proportions of NAF, PAF_{LC} and PAF waste rock are outlined in section 4.4.3.3 of the ERD (about 75% of all waste rock from the major pit, Kaolin, is NAF). While kinetic testing has also been proposed and will be undertaken by ACH, from a risk perspective the various materials can be readily distinguished by the degree of oxidation (see Table 4-28 of the ERD). In the unlikely event there is uncertainty about appropriate waste classification, sulphur content can be determined from blasthole cuttings. The general approach to placement of waste rock with the waste rock landforms is shown in Figure 4-25 of the ERD. Further detail will be presented when seeking approval under the *Mining Act 1978* and ACH proposes development of internal procedures consistent with undertakings in a Mining Proposal to guide day-to-day management.
14.		In Section 4.4.7 the statement that "*there is very limited potential for metalliferous drainage from waste rock*" needs to be supported with evidence.	This statement is based on: • The incorporation of low permeability barriers within each of the waste rock landforms to minimise ingress of rainfall (see Figure 4-25); and • Water extracts undertaken as part of the Project's geochemical testing recorded values "characterised by minor-element concentrations either below, or near, the respective detection-limits (0.1-1 µg/L range typically)" (Appendix L, ERD).

Item	Issue/Factor	Comment	Response
15.		A more detailed closure plan will be required that meets the *Guidelines for Preparing Mine Closure Plans (DMIRS and EPA 2015)*.	ACH included a draft Mine Closure Plan (MCP) with the ERD (Appendix F) for consultation purposes. The MCP is consistent with the guidelines at the time and provides sufficient information to allow assessment under the EP Act. ACH also notes that: • New guidelines were released in draft in September 2019 and have not been finalised; and • The DMIRS review was limited (i.e. did not consider geotechnical aspects – see item 42). It is ACH's expectation that an updated MCP consistent with the guidelines expected to be released in early 2020 will be provided for assessment of the Project under the *Mining Act 1978*. ACH acknowledges that additional information will be required "in order to meet the requirements of the Mining guidelines and gain operational approvals under the Mining Act" (DMIRS comment, Item 42).
16.		The closure plan needs to address post closure water management and in particular, management of flood events to prevent erosion/instability of pit walls as identified in figure 4-35 of the ERD.	ACH acknowledges the findings of the flood modelling and the implications for surface water management post-closure. The key areas of inundation as identified in the modelling at closure will be the targets for additional surface water controls and waterway diversion. Diversion structures will be designed to re-route run-off from a Probable Maximum Flood (PMF) rainfall events. Drainage will be routed around the landforms/pits to meet up with the natural drainage in a controlled way through the use of diversion structures. The design measures will be incorporated into the site's Mine Closure Plan prior to submission to DMIRS for formal approval.

Item	Issue/Factor	Comment	Response
17.		In Section 4.4.5.2 of the ERD – Tailings management – Capping of the TSF refers to 0.5 to 2m in one paragraph and then 2 meters in another. ACH Minerals should update Appendix P –Tailings Storage Facility to reflect the current proposed method of operation and closure of the facility.	The documented design at the time of submission of the ERD (Appendix P of the ERD) was for a capping thickness of 0.5 – 2 m. Section 4.4.5.2 refers to an update to this design to a minimum 2m thickness, after considering further information on the characteristics of the tailings. This change is reflected in an updated revision of the design documentation (Appendix A). Detailed closure design of the facility will now likely include cut-off drains upstream of the facility in addition to the 2 m (minimum) thick cover which will be designed as “store and release”. The thickness of this cover will depend on the capillary break required and the makeup of the tailings at closure.

3 General

Item	Submitter	Submission / Issue	Response
18.	Private submissions (30 proforma submissions)	Multiple positive proforma responses to proposal citing investment in local community, employment opportunities and mitigation of legacy issues at the site as positive outcomes were received.	ACH is appreciative of the community's support and undertakes to maintain and where possible improve its levels of community consultation.
19.	Shire of Ravensthorpe	Council supports the ACH Mineral's endeavours to expand their mining enterprise within the Shire of Ravensthorpe.	ACH is appreciative of the Shire's support and looks forward to working with the Shire to develop and implement the Project (subject to all the necessary approvals being obtained).
20.	Livingston Medical	The submitter has expressed their support for the project citing investment in the region, potential job opportunities and the ability to deal with legacy issues as positive outcomes.	ACH is appreciative of Livingston Medical's support and acknowledges the vital role that organisation plays in the local community.
21.	Private submissions (Non proforma) ANON-E5P7-Z8SM-K ANON-E5P7-Z8SQ-Q ANON-E5P7-Z8SA-7 ANON-E5P7-Z8S8-X ANON-E5P7-Z8S1-Q ANON-E5P7-Z8SP-P ANON-E5P7-Z8SW-W ANON-E5P7-Z8SB-8 ANON-E5P7-Z8ST-T	Positive response to proposal.	ACH is appreciative of the community's support.

Item	Submitter	Submission / Issue	Response
	ANON-E5P7-Z8SY-Y ANON-E5P7-Z8S6-V ANON-E5P7-Z8SF-C ANON-E5P7-Z8SU-U ANON-E5P7-Z8VM-P ANON-E5P7-Z8S5-U ANON-E5P7-Z8VB-B		
21.	Hopetoun Men in Sheds	Positive response to proposal	ACH is appreciative of the support from the Hopetoun Men in Sheds.
22.	Ravensthorpe Hotel	Positive response to proposal citing investment in the region and potential economic benefits.	ACH is appreciative of the support from the Ravensthorpe Hotel and agrees that the Project, if approved, will bring economic benefits to the Ravensthorpe area.
23.	West Coast Analytical Services	Positive response to proposal.	ACH is appreciative of the support West Coast Analytical Services and acknowledges the importance of having a NATA-accredited Environmental Laboratory located in South West WA.
24.	ANON-E5P7-Z8VC-C	Positive response noting the following concerns: Protection of the water catchment, which is the upper catchment of the Steere River which flows into the Phillips River; Avoid dust pollution - the close by old Copper mine Elverdton is a local disaster and needs fixing as soon as possible; and Good Fire mitigation planning.	ACH is appreciative of the submitter's support and acknowledges the importance of the issues raised. It is noted that the presence of a mineral processing plant and engineered tailings storage facility in close proximity to the Elverdton site may provide alternative approaches to remediation of the legacy issues associated with Elverdton.

Item	Submitter	Submission / Issue	Response
		The submitter believes ACH Minerals are fully aware of these issues and have adequately planned for them.	
25.	Ravensthorpe Community Resource Centre	Positive response to proposal citing ACH Minerals demonstrated commitment to the community and the potential positive effect on the local economy.	ACH is appreciative of the support from the Ravensthorpe Community Resource Centre and agrees that the Project, if approved, will bring economic benefits to the Ravensthorpe area.
26.	ANON-E5P7-Z8V1-T	The submitter believes that the EPA should not allow the Ravensthorpe Gold Project to proceed for the following reasons. The proponent claims that "due to the similarity between Phillips River Project (PRP) and the Ravensthorpe Gold Project (RGP) a further referral to the DEE has not been made". The previous referral was in 2005, almost 15 years ago. There are stark differences in the earlier PRP from the current RGP proposal – for example, clearing of native vegetation would increase from 80 ha to more than double to 197.8 ha; Offsets proposed by the PRP as opposed to No offsets with the current RGP proposal. In the intervening years the Western Ground Parrot (Critically Endangered) has become locally extinct. The RGP proposal is within the Fitzgerald region Biosphere, and the Ravensthorpe Range, an area of unique and diverse species of flora and fauna. The EPA should bring to bear the principle of intergenerational equity and a consideration of a full accounting of greenhouse gas emissions and the precautionary principle to its assessment of this proposal. The	With regard to referral under the EPBC Act, refer to the response to item 1. Offsets were considered against the current guidelines (Section 6 of the ERD). These guidelines were not in place at the time of the previous assessment. ACH acknowledges the biodiversity values associated with the Fitzgerald River National Park and the Ravensthorpe Range. ACH would also draw attention to the significant disturbance that has occurred at the site historically. Photos of Kundip in the early through to the mid-1900s clearly demonstrate the area had significant tracts of vegetation removed for the purposes of mine bracing, fuel and to expose surface expressions of the mineralised lodes (e.g. see Plate 2-2 , ERD). Direct comparison of the vegetation of the Project Area with pristine areas of the Fitzgerald Region Biosphere and the Ravensthorpe Range are potentially misleading.

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		EPA should consider the primary responsibility to protect the environment and reject this proposal.	The ERD contains a comprehensive assessment of the impact of the Project on the biodiversity values of the Project Area. The assessment concluded that the threat category of any flora and fauna is unlikely to be altered by the proposed project – consequently the EPA's principles are not compromised. The EPA did not consider air quality / greenhouse gas emissions as a relevant environmental factor for this assessment. The relevant guideline sates that the EPA will consider "proposals that have the potential to significantly increase the State's greenhouse gas emissions" (EPA 2016). The RGP proposal does not fall into this category. For completeness, ACH undertook an assessment that was included in the ERD (Appendix T).

4 Flora and vegetation

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27.	ANON-E5P7-28SD-A	The ERD has failed to adequately recognise the impact the proposal will have on priority species.	Flora and fauna surveys have been undertaken in accordance with the EPA's guidelines. The surveys comprised an initial desktop survey (what has been found there previously and what could occur there) followed by multiple field surveys across different seasons. ACH was also able to draw on the results from multiple past flora and vegetation surveys conducted by government and by consultants on behalf of previous proponents. Based on all of the above, ACH has identified a total of 18 Priority flora. The potential impact on each of these species is discussed in Table 4-12 of the ERD. The ERD also discusses the potential for indirect impacts on flora and vegetation. Overall, ACH believes the ERD presents a fair assessment of the impacts on Priority flora.
28.	ANON-E5P7-Z8VP-S Group of 6 individuals.	There is a significant number of priority species present at the site. ACH Minerals has not adequately addressed the protection of these species and communities and that further work is required to better define the spatial extent of the species on and adjacent to the site and also the status of certain species for example *Eucalyptus astringens.* In relation to the Threatened and Priority ecological communities (p 4-26), the submitter suggests that ACH Minerals has not clearly acknowledged that "*Proteaceae dominated kwongan shrublands of the*	Surveys have recorded a total of 18 Priority plant species. No Threatened species has been recorded. Each of the Priority species has been considered individually within the ERD (Table 4-12) in terms of their local occurrence and the likely impact of the Project. After the release of the ERD, additional information on selected species has been collected. This work is discussed in the response to item 36 (see also report included as **Appendix B**). With respect to *Eucalyptus astringens*, this species has been commonly recorded in surveys in the Project Area. This

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		southeast coastal floristic province of Western Australia ecological community" is an endangered community protected under the EPBC Act. The submitter is of the view that Figure 4.13 needs to be refined to indicate the actual occurrence of the Kwongan community. The occurrence of Dieback (*Phytophthora cinnamomi)* has now been recorded in the region, specifically at Hamersley Drive and on the Desmond Track and the ERD should reflect this.	species is not listed as Threatened, nor is it listed as a Priority species. ACH has mapped the "*Proteaceae dominated kwongan shrublands of the southeast coastal floristic province of Western Australia ecological community*" in Figure 4-13 of the ERD. Mapping was undertaken by initially mapping each vegetation community (there were 12 recorded) and then determining whether the vegetation community met the requirements (of which two vegetation types did – community 5 and community 9 (in part)). The exclusion of communities was largely on the basis of insufficient proteaceous cover values. While the Project Area is believed to be free of *Phytophthora cinnamomi*, ACH assumes that the introduction of dieback to the Project Area is a significant risk without the appropriate management measures. Any instances of local occurrences of dieback do not change this position.
29.	ANON-E5P7-Z8VU-X	Cumulative clearing of native habitat in the Ravensthorpe area needs to be more fully considered. Further consideration of the protection of threatened flora should also be made in particular the variant *Eucalyptus astringens* which is potentially a distinct species as well *as Calothamnus roseus, Pultenaea craigiana, Melaleuca sophisma* and *Melaleuca stramentosa*.	<u>Cumulative clearing</u> ACH has researched available data on remnant vegetation within the Shire of Ravensthorpe. Based on aerial photography undertaken between 2014 and 2018, **Figure 5** shows the extent to which land clearing has occurred. Based on the data extracted from this figure: • 62% of native vegetation remains uncleared;

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		Consideration of the area as a centre of plant endemism and its effective conservation is required. An investigation, including DNA analysis, should be undertaken into moort (*Eucalyptus platypus*) variant in the Kundip area to better understand its taxonomic rank, and further, if found to be worthy of subspecies ranking a conservation classification determined (recommend P1) and a taxonomic treatment prepared for submission to formalise its recognition. The restoration of the areas cleared should be diligently undertaken to ensure continued cover post-disturbance of the local vegetation, including those taxa mentioned above. A restoration or revegetation discussion or plan in the appendix as mentioned in the referral information could not be found. The removal of native vegetation for mining as proposed would present the opportunity to save and store topsoil and vegetative material containing propagules to supply restoration materials for sites affected. The submitter has recommended that the involvement of restoration expertise such as that developed by Kings Park and Botanic Garden scientists for Rocla and other mining and extractive companies' restoration achievements.	• There remains significant connectivity between coastal vegetation and woodlands to the north. See also response to item 41. <u>Eucalyptus platypus</u> Florabase (<u>https://florabase.dpaw.wa.gov.au</u>) recognises this species and two subspecies (*Eucalyptus platypus* subsp. *congregata* and *Eucalyptus platypus* subsp. *platypus*), none of which is Priority listed. *E. platypus* was recorded in site surveys. Florabase also recognises *Eucalyptus dielsii* × *platypus*, a P1 taxon. This taxon was not recorded in site surveys and records indicate it is known from "NW of Munglinup", about 70 km east of Kundip. <u>Rehabilitation and existing disturbance</u> ACH included a draft Mine Closure Plan with the ERD. The plan was prepared in accordance with guidelines issued by the Department of Mines, Industry Regulation and Safety (DMIRS). ACH has already committed to management of topsoil to optimise rehabilitation outcomes. ACH will recover and stockpile topsoil and has identified two opportunities – the embankment of the tailings storage facility and the batters of waste rock landforms – where fresh topsoil can be used (i.e. direct transfer of topsoil onto newly-constructed surfaces. If the proposal is approved under the *Environmental Protection Act 1986*, a more detailed Mine Closure Plan will

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		The referral information states that the some of the area subject to mining is already heavily degraded. The submitter disputes this characterisation and indicates that it would be more accurate and honest to say that some degradation has occurred through past mining and exploration practices, with the levels of disturbance and degradation varied from most disturbed and modified in some small patches and access roads, through to light disturbance and modification along exploration lines. Most places of disturbance would likely respond to quality and locally appropriate restoration techniques, given the availability and quality of well managed materials, and the apparent dominance of obligate-seeding taxa. The conservation and restoration of this site post-disturbance could be an opportunity for leadership by ACH minerals in an area well-known for its conservation and endemism significance and under the public gaze being close to a main road. If restoration planning and implementation is given priority and resources, and done well, it could provide an important and useful exemplar.	be submitted to DMIRS for review. Further details about the rehabilitation processes to be used will be provided at that time. ACH accepts that the community considers rehabilitation to be a key aspect of the Project and will be looking to see progress in this area. There will be an opportunity through the proposed Community Reference Group (see item 73) for community input. ACH stands by the characterisation of some of the areas subject to mining under the proposal as being heavily degraded. The presence of multiple open pits, waste dumps, extensive underground workings which are open to surface, tailings storage facilities, abandoned heap leach pads and abandoned processing infrastructure are by definition heavily disturbed areas. The mineral leases that are the subject of the proposal were assessed by the Government of Western Australia under the *Mining Rehabilitation Fund Act 2012* during 2019 and found to have over 59 ha of disturbance. In accordance with the requirements of the Act, ACH pays an annual levy on this disturbance. Where existing disturbance occurs and does not form part of the Project footprint, ACH has committed to rehabilitating those areas.
30.	ANON-E5P7-Z8SV-V	Flora and fauna studies have been carried out extensively and threatened species have been noted. However the submitter could not find reference to	All flora and fauna recorded during field studies are listed in Appendix C of the ERD. Appendix C includes a full list of flora. For a list of fauna see Table 5-2 (birds), Table 5-3

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		species that do not fall into the threatened category. For example *Eucalyptus erythandra* (*Eucalyptus* sp Kundip) does not appear to be mentioned. Existing flora and fauna studies should be deemed comprehensive by the Department of Biodiversity Conservation and Attractions (DBCA) or other qualified bodies.	(amphibians, reptiles and most mammals) and Table 5-4 (bats) of Appendix C. Regarding *Eucalyptus erythandra* (*Eucalyptus* sp. Kundip), this species was not recorded during surveys. The current epithet, *Eucalyptus x erthyrandra*, is widespread, from near Albany to east of Esperance (see below from Florabase).

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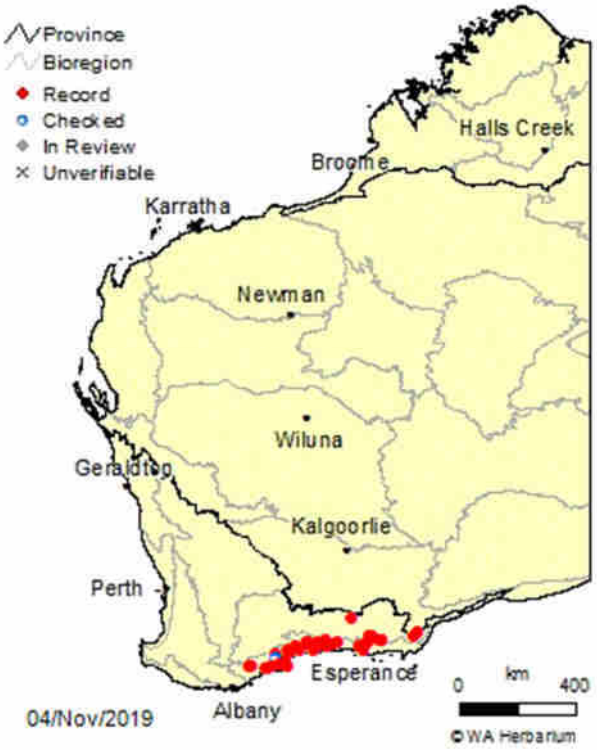
			Eucalyptus x erythrandra  Consultation has been undertaken with DBCA during the assessment process (see Table 3-2 of the ERD) who also commented on drafts of the ERD prior to its final release. See also item 34 in relation to further comment from DBCA.

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31.	ANON-E5P7-Z8SN-M	The level of clearing required and its impact on native fauna particularly Carnaby's Black Cockatoo, Chuditch, Malleefowl and the Heath Mouse is a concern.	Clearing will be restricted to that which is necessary to implement the mine plan. ACH accepts that clearing of native vegetation does reduce the available habitat for fauna but the impact assessment has determined that the loss of habitat is not material for any of the species that occur or could occur in the Project area. ACH also notes that areas that are already cleared due to historical mining activities will be rehabilitated during or after the proposed Project is completed.
32.	ANON-E5P7-Z8SE-B	The extent of the clearing required should be minimised, with all possible vegetation being left and cleared areas kept to an absolute minimum.	ACH agrees that clearing of native vegetation should be restricted to what is necessary to implement the mine plan. It is in ACH's interest to minimise clearing as it will: • Help to demonstrate the Company's environmental management credentials; • Minimise the cost associated with clearing native vegetation and stockpiling topsoil; • Minimise the Company's Mine Rehabilitation Fund (MRF) liability; and • Minimise the overall rehabilitation liability and provide linkages between areas requiring rehabilitation.
33.	Gondwana Link	This is sited in an area which, while already impacted by historic mining activity, supports an exceptionally rich flora and a significant number of rare and little known wildlife. There is little recognition in the proponents	While there are examples of historical mine disturbance (e.g. Kundip, Elverdton), every mine proposal in recent years has gone through an extensive environmental impact assessment process. Both the current proposal and the Ravensthorpe

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		documentation of cumulative impacts successive mining developments will have on site or wider, with information restricted to a few paragraphs of subjective comment at the end of the Public Environmental Review (PER) document (pages 76-7). Notwithstanding this, the document does recognise the extreme biological richness and importance of the area. The fact that this is widely recognised, and substantiated by the significant number of important plant and animal species on site and nearby, even given the very low level of survey and documentation that has occurred to date. The PER document is correct in noting the very low level of attention and funding government has given to understanding the species richness of the area, and of course implicit in that is the almost total lack of attention given to key ecological functions, such as connectivity, and the likely impact of increased regional mining pressure. But that is no excuse for allowing further mining in such an important and sensitive area, even given potential mine funding for a couple of short term studies (which is of course not a realistic remedy for the current lack of ecological knowledge and understanding). The submitter recommends that the Kundip Mine proposal not proceed and that the Environmental Protection Authority (EPA) recommend government	Nickel Project have been or are undergoing assessment under Part IV of the *Environmental Protection Act 1986* and in both cases flora and vegetation are key environmental factors. Another significant local project, the Mt Cattlin Spodumene Project, was not assessed under Part IV of the EP Act but did seek and was granted clearing permits. In terms of survey effort, the Kundip area has been the subject of multiple botanical surveys over a number of years, as described in the ERD. ACH rejects the statement that the Project Area has a low level of survey and documentation. While the level of survey and documentation relevant to the Project Area does not extend to the broader Ravensthorpe Range area the results of a regional survey (Craig et al 2007; Craig et al 2008; Markey et al 2012) are available and were considered in the impact assessment described in the ERD. Habitat connectivity was also considered in the ERD and is again discussed in this document (see item 29). Other comments in this submission are directed towards government.

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		address its conservation management priorities in this area by resourcing an intensive study, including the cumulative impact of further mining, and give full consideration to the raft of historical and current proposals for Class A conservation in the area.	
34.	Department of Biodiversity Conservation and Attractions (DBCA)	***Recommendation 1:*** *That further detail is provided on cumulative impacts of the proposal on conservation significant flora, threatened ecological communities and priority ecological communities.* **Discussion:** The ERD primarily considers direct (clearing related) impacts within the development footprint and appears to provide only limited assessment of indirect impacts (e.g. Table 4-13 page 4-46, and Table 4-14 page 4-48). Despite previous advice and recommendations provided by DBCA, the document contains no assessment of the cumulative impacts of relevant proposals and developments on conservation significant flora. The Ravensthorpe Range area has known high conservation significance and cumulative impacts on local species and their habitat are potentially an important issue, particularly for endemic taxa restricted to the Ravensthorpe Range. The Ravensthorpe Range area is highly prospective for minerals and areas that support conservation significant values outside of the Ravensthorpe Gold project area, including pending Exploration Licence	ACH disagrees that the assessment of indirect impacts included in the ERD is "limited". ACH conservatively applied a 20 m buffer to the proposed direct disturbance and included a discussion of potential indirect impacts (sections 4.2.5.4 through to 4.2.5.10). This is consistent with the appropriate guideline (EPA 2016) which defines a proposal area as "The area impacted by clearing for proposal and any adjacent indirect disturbance or impacts that may result from operation, including changes to hydrology or introduction of weeds." With regard to cumulative impacts, impacts attributable to agricultural clearing are unknown. There are two major mining projects in the area – the Ravensthorpe Nickel Project (RNP) and the Mt Cattlin Spodumene Project. ACH reviewed a survey undertaken for the most recent proposal from the Ravensthorpe Nickel Project (Eco Logical Australia, 2018) and included the results in Table 4-12 of the ERD. There were only two Priority species in common with the RGP proposal – *Lepidosperma* sp. Maydon (S. Kern, R. Jasper, H. Hughes LCH 17844) and *L.* Mt Short (S. Kern et al LCH 17510) – both of

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		applications held by the proponent (ACH Minerals) in the nearby Kundip Nature Reserve and Overshot Nature Reserve, which are the subject of current or future proposals for mining activities (exploration) submitted under the *Mining Act 1978*. DBCA previously recommended that the final ERD should confirm whether known occurrences of conservation significant flora have been impacted by previous exploration or mining activities and, if so, an attempt to describe and quantify these impacts should be made. Based on the information provided it appears that no new information was collected or compiled and presented in the ERD.	which were recorded outside of the proposed area of impact at RNP. ACH has subsequently reviewed clearing permits 3045 and 8052 granted to Galaxy Resources for the Mt Cattlin project. Surveys supporting these permits recorded only one species – *Grevillea fulgens* (P3) – common to the Priority species recorded at RGP. The decision report indicated that these plants would not be impacted. ACH confirms the Company does hold Exploration Licences E74/413 and E74/578, portions of which cover the Kundip Nature Reserve. ACH is not the holder of Exploration Licences over the Overshot Hill Nature Reserve but has an interest in minerals other than lithium and tantalum through a commercial agreement with the tenement holder, Galaxy Resources. Proposals for non-ground disturbing sampling (e.g. collection of rock chips and soil sampling) are under consideration.
35.	DBCA	**Comment:** Due to limited available resources, DBCA has only undertaken a preliminary review of the management plans provided with the ERD. It is requested that the opportunity is provided for DBCA to review further versions of management plans relating to conservation significant species and communities prior to their approval but following confirmation by the DWER on a preliminary basis that they meet the	<u>Management plans</u> In relation to the Flora and Vegetation Management Plan, Dieback Management Plan and Terrestrial Fauna Management Plan, specific comments on the plans are addressed elsewhere. ACH proposes to produce updated

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		basic content requirements of the environmental approval conditions. ***Recommendation 2:*** *Further consideration be given to the mitigation hierarchy to avoid, minimise, rehabilitate or offset impacts on conservation significant flora, fauna and ecological communities.* **Discussion:** Environmental Scoping Document (ESD) requirement 9 indicates that the ERD is to demonstrate that all practicable measures have been applied to reduce the area of the proposed disturbance footprint and development envelope. In previous advice DBCA requested clarification on the extent of flexibility in relation to the boundaries of the development footprint and the locations of project elements within the development envelope. While Table 4-15 (page 4-51 to 4-53, replicated in Table ES3 page xvi) makes a commitment to review the proposal footprint prior to commencement of construction, DBCA is of the view that the project footprint and layout of the infrastructure, waste rock landforms etc should be optimised to avoid or minimise direct and indirect impacts upon conservation significant flora, fauna, vegetation and threatened and priority ecological communities, prior to finalisation of the assessment. Where unavoidable impacts are identified during the assessment, the application of measures to minimise,	draft Management Plans in response to Ministerial conditions (should the proposal be approved). <u>Footprint review</u> With regard to the footprint and the potential for modification, ACH confirms that modifications will be made where possible, although a view of the proposed site layout (Figure 1-2 of the ERD) shows that the Project elements are already tightly constrained within the disturbance footprint. Consequently, it is expected that future footprint changes will be of a minor or incremental nature. One measure that is currently proposed, however, is an Exclusion Zone that offers an increased level of protection to *Calothamnus roseus* (P1) (see discussion in next item). This will necessitate the relocation of some infrastructure.

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		rehabilitate and offset may be appropriate, in accordance with the mitigation hierarchy.	
36.	DBCA	***Recommendation 3:*** *That the following information is considered in the context of assessment of the significance of impacts on conservation significant flora from this proposal.* **Discussion:** DBCA has reviewed the information presented in the ERD and considers that the assessment of the significance of impacts on conservation significant flora and communities, as presented in Table 4-12 and elsewhere in the ERD, appears to be largely qualitative and requires a more systematic and quantitative assessment based on empirical data where possible. In many cases, advice previously provided by DBCA on deficiencies and limitations in information presented in the draft ERD remains valid and key aspects of that advice has been re-iterated below where applicable: <u>Description and evaluation of impacts and their significance</u> In several cases, assessments of the impacts of the proposal on conservation significant flora populations (numbers and percentage) are either not provided or based on extrapolation of inadequately validated population estimates rather than population counts (e.g. *Melaleuca sophisma* Table 4-12 page 4-38, and	<u>Description and evaluation of impacts and their significance</u> In the light of the comments from DBCA, ACH undertook a further targeted survey for: • *Calothamnus roseus* (P1); • *Melaleuca sophisma* (P1); • *Thomasia* sp. Hopetoun (K.R. Newbey 4896) (P2); • *Hydrocotyle tuberculata* (P2); and • *Dampiera* sp. Ravensthorpe (G.F. Craig 8277) (P3). The report on the survey is included here as **Appendix B**. The survey aimed to undertake plant counts within the Development Envelope for each of the five taxa and to collect additional information via a new DBCA database survey. The survey also included a review of records that had not yet been entered into the DBCA database. The outcome of the survey is summarised in **Table 5**. One clear conclusion from the study is that a significant portion of the overall population of *Calothamnus roseus* occurs within the Development Envelope. In light of this, ACH has elected to add an Exclusion Zone (**Figure 6**) to the Development Envelope, <u>within which ACH will not undertake any disturbance, including exploration</u>. The level of protection

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		Calothamnus roseus Table 4-12 page 4-35). This results in significant uncertainty and difficulties for DBCA in providing informed and definitive advice on the significance of impacts. Further information on the methodology used to assess significance and quantification of impacts on conservation significant flora is considered necessary to reduce the level of uncertainty to an appropriate level, particularly with respect to *C. roseus* (Priority 1), *M. sophisma* (Priority 1), *Thomasia* sp. Hopetoun (K.R. Newbey 4896) (Priority 2), *Hydrocotyle tuberculata* (Priority 2), *Dampiera* sp. Ravensthorpe (G.F. Craig 8277) (Priority 3), and *Marianthus mollis* (Priority 4). Confirmation of the adequacy of targeted searches for conservation significant flora by DWER would benefit the assessment. For example, a review of the survey track logs by DBCA shows very low intensity of targeted searches within the area of *C. roseus* habitat. Appendix C (Section 6.1 page 109) states "*that the number of individuals was not counted as the population did not occur within the proposed Project area at the time*". It was concluded that "*the majority of the population will not be impacted by the Project directly or indirectly*" and as detailed in Table 4-12 of the ERD (page 4-35) the expected impact was determined as "*unlikely to be significant*". This assessment appears to be on the basis of estimates on the number of plants likely to occur in	afforded to this taxon by the Exclusion Zone is detailed in **Table 5.** The Exclusion Zone includes a 20 m buffer to provide protection from potential indirect impacts. Should future surveys identify that *C. roseus* is more widespread than current knowledge suggests, ACH may seek to have the Exclusion Zone removed. The survey found that less than 1% of almost 60,000 known plants of *Melaleuca sophisma* occur within the Development Envelope. The Project is not expected to have a significant impact on this species. Regarding *Thomasia* sp. Hopetoun (K.R. Newbey 4896), the survey recorded 44 plants in the Development Envelope, 18% of all known plants. While this is a substantial proportion, the taxon has several secure populations in Fitzgerald River National Park. The survey did not record any individuals of *Hydrocotyle tuberculata* or *Dampiera* sp. Ravensthorpe (G.F. Craig 8277) in the Development Envelope but the timing of the survey was sub-optimal for these taxa. *H. tuberculata* is known across a range of 250 km and the population within the Development Envelope is unlikely to be significant. Similarly, *D.* sp. Ravensthorpe (G.F. Craig 8277) also appears to be well-represented outside of the Development Envelope.

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		the proposal area and estimates of those impacted within the development envelope. Clarity should be sought as to how the population extent and estimated total number of plants were derived for *C. roseus* occurring within and proximate to the development envelope. Habitat requirements and restricted distribution of conservation significant flora Technical experts within DBCA have indicated that *C. roseus* (Priority 1) was rarely encountered during analysis of plot-based data by Markey (2012)[1] for survey data acquired by Kern *et al.*[2] and Markey *et al.* (2012) (2 plots of 266 analysed, or <1% of plots). This information, when combined with other information from WA Herbarium records, appears to indicate that this species is restricted to a small area in the southern portion of the Ravensthorpe Range. *C. roseus* also appears to be more-or-less restricted to Kundip Quartzite, which is an uncommon geological unit in the Ravensthorpe Range. The significance of impacts of the	Habitat requirements and restricted distribution of conservation significant flora For information, ACH has added a figure (**Figure 7**) showing the known distribution of the Kundip Quartzite and of *Calothamnus roseus.* ACH reiterates its commitment to undertake further subregional surveys of conservation significant *Lepidosperma* spp.

[1] Markey, A. (2012). "Floristic communities of the Ravensthorpe Range, Western Australia." Conservation Science Western Australia **8**(2): 187-239.

[2] Kern SR, Jasper R, True D (2008) 'Floristic survey of the Ravensthorpe Range, 2007'. Unpublished report prepared for the Department of Environment and Conservation by Western Botanical/Landcare Services.

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		proposal on this species should be assessed in the context of the current understanding of its restricted distribution and specific habitat requirements. *Lepidosperma* sp. Elverdton (R. Jasper *et al.* LCH 16844) (Priority 1) is currently known from three collections in the WA Herbarium, all of which were collected in 2007 during the Ravensthorpe Range survey[3]. Its current known distribution is restricted to the Ravensthorpe Range and the southernmost collection (PERTH 7973195) was from within the development envelope. The WA Herbarium record for this collection indicates that "isolated plants" were recorded in this location. *L*. sp. Elverdton was not recorded in the APM surveys (Appendix C) and no quantitative proportional impact data was provided in the ERD (Table 4-12, page 4-35). Given the known restricted distribution of this species, and uncertainties as to the occurrence within the development envelope, impacts have the potential to be of high conservation significance at both the local and regional scale. A similar situation occurs for *Lepidosperma* sp. Maydon (S. Kern, R. Jasper, H. Hughes LCH 17844) (Priority 1) and *Lepidosperma*. sp. Mt Short (S.Kern *et al.* LCH 17510) (Priority 1) as these species are also known from very few locations, with a	

[3] Gibson (2009) Ravensthorpe Range Biological Survey: Information Sheet 30/2009. Science Division. Department of Environment and Conservation

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		distribution restricted to the Ravensthorpe Range. The proponent's commitments in Table 4-15 to undertake further sub-regional surveys for *Lepidosperma* species and to reduce or eliminate direct impacts on *Lepidosperma*. sp. Mt Short (S. Kern et al. LCH 17510) (Priority 1) are supported.	
37.	DBCA	***Recommendation 6:*** *That if the proposal is considered acceptable, a condition of approval is applied that requires the development and implementation of a Dieback Management Plan (with review at regular intervals) in consultation with DBCA.* **Discussion:** DBCA has undertaken a basic risk assessment of the proposal in accordance with relevant guidance[4] and determined that without appropriate management, *Phytophthora* dieback[5] is 'almost certain'[6] to be introduced or spread within the development envelope. Given the high biodiversity values within the	ACH agrees with DBCA's assessment that, without appropriate management, there is a high risk of the introduction and spread of dieback. Therefore, ACH will: • Undertake a further dieback survey of the Development Envelope prior to the commencement of operations; • Develop an updated Dieback Management Plan in consultation with DBCA; and • Implement the Plan throughout the life of the Project.

[4] Department of Biodiversity, Conservation and Attractions (2017). *Phytophthora Dieback Management Manual*. Prepared by Parks and Wildlife Service, Forest and Ecosystem Management, Department of Biodiversity, Conservation and Attractions, Perth.

[5] The term "Phytophthora Dieback (or Dieback) refers to the disease caused by soil borne plant pathogens from the genus *Phytophthora.* Forty-two *Phytophthora* species have been identified in Western Australia (DBCA 2017)

[6] Phytophthora Dieback Management Plan guideline FEM079

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		development envelope and adjacent areas, the consequence rating for introduction of dieback to areas of native vegetation is considered to be 'significant' to 'severe'. Poor dieback hygiene (e.g. inappropriate procedures for management of vehicle movements, or contamination of 'dieback free' topsoil) will likely impact on the environmental outcomes of the proposal, such as the achievement of rehabilitation outcomes, with potential for direct impacts on conservation significant values both within and outside of the development envelope. DBCA has completed a preliminary review of the Dieback Management Plan (Appendix G) and determined that further survey effort and revision is necessary. Several commitments made in Table 2-1 (page 10 of Appendix G), such as conducting a new dieback survey, are supported by DBCA and the proposed management controls are considered generally consistent with best practice, although improvements can be made and alternative approaches adopted to further reduce the likelihood of the introduction, or spread of dieback to the project area. It is recommended that if the proposal is considered acceptable, the advice of a registered and suitably experienced dieback interpreter is sought to inform the development and implementation of a Dieback Management Plan. This plan should be developed on	ACH notes that the granting of Section 40E Permits for access to Prospect on Crown Land (Prospecting Licences) within granted mineral licences continues to occur within the Company's tenure, both inside and outside of the Project Area. Prospecting Licences are granted with no conditions imposed on the holder that in any way address dieback risk, thereby undermining the Company's efforts to manage the risk.

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		the basis of current and valid dieback interpretation and mapping and include specific details on the intended prevention and management of dieback and related impacts. DBCA is a lead State agency with respect to the provision of advice on the management of dieback and therefore it is appropriate that DBCA be consulted during the development of a Dieback Management Plan.	
38.	Department of Water and Environmental Regulation (DWER)	The flora and vegetation survey has not been revised since review of the draft ERD. DWER has previously advised (15 January 2019) that the flora and vegetation survey was adequate. It is not obvious therefore how impacts to significant flora have increased from the draft ERD, and this should be clarified by the proponent. The increases are: Figure 4-4 – Significantly more *Melaleuca sophisma*, *Calothamnus roseus* and *Lepidosperma* sp. Mt Short shown within or adjacent to the Project Area than previous versions of the ERD. Figure 4-6 - Significantly more *Pultenaea craigiana* shown within and adjacent to the Project Area. Figure 4-7 - More *Stachystemon vinosus* shown within the Project Area. Figure 4-8 - Increased area of both *Melaleuca sophisma* and *Pultenaea craigiana* populations.	Subsequent to the initial draft of the ERD, ACH uncovered some additional sources of information comprising previous survey work that was not included in DBCA databases. This work includes surveys by Craig (2004, 2005); Eco Logical (2018); Hickman (2009); McQuoid (2009); and Rathbone (2013). All of these contained information that was relevant to the assessment. The impacts outlined in Table 4-12 of the ERD reflect this additional information. Note that Figure 4-4 shows only two locations for *Lepidosperma* sp. Mt Short, as stated in the ERD. This is more clearly evident in Figure 4-16. Also note that some taxa have been the subject of additional survey since the release of the ERD. This is discussed in the response to item 36. Regarding the P3 PEC "*Proteaceae dominated kwongan shrublands of the southeast coastal floristic province of Western Australia ecological community",* we include here a

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		Table 4-12 - Comment on *Lepidosperma* Mt Short states there are 2 known populations within the Development Envelope but can be avoided. The new Figure 4-4 shows 8 locations of the species, several of which appear to be in the disturbance area. Table 4-12 – As with comment above, other species require updating in terms of the numbers impacted and the significance of the impact. Figures 4-17 to 4-19 – More information provided now than in previous versions.	modified version of Figure 4-14 from the ERD. This figure (**Figure 8** in this report) shows the distribution of the PEC as mapped by APM and the project's disturbance footprint. ACH also takes the opportunity to add further information in relation to *Lepidosperma* sp. Elverdton (R. Jasper et al. LCH 16844). We include an additional figure here (**Figure 9**) which shows the existing known populations and the cover values associated with each.
39.	DWER	In comparing Table 4-12 in the draft ERD (version f) and the final ERD (August 2019), there are obvious increases in number of significant flora recorded. It appears that much of the increase comes from historical studies (Craig 2004, 2005) as well as changes to the various Figures' scale. Due to these, and other unclarified factors, it appears that there may be potential increase in impact to significant flora, however given that all individuals now counted are not necessarily in the development area, the proportional impact to significant flora may have decreased. It is not obvious if numerical values are also reflected in the quantification of impact and management actions, as well as assessment of the proposal's impact on significant flora.	See response to item 38.

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		The proponent should revise its analysis of impacts to significant flora and appropriate management actions based on new values presented.	
40.	DWER	Appendix E - Flora and Vegetation Management Plan has not adequately addressed the impacts associated with the project. The Flora and Vegetation Management Plan duplicates information from the Flora and Vegetation Survey without applying the information into the Management Plan. Additionally, the plan also does not adequately describe a monitoring program to measure the suitability of proposed management. Particular attention should be paid to revising and applying appropriate monitoring and management to "management actions" in Table 2-1 of the Flora and Vegetation Management Plan for vegetation clearing, project layout, weeds, closure and rehabilitation, progressive rehabilitation and vegetation health as targets and detailed management are currently inadequate. This advice is in line with DWER's previous advice on the draft ERD (15 January 2019), for example - a management target for closure and rehabilitation is stated as "*successful rehabilitation (germination of seeds)*". The basic nature of this management target shows a lack of understanding of rehabilitation works. As stated in DWER's previous	ACH generally accepts that the plan would benefit from more detail. ACH would agree to a Ministerial condition (should the proposal receive approval) requiring ACH to provide an updated Flora and Vegetation Management Plan that addresses the requirements in more detail.

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		advice, rehabilitation in a floristically diverse region should not be committed to without any determination of feasibility.	

5 Landforms

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41.	ANON-E5P7-Z8VP-S Group of 6 individuals.	Submitter commented on the geological significance of the Ravensthorpe Range and the ecological linkage that it creates between the Fitzgerald River National Park and the Great Western Woodland with concern over the proposals disruption to this link. The Submitter has also commented that the proposal will have a significant impact on the landscape amenity which is currently largely untouched and that the Steere River has been misrepresented in the document (s 4.5.3.2) in that it has been identified as a tributary rather than the river itself.	ACH acknowledges the importance of the ecological linkage referred to in the submission. The vegetation linking these areas is shown in **Figure 10**. The proposed Project area is not a 'greenfields' site as it has a long history of mining and processing, with numerous mines known from the area (as shown in Figure 4-22 of the ERD). Disturbance at the local scale also includes related infrastructure, including a railway and the township of Kundip. While the Project will create significantly more substantial waste rock landforms over those that currently occur, these structures will not approach the adjoining Ravensthorpe Range in elevation and will be rehabilitated progressively during operations. With regard to the Steere River, there are several branches that originate at the top of the catchment and meet south of Kundip. Based on data from the Department of Water (see Figure 4-28 from the ERD), the branch of the Steere River that occurs in proximity to the proposed Project is not shown while two other branches are shown. ACH infers from this information that it could be considered a tributary. This has no effect on the impact assessment.
42.	Department of Mines, Industry, Regulation and Safety (DMIRS)	DMIRS has not conducted a Geotechnical assessment of the proposed TSF design and management. As part of the mining proposal (MP) and mine closure plan (MCP) review process under the *Mining Act*	ACH acknowledges that documentation submitted for approval under the *Mining Act 1978* will require a level of detail consistent with guidelines issued by the Department of Mines,

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		1978 (Mining Act), TSF design and other elements requiring geotechnical assessment will be referred to DMIRS, Mines Safety Division for assessment. As previously noted, the ERD and MCP present only generic TSF closure design principles. There is insufficient information presented in the documents to provide comment as to the whether the potential environmental impacts can be adequately managed post-closure. This information will need to be addressed in order to meet the requirements of the Mining guidelines and gain operational approvals under the Mining Act.	Industry Regulations and Safety. ACH will consult with DMIRS when developing the necessary documentation.
43.	DMIRS	An additional waste characterisation study was completed by Graeme Campbell and Associates in July 2019. A conservative approach was taken in the classification of PAF waste materials. This has resulted in two categories for PAF material being identified. Samples with total sulfur content of greater than 0.3% where classified as PAF and samples with total sulfur content of between 0.1-0.3% were classified as low capacity PAF (PAF-LC), material with the potential to generate acid in limited amounts. The PAF and PAF-LC material will make up 27% of the total waste volume from the Kaolin pit.	ACH acknowledges that some mine waste has the potential, to varying degrees, to produce acid leachate but that the overall material balance is favourable. The general approach to managing PAF-$_{LC}$ and PAF material within waste rock landforms is shown in Figure 4-25 of the ERD and involves: • A NAF blanket underlying the full extent of the WRL with a low permeability barrier at the outer edge; • Embankments comprised only of NAF material with a low permeability barrier underneath; • Capping the final upper surf ace with NAF and a low permeability barrier.

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		The majority of the total of waste volume (62%) is comprised of oxide material that is chemically benign but prone to erosion. It is noted that the solubility of metals and metalloids in the waste material has not been tested under range of pH conditions. Based on the waste characterisation results the material may be subject to acidic conditions and this may influence the solubility of Arsenic, Bismuth and Copper found to be enriched in the some of the waste samples. The ERD states water extraction testing recorded very low solubility for Arsenic, Bismuth and Copper however the potential for metalliferous drainage may have been underestimated. To manage PAF material it is proposed the waste rock classified as PAF and PAF-LC is co-mingled with non-acid forming (NAF) material in the centre of the waste rock landform, encapsulated by oxide NAF material and a one metre layer of NAF competent fresh rock material. As indicated in the Landform Evolution Modelling report (Appendix O) the long term stability of the landforms is highly dependent on the type of cover material used. The successful management of PAF is dependent on adequate volumes of NAF fresh rock material being recovered from the mining operations. A rehabilitation material	The intent of this design is to prevent conditions under which mixed NAF- PAF-$_{LC}$-PAF material can form leachate. In the event that the proposal receives approval under the EP Act, ACH will be required to submit a Mining Proposal and an updated MCP to DMIRS for approval under the Mining Act. ACH acknowledges the following as requirements for an updated plan: • Material balance; • Leachate quality under acidic conditions; and • Updated final landform structures. In regards to the landform/pit post closure surface water management measures see response to item 15. With regard to the Landform Evolution Modelling Report (Appendix O of the ERD), the initial design used was representative of waste rock landforms used across the state. The intent of the investigation was to assess the ability of the abundant oxide materials to provide a stable surface for waste rock landforms. The findings indicated that a satisfactory result was not likely to be achieved through the use of oxide materials alone. The report also identified some basic flaws in the landform design which ACH would remedy prior to submitting documents for approval under the Mining Act.

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		balance has not been presented to demonstrate that there will be sufficient quantities of competent NAF material to adequately complete the waste landform design at closure. Post-closure surface water modelling presented in Figure 4-35 of ERD shows there is potential for water ponding (greater than 2m depth) to occur in areas around the landforms and open pit bunds. Insufficient information has been provided on waterway diversions to provide confidence that the management measures proposed for the PAF material (including landform design) will be adequate to management the post closure environmental risks. As previously noted the Landform Evolution Modelling report (Appendix O) completed by Soilwater in 2018 recommended a change to the landform design for the South Waste Rock Landform due to unacceptable gully formation, and alludes to the long term stability challenges presented by a batter/berm design. Insufficient information is provided in the ERD to detail how the initial design was selected and to justify how this design is the most appropriate to reduce potential environmental impacts to an acceptable level.	

6 Terrestrial environmental quality

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44.	Shire of Ravensthorpe	The closure plan should have set key milestones relating to rehabilitation of the site instead of waiting until the end of the project to action the closure plan.	The potential for progressive rehabilitation has been considered and construction of the TSF and the WRLs both allow for progressive rehabilitation. The TSF embankment will be constructed at its final height and angle. This means the wall can be rehabilitated immediately following construction. Similarly, the WRLs will be constructed by paddock dumping in 10 m high benches. Each bench can be constructed at its final angle and rehabilitated. This approach will be included in the next iteration of the Mine Closure Plan.
45.	Shire of Ravensthorpe	If the mine operation is to be placed into care and maintenance for longer than three years the closure plan is to be activated.	ACH does not agree that the site should automatically proceed to full closure after a three year care and maintenance period. Many gold mining operations are left in a 'mine-ready' state for extended periods of time, provided there is no ongoing environmental impact (e.g. discharge of contaminated water). The cyclical nature of the gold mining industry means that a change in gold price can enable recommencement of profitable mining at sites where mining had been suspended. It is likely to be in the community's interest to allow the future possibility of further mining. However, in the event that the site's resource has been effectively exhausted, mine closure should proceed immediately after the cessation of operations.

7 Terrestrial fauna

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46.	ANON-E5P7-28SD-A	The submitter is concerned about the level of clearing of native habitat and its impact on vulnerable species such as the Carnaby's cockatoo, Malleefowl, Western Whipbird, Western Ground Parrot and Chuditch which are known to inhabit the area.	The submitter's concerns are acknowledged. In conducting the impact assessment, ACH has formed the view that the Project Area does not form critical habitat for any of these species.
47.	ANON-E5P7-Z8VP-S Group of 6 individuals.	The submitter acknowledges that the ERD establishes that the area is important for a wide range of fauna including many conservation significant species (Table 4-22 and 4-23). Given this the submitter has asked if the proposal has been referred to the Commonwealth Government under the EPBC Act. The submitter has also expressed concern that the Steere River will be adversely effected downstream of the proposal through the use of saline water on site and potential turbid runoff from cleared areas and that this will in turn impact on the use of the river by fauna.	With regard to referral under the EPBC Act, the current proposal has not been referred for the reasons outlined in the response to item 1. ACH acknowledge the risk of impacts to the Steere River through the use of saline water and turbid runoff and the potential impact to fauna. In regard to the risks associated with soil erosion and siltation of rivers from clearing the following have been proposed in the ERD: • Dust suppression on haul roads will be undertaken to minimise dust generation and will utilise small windrows along the edge of roads to control erosion and sedimentation. • In addition to culverts and drains (ERD Figure 4-34) sediment traps and detention basins will be used to slow flow of surface water and give any mobilised sediments the opportunity to settle (a modified version of Figure 4-34 is presented here as **Figure 11** to show these features). Regular maintenance will be required to ensure

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			they remain effective and a monitoring program implemented. • In addition silt and salts removed from sediment traps that have had dust suppression water applied or that have been in contact with any saline waters will be disposed of within the tailings storage facility or waste rock landform. Saline water spills are another pathway for potential impact. The following controls are in place to prevent saline water spills: • Construct water pipelines with spill protection and undertake daily inspections; and • Educate workforce on reporting and effective management of spillages.
48.	Cocanarup Conservation Alliance Inc. (CCA)	The area proposed for the mining development is acknowledged to be suitable habitat for the malleefowl, which is currently listed as "Vulnerable" (facing a high risk of extinction in the wild in the medium-term future). Members of CCA who are familiar with the area involved have indicated that these birds have been regularly seen here over many years – so much so that warning signs have been erected on the Ravensthorpe-Hopetoun Road. The submitter believes that the negative impact of the proposed mining operation on this species will extend beyond the already substantial area that is to be cleared, via increased vehicle movements, noise and dust etc.	During surveys, no active or recently active mounds were recorded. However, the submission correctly identifies that sightings have been made in the area over a number of years and that the Project Area may be used by malleefowl, even if this only involves movement through the area. There is suitable habitat to the north and the south of the Project Area so the passage of birds through the area should not be significantly impacted. The risk of roadkill will increase with an increase in the amount of traffic. ACH will educate employees and

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			contractor about this risk and any incidents will be reported to DBCA.
49.	BirdLife WA (BWA)	BWA understand that 197.8 hectares (ha) of native vegetation will be affected (cleared or disturbed) within a development envelope of 428 ha. It is understood that the proposed development includes open cut and underground mining, as well as on-site processing with tailings and other waste management. BWA is concerned about the scale of the impact within an otherwise extensively disturbed landscape within the Fitzgerald Biosphere Reserve. We have further concern that the proposed impact area is habitat suitable for the vulnerable malleefowl and Western Whipbird. Malleefowl are vulnerable to road-strike, as currently occurs on the Ravensthorpe-Hopetoun Road. The mining proposal, if it were to proceed, would significantly increase the risk of road-strike for this species. It is also vegetation that provides a food resource for the endangered Carnaby's Black Cockatoo. This species is known to breed near the proposed impact area. It is essential that breeding cockatoos have adequate food resources during the breeding season within close proximity to support the local population. During the period February-March 2019, a flock of approximately 800 Carnaby's were roosting in trees in an area just south of the proposed impact site. One reason for them roosting at this location is the proximity to the available supply	While large areas of the Shire of Ravensthorpe have been cleared for agriculture, there is a substantial area of remnant vegetation (see response to item 29 and **Figure 5**). This remnant vegetation maintains a linkage from the coastal areas through to inland woodlands (**Figure 10**). Site surveys confirmed the presence of the malleefowl, western whipbird and Carnaby's cockatoo in the area. With regard to the latter, no breeding trees were recorded although the site does contain vegetation suitable for roosting and feeding. With regard to malleefowl, also see response to item 48. It terms of the overall impact of the Project on the extent of remnant vegetation, ACH's position is that it is unlikely the clearing required to implement the Project will materially impact available habitat, particularly considering the Project will rehabilitate existing disturbance and undertake progressive rehabilitation of new disturbance during the course of the Project (see item 29 for an outline of opportunities to undertake rehabilitation early in the Project life).

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		of suitable water in the Steere River. BWA is concerned about the potential impact the proposed development may have on this critical environmental water source now required by cockatoos. While assessment of the site is focused on the specified area, for bird conservation requirements, there is a need to consider the cumulative impact of disturbance in the broader landscape with particular consideration of potential immediately adjacent off-site impacts, as could occur with reduced regions food and water resources for Carnaby's Black Cockatoo.	With regard to the Steere River and the role it may play in supporting cockatoo populations, ACH notes that flows are irregular and it is naturally brackish to saline, with salinity increasing downstream as branches of the river originating in agricultural areas have more influence. ACH disputes the assertion that standing water was present in the Steere River or its tributaries during the period February-March 2019 which may have provided a water source for animals. In efforts to establish baseline ground water monitoring sites upstream and downstream of the Project Area, no standing water was observed at any time including during the wetter months. Nonetheless, protection of the existing water quality in the Steere River is a relevant concern for ACH. This issue is discussed in item 47 where management actions to maintain water quality are outlined.
50.	ANON-E5P7-Z8V1-T	The EPA should not allow the Ravensthorpe Gold Project to proceed. The proponent claims that "due to the similarity between Phillips River Project (PRP) and the Ravensthorpe Gold Project (RGP) a further referral to the DEE has not been made". The previous referral was in 2005, almost 15 years ago. There are stark differences in the earlier PRP from the current RGP proposal – for example clearing of native vegetation would increase from 80 ha to more than double to 197.8 ha; Offsets proposed by the PRP as opposed to No offsets with the current	With regard to referral under the *Environment Protection and Biodiversity Conservation Act 1999*, see response to item 1. ACH acknowledges the habitat value of the Project area and this value has been fully described within the ERD. A draft Fauna Management Plan has been developed and disturbed areas (including historically disturbed areas dating back to the early 1900s) will

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		RGP proposal. In the intervening years the Western Ground Parrot (Critically Endangered) has become locally extinct. However there is suitable foraging habitat for Carnaby Black Cockatoo (EN), and the Malleefowl (VU) and the Western Whipbird (VU) have been recorded in surveys of the area. Although the Kundip minesite has been disturbed in the early years of the previous century, the local vegetation has come back. There is a variation of habitat from the dense vegetation of the creek lines, up the slopes through mallee to eucalyptus. The Biota 2004 phase 1 survey noted that the "local population of Western Whipbird will very probably be impacted...the birds are resident in the area and may be displaced ". The proponent's claim that "active Malleefowl mounds will be avoided" is at best disingenuous.	be rehabilitated, as outlined in the draft Mine Closure Plan. Both of these plans will be modified in the light of comments receive – ACH anticipates a Fauna Management Plan will be a condition of approval (if project approval is forthcoming) and a Mine Closure plan will require assessment and approval under the Mining Act. The submission notes that the Western Whipbird was recorded in the Biota survey and it was also recorded in the 2017 APM survey. ACH notes that the species has persisted in areas of historical mining disturbance and that there is abundant undisturbed habitat nearby. There is no reason why the species will not continue to use the area as habitat, particularly after mining has finished and rehabilitation has been completed. With regard to malleefowl, ACH's commitment is very clear – no clearing within 100 m of active malleefowl mounds.
51.	DBCA	***Recommendation 4:*** *That if the proposal is considered acceptable, a condition of approval is applied that requires the development and implementation (and regular review) of a conservation significant fauna management plan that specifies objectives and monitoring protocols to identify and manage conservation significant fauna and fauna habitat for target fauna species.*	ACH has committed to updating the draft Fauna Management Plan prior to commencing operations – see response to item 50. The revised management plan will consider the particular species referred to in the submission but ACH notes that only the malleefowl, chuditch and

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		Discussion: Conservation significant fauna (and their habitat) listed under the *Biodiversity Conservation Act 2016* (BC Act) are known to occur within the development envelope. Information about key aspects of proposed fauna monitoring presented in the proposal and supporting appendices, such as survey effort, methodology, and proposed management procedures (e.g. for relocation of conservation significant fauna), is insufficient to confirm suitability and requires further discussion, or clarification. For example, the Fauna Management Plan (Appendix J) contains the basic provisions of a generic environmental management plan, however important detail on the frequency or timing of monitoring is absent in many instances. DBCA has conducted a review of the overarching ERD and its appendices (Appendices C, H, I and J), and provides the following comments for consideration in relation to the Fauna Management Plan: The plan should be developed to manage and monitor impacts on conservation significant fauna (and their habitat) within the Project Area, including but not limited to heath mouse (*Pseudomys shortridgei),* Carnaby's cockatoo *(Calyptorhynchus latirostris*), chuditch (*Dasyurus geoffroii*), malleefowl (*Leipoa ocellata*), western bristlebird (*Dasyornis longirostris*), dibbler (*Parantechinus apicalis*), and western ground parrot (*Pezoporus flaviventris*).	Carnaby's cockatoo are known to occur in the Project Area. With regard to the heath mouse, the potential for this species to occur with the Project Area has not been discounted. However, the species has not been recorded – this is explained in the ERD (Appendix C p107), also see response to item 6.

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		The plan should include adequate detail in relation to the proposed management and monitoring of conservation significant taxa, for example during pre-clearing activities (such as fauna relocation) to demonstrate that the proposal will be appropriately managed with respect to protection of these fauna. This would also assist the proponent by helping to inform any future applications to 'take or disturb' threatened fauna in accordance with requirements of an application for a Section 40 Authorisation under the BC Act. Consideration should be given for the development of outcomes-based provisions within the plan, particularly where environmental components can be objectively measured and reported (e.g. active malleefowl mounds and introduced predators). The plan should include trigger and threshold criteria / management targets that are based on clearly defined SMART (specific, measurable, attainable, relevant, time-bound) objectives and outcomes and BACI (before, after, control, impact) design principles. It is recommended that the Fauna Management Plan is further refined in alignment with the relevant EPA guidance, and outcomes of the assessment. Noting the clear evidence that threatened fauna are known to use the area, a well-developed Fauna Management Plan should be required as a condition of any environmental approval. **Comments:**	

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		Heath mouse (*Pseudomys shortridgei)* The ERD contains conflicting information regarding the possible presence of the heath mouse (*Pseudomys shortridgei)* (Vulnerable – BC Act, Endangered – EPBC Act) within the project area that should be clarified. For example Table 4-22, page 4-65, indicates that the species has been recorded within the project area and further in the document, in relation to the heath mouse the ERD states, *"Not recorded in surveys of the Project Area but suitable habitat (Low Woodland Mallee and Heath) present"* (Table 4-23, page 4-67). The heath mouse is known to have previously occurred in the Ravensthorpe Range area and the Project Area contains suitable habitat, with the heath mouse being reported as a capture within the project area during a 2016 survey (Appendix C, page 107). Despite this, it appears that in the supporting survey documents the species has been discounted as occurring on the basis that this capture in 2016 was determined as being a misidentification and stating, *"an intensive trapping program was implemented for the heath mouse on two occasions (winter and spring) with aluminium box traps set at a high density in several different habitats across the Project Area. The trapping effort totalled almost 1000 trap nights. No records of the heath mouse were made despite abundant captures of the Bush Rat"* (Appendix C, page 107). A precautionary approach is recommended in the determination of the presence/absence of the heath mouse	

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		within the project area. There is suitable habitat within the project area and without a vouchered specimen from the 2016 survey its presence should not be conclusively discounted. It appears that current known populations of the heath mouse are low in abundance and the presence of other more abundant species such as the bush rat (*Rattus fuscipes*) may reduce the detectability or chance of recording heath mouse.	
52.	DBCA	***Short Range Endemics*** ***Recommendation 5:*** *That the proponent provides additional information through survey / assessment of habitat to support an adequate level of confidence that snail from genus Bothriembryon will not be directly impacted by the current proposal.* **Discussion:** The land snail from the genus *Bothriembryon* recorded in the Project Area is a potential short-range endemic species (SRE). Further survey is proposed to occur after operations have already commenced (Table ES3, page xviii). However, determination of the SRE status of the land snail should occur prior to operations commencing to ensure that impacts on this taxon are understood and managed accordingly.	Some additional work has been undertaken in regard to the *Bothriembryon* specimen. Biota (**Appendix C**) undertook a review of the original collection and the likelihood that the collection represents a SRE. Their report concluded: • the habitat from which the specimen was recorded belongs to a group of vegetation types that occurs more widely, only a small proportion of which will be impacted by the project; • other, better resolved, potential SRE taxa collected from the same location have been demonstrated to have wider distributions, consistent with the lack of habitat barriers to dispersal, suggesting that *Bothriembryon* sp. may also be similarly more widely distributed; and • other members of the same genus in the region do not show distributions that

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			suggest *Bothriembryon* sp. could possibly be restricted to an area as small as the project development envelope. See also response to item 54 regarding further survey work.
53.	DBCA	***BC Act Notifications*** **Comment:** The proponent should be made aware of the following: Under regulation 124 of the Biodiversity Conservation Regulations 2018, DBCA is to be notified within 24 hours, of any threatened and specially protected fauna that is injured or abandoned. A notification form is available on the department's website and the same form can be used to notify of mortalities (fauna licences, licences for fauna rehabilitation, https://www.dpaw.wa.gov.au/plants-and-animals/licences-and-authorities?showall=&start=3). All fauna found deceased, accidentally killed or required to be humanely killed due to injury, should be offered to the WA Museum as specimens. Opportunistic sightings of conservation significant fauna should be reported to DBCA via the fauna report form available on the website (https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/threatened-animals, and emailed to fauna@dbca.wa.gov.au).	ACH notes these requirements under the BC Act and will incorporate them into the next iteration of the Terrestrial Fauna Management Plan.
54.	DWER	The terrestrial fauna surveys have not been revised and no new surveys have been undertaken since DWER last provided advice	ACH acknowledges that further survey work for SREs would be beneficial. ACH agrees to undertake a

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		on the draft ERD [15 January 2019]. The terrestrial fauna surveys for vertebrate fauna were appropriate and meet EPA guidance for Terrestrial Fauna Survey (2016). While the early short-range endemic invertebrate (SRE) surveys (Appendices H and I) meet current EPA guidance, it is difficult to evaluate the adequacy of the survey work for SRE invertebrates, for the reasons discussed below. <u>Short-range endemic invertebrates</u> The project area was last surveyed for SREs in 2004 and the broader area was surveyed in 2008 (Harvey and Leng, 2008). The proponent has proposed to undertaken surveys for SREs as a mitigation measure (Table ES3 and 4-25). Considering the long time span (15 years) since the last surveys and the increase in SRE knowledge over the last decade, it is recommended that a survey for all SREs groups, as listed in EPA guidance (EPA 2016), is completed prior to the commencement of vegetation clearing so that any additional mitigation required can be considered, as discussed below. The Fauna Management Plan (Appendix J, Table 2-1) includes a survey for *Bothriembryon* land snails as a management action and target as mitigation for SREs, with "survey to be conducted within first year of operation" (pg. 13) and a "report to be provided to the WA Museum" (pg.13). Surveys should not be restricted to *Bothriembryon* land snails only. To meet EPA guidance (2016), all of the groups that may contain SREs should be surveyed (e.g. trapdoor spiders, millipedes and slaters).	further survey for SREs prior to the commencement of operations. Furthermore, as a precaution ACH has developed a further Exclusion Zone around the location of the original *Bothriembryon* collection (**Figure 12**). See also responses to item 51 regarding the Fauna Management Plan and item 52 regarding *Bothriembryon.* With regards to fauna habitat generally, Figure 4-21 of the ERD shows fauna habitats across the project area. This report includes a revised figure (**Figure 13**) that also includes the disturbance footprint.

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		Additionally, no monitoring or mitigation strategies have been proposed where SRE invertebrates are recorded. The mitigation outlined in the ERD includes "Undertake a further SRE survey during operations. The survey should be conducted in winter to target land snails" (Table 4-25); and the Fauna Management Plan includes the management target that surveys should be "conducted within the first year of operation" (Table 2-1). Surveys for SREs should be undertaken prior to vegetation clearing. This mitigation action should be included as a condition on the proposal. The maps provided in the ERD are not sufficiently detailed, as they do not show the development area in relation to the potential SRE habitat, as requested by DWER [15 January 2019]. In addition, the fauna habitats used for SREs are simplified in comparison to the vegetation mapping. For example, Figure 4-21 maps combined habitat types e.g. 'low dense forest / forest habitat' and 'low woodland mallee and heath habitat', as compared with Figure 4-11 vegetation communities mapping, which appears to be a heterogeneous habitat composed of many different vegetation types. Damplands and Drainage Lines habitat, as identified as likely SRE habitat in EPA Guidance (EPA 2016), make up a relatively small proportion of the project area (Table 4-19), but are within a significant portion of the disturbance footprint and development area. Therefore, impacts within this habitat type may affect potential SRE taxa.	

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		Where surveys identify prospective high quality SRE habitat, clearing of these habitats should be avoided where possible, and avoidance should be included in the Fauna Management Plan. Specimens collected during surveys should be submitted to the WA Museum.	
55.	DWER	<u>Vertebrate fauna</u> The current Fauna Management Plan (Appendix J) for Malleefowl and Chuditch is generally appropriate, although the following points should be considered. The Fauna Management Plan (Appendix J, pg 13) states that "If active Malleefowl mounds are located, area will be designated a No-Go Zone, and a 100 m buffer set around the mound." The proponent should justify the use of a 100 m buffer around the mound and state whether this buffer size is considered appropriate by DBCA. Larger buffer sizes around Malleefowl mounds have been used in other fauna management plans. For example, the Mt Gibson Iron Ore project's Environmental Plan from 2008 had 250 m buffers (Mount Gibson Mining & Extension Hill 2008). It is recommended that pre-clearance surveys for Chuditch and Malleefowl should be changed from 'monitoring provisions' to 'management actions' in Table 2-1 (Appendix J) of the Fauna Management Plan in order to meet objectives for Terrestrial Fauna.	ACH considers a 100 m buffer size to be appropriate. The vegetation at Kundip is likely to afford more protection to malleefowl than less dense vegetation elsewhere. This issue will be considered again when the next draft of the Fauna Management Plan is developed. ACH anticipates this plan will require formal approval prior to any ground-disturbing activities. The requested change in relation to pre-clearance surveys will be made in the next iteration of the Fauna Management Plan.

8 Subterranean fauna

No.	Submitter	Submission / Issue	Response
56.	DWER	The ERD states that "no field surveys for subterranean fauna have been undertaken within the Project Area (pg. 5-14)". A subterranean fauna habitat assessment based on two desktop investigations (Appendix U; Appendix V) concluded "that assemblages of subterranean fauna at the Project, if present, are likely to be low in terms of abundance and species (pg. 5-15)". This conclusion was drawn based on the geologies supporting subterranean fauna habitat being located primarily outside of the proposed pit areas (Appendix V). A map showing the potential subterranean fauna habitat overlaid with the pit outline is required, as per DWER advice [1 January 2018], to support the conclusion that the geologies that contain potential subterranean fauna habitat are not found within the mine pit areas (see Appendix V).	Higher quality groundwater is associated with alluvial formations. This groundwater is recharged directly by surface water flows from the Steere River. As the alluvial formations do not intersect the proposed open pits (see **Figure 14**) to any great extent, ACH does not anticipate any impact on stygofauna, in the event that they do occur in the Project Area.

9 Inland waters environmental quality

No.	Submitter	Submission / Issue	Response
57.	ANON-E5P7-Z8VP-S Group of 6 individuals.	The submitter has identified that the ERD does not address the characteristics of the water supply at the RAV8 pit. Concern in relation to the use of this water as it is likely to be hypersaline and its potential to impact water quality in the Steere River.	**Table 2** shows the water quality in the RAV8 open pit (see also response to item 4). The water quality at RAV8 is comparable with groundwater in the Project Area. See response to item 47 for an outline of how water quality impacts on the Steere River will be prevented.
58.	ANON-E5P7-Z8SV-V	The location of the TSF is inappropriate given that it crosses into two water catchment areas. The submitter proposes that the TSF be relocated so that it only intersects the Steere River catchment. The accuracy of the hydrological model has been questioned given recent significant flood events in the area and predicted climate change.	The TSF is located in the Jerdacuttup River catchment only. The proposed location was selected on the basis of suitable basement materials and a very small upstream catchment area. There are no suitable locations within the Project Area and within the Steere River catchment to situate an independent paddock style Tailings Storage Facility such as that described in the ERD. With regard to the hydrological model, ACH assumes the submission is referring to above average rainfall events that occurred in March 2016 and February 2017. These events are very unlikely to make a material difference to the calculation of the rainfall associated with extreme events on which the engineering designs are based.
59.	Cocanarup Conservation Alliance Inc.	The primary concern with the ACH Ravensthorpe Gold Project proposal is that they consider that it poses a direct and immediate threat to the water quality of the Steere River downstream of the proposed development area. The Steere River runs through the development area and crosses the Ravensthorpe – Hopetoun Road immediately	ACH acknowledges the requirement to ensure low quality water is prevented from entering the Steere River. Saline water use on site and potential sediment runoff impacting downstream of the Project are discussed in response to item 47. ACH reiterates that there is no intention to discharge Project water to the environment other than

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		south of the proposed mine and processing centre. From there it runs through high quality bush in the proposed Cocanarup – Kundip Class A Reserve area, through cleared land and eventually to the Culham Inlet (a wetland of international importance). It is of concern that such a substantial development is proposed at Kundip directly adjacent to the bed of the Steere River for the following reasons: Clearing of vegetation must increase the soil erosion risk and therefore the likelihood of siltation of the river. We have not been able to find a description of the quality of the water that is to be used for processing and dust mitigation but this would seem to be important because of the proximity to the Steere River. This needs to be clarified, and if the project is to proceed there should be strict controls over the quality of water brought in for these purposes. The Tailings Storage Facility is a major concern because it introduces a serious risk in this sensitive environment. The consequences of a spill from the tailings dam could be catastrophic for the water quality downstream in the Steere River and Culham Inlet. Apart from operational accidents, floods do happen in the Ravensthorpe – Hopetoun area, reference February 2017 when Ravensthorpe recorded 240 mm in early February, and January 2000 when 223mm was recorded. Both of these events caused serious damage in the district, including burst dam banks and serious soil erosion.	through evaporation and through dust suppression activities. The quality of the water being use from RAV8 Pit is shown in **Table 2**. The RAV8 pit water is of similar quality to the groundwater at Kundip. Water use has been discussed in response to item 47. Note that the tailings storage facility is proposed for the Jerdacuttup River catchment although the need to control the quality of runoff water from the proposed Project applies to all affected catchments. A spill from the TSF itself is a very unlikely scenario for the reasons outlined in the response to item 6.

No.	Submitter	Submission / Issue	Response
		Deterioration of water quality in the Steer River will have a significant impact on Carnaby's Cockatoo and the water rat Rakali (*Hydromys chrysogaster*) which are known to use the river.	
60.	ANON-E5P7-Z8SE-B	Due to recent storm events in the area the submitter has highlighted the need for up to date reports to incorporate these scenarios.	See response to item 58 – the storm events referred to are very unlikely to materially affect the basis for engineering design.
61.	DWER	It is recommended that a trench drain be installed around the base of the TSF that will be able to capture any leachate that may leak from the TSF. Although there are two groundwater monitoring bores to be installed down gradient of the TSF, the nature of the fractured rock aquifer means that the local groundwater is commonly unconnected and spatially restricted. The location of the groundwater monitoring bores may not necessarily detect any leakage from the TSF, whereas a trench drain will capture any leakages from the TSF and allow for sampling and monitoring of leachate.	As with seepage controls discussed in the response to item 6, there will be a cut-off drain installed with the aim of intercepting shallow seepage from under the embankment. See **Figure 4** for all proposed seepage controls. Monitoring of the quality of water intercepted by the cut-off drain will also be undertaken. To assist in the early detection of seepage the groundwater monitoring bores have been amended to be closer to the TSF and additional bores have been proposed (see **Figure 2**).
62.	DWER	Previously queried whether there was the potential for any groundwater dependent ecosystems (GDE) given shallow depth to groundwater at KMB5 (~4m). The ERD now states that no species recorded in the surveys are obligate phreatophytes, but there may be facultative phreatophytes (*Eucalyptus occidentalis, Melaleuca cuticularis)* present. The proponent should confirm this with a person with botanical expertise.	The area has been the subject of botanical surveys. *E. occidentalis* and *M. cuticularis* were suggested as examples of species that are likely facultative phreatophytes. It is beyond the scope of the assessment to determine all species that may be facultative phreatophytes. The key finding is that obligate phreatophytes were not recorded. KMB5 was damaged some years ago and is not recoverable. For monitoring purposes, ACH will construct a new bore that intercepts the alluvial material associated

No.	Submitter	Submission / Issue	Response
		The shallow groundwater in bore KMB5 was found on western part of site adjacent to waterway (tributary to Steere River). This bore is located in a valley and it is considered that the shallow groundwater may be representative of a localised perched groundwater occurrence. KMB5 should be added to the groundwater monitoring program to determine if there will be any impact on this perched groundwater which may have connectivity to the surface water system.	with the Steere River in a similar location (see proposed location of KMB5a on **Figure 2**). The updated monitoring program is detailed in **Table 3**.
63.	DWER	Alteration of surface water flows – As the proposed mine site is at top of the catchment, the surface water systems to be diverted are minor systems with ephemeral flows. Flows will be maintained via diversion structures, so limited impact with maintaining flows to downstream environment during operational phase, with flows reinstated post closure, albeit with some modification to protect the waste rock landforms. The proponents are advised that the disturbance to the waterways will require a bed and banks permit under section 21 of the *Rights in Water and Irrigation Act.* Although the mine site is not in a proclaimed surface water area, as the works are being undertaken on Crown land, a permit will be required from DWER.	ACH acknowledge DWER's comments and will liaise with DWER in respect of any approvals required under the *Rights in Water and Irrigation Act* prior to works being undertaken.
64.	DWER	Groundwater abstraction – the proponents are advised that they will likely require approval from DWER for groundwater abstraction for the purpose of dewatering the mine pits. Although the mine site is not in a proclaimed groundwater area, the aquifer is confined or semi-confined and may require	ACH acknowledge DWER's comments and commit to obtaining a licence under the *Rights in Water and Irrigation Act* prior to groundwater abstraction if required.

No.	Submitter	Submission / Issue	Response
		licencing under the *Rights in Water and Irrigation Act.* The proponents are requested to contact the SCR office in Albany for further advice.	
65.	DWER	ESD Task 72 - Characterise the baseline water quality through further surface and groundwater monitoring. This hasn't been fully completed, though the monitoring plan does include further monitoring sites upstream and downstream of the mine site. It is understood that it is difficult to collect surface water in an ephemeral environment. Some upstream information has now been provided. STE01W could be considered to be representative of mine site surface water system, whereas Jones Rd surface water quality would be impacted by farming. Groundwater monitoring should commence at least 12 months prior to dewatering to ensure that the pre-development groundwater environment can be determined.	See response to item 5 regarding the current baseline water quality data available. ACH have increased the number of surface water and groundwater monitoring locations as per **Figure 2** and **Table 3**. The latest surface water and groundwater results have been incorporated into the analysis that was undertaken in the ERD (see **Table 1** and **Table 4**). Groundwater monitoring has been underway for some time and additional bores will established prior to the commencement of operations.
66.	DWER	The ERD discusses risks to the Jerdacuttup system through TSF failure (as requested by DWER). As the sensitive receptors in the Jerdacuttup system are a significant distance downstream ~36 kilometres (km), considered to be a low risk. Surface water and groundwater monitoring will assist with identifying any leakage from the TSF, and the removal of cyanide in the TSF further reduces the risk.	ACH acknowledge DWERs comment. The response to item 6 contains further information on how the potential for a TSF failure has been considered and details the controls in place in regards to the design and operation of the TSF.

No.	Submitter	Submission / Issue	Response
67.	DWER	The plan captures upstream and downstream of both Steere and Jerdacuttup catchments. J2 should be located further north, perhaps ~ 1km from the boundary of the tenement P2 and P3 should also be surface water quality monitoring sites, not just photo monitoring. KMB5 should also be added to the groundwater monitoring program to identify any mining / dewatering impacts on this area of apparent perched groundwater. KMB6 should be added to the groundwater monitoring program. Hydrogeological assessment indicates that the fractured rock aquifer system that characterises the site shows an apparent lineation across the central portion of the tenement. KMB6 is down gradient of that lineation, so would capture any changes in groundwater quality or movement along this lineament. DWER have previously queried the location of groundwater monitoring bore G5. It is considered that this bore would not effective at this location to monitor impact of TSF failure. The bore should be located further south adjacent to wall of TSF. If a trench drain is constructed around the base of the TSF, then surface water monitoring in the drain should also be included. The post closure water monitoring needs to be included in the surface and groundwater monitoring plan (Table 4-43)	ACH have updated the surface water and groundwater monitoring program as well as increased the number of monitoring locations as per **Figure 2** and **Table 2**. The position of the surface water monitoring points have been amended in light of recent on-site reconnaissance in relation to the motoring point accessibility. It will be important to be able to reach monitoring points during or soon after rainfall events and the siting of sampling points has been undertaken with this in mind. However, a water monitoring and management plan has been proposed by ACH (see item 10) and further consideration can be made in the development of that plan. In the interim period, ACH agrees to the following: • P2 and P3 have been including in the surface water monitoring program (see **Figure 2**). • KMB5 was destroyed but KMB5a has been proposed in a nearby location. KMB6 will be destroyed as per the current project, however, KMB6a has been proposed in a nearby location. • G5 has been removed and an additional four groundwater monitoring bores have been proposed closer to the toe of the TSF for earlier detection of impacts. Note that when the suggested new location for J2 was inspected, it was observed that the location was very high in the catchment and the water course very poorly

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			developed such that the collection of flowing water at that point would be very unlikely at any time. The existing position for J2 has been retained. Monitoring of water collected by the cut-off drain at the TSF will also be undertaken. Post closure water monitoring has been included. Groundwater and surface water monitoring will continue post closure until such a time as the completion criteria are met as per an approved Mine Closure Plan (MCP) under the Mining Act.
68.	DWER	It is essential that groundwater monitoring commence 12 months before dewatering occurs to establish the baseline groundwater conditions.	ACH currently have sufficient groundwater data to establish a baseline. While ACH will commence additional groundwater monitoring prior to dewatering not all bores will have been monitored 12 months prior to dewatering. Also see response to items 5 and 65.

10 Air Quality

No.	Submitter	Submission / Issue	Response
69.	ANON-E5P7-Z8SV-V	The submitter has identified that there may be an issue with dust lift off from the TSF if there are significantly higher evaporation rates than anticipated and if the operation is placed into care and maintenance. The submitter could not find any evidence of contingencies for this possibility.	Tailings will be deposited evenly across the surface of the facility to allow air drying and consolidation. As much of the surface will be actively receiving tailings at any one time, dust emissions are very unlikely during operations, regardless of evaporation rates. The draft Mine Closure Plan includes provision for a cap of rock and soil so the tailings surface will not be exposed, thus preventing any mobilisation of tailings material. Should operations cease and the company elects to enter a care and maintenance period, the unrehabilitated tailings surface may dry and become prone to dust generation. If an extended period of care and maintenance appears likely, a temporary cover may be required for the tailings surface. This is likely to comprise waste rock material but suitable alternatives would be considered. This issue will be addressed in a revised Mine Closure Plan to be submitted to DMIRS for approval under the Mining Act.

11 Social Surroundings

No.	Submitter	Submission / Issue	Response
70.	Ravensthorpe Historical Society	The submitter has raised concern over the impact the proposal will have on the structural integrity of the former railway alignment and heritage walk trail. Section 5.1.5.1 of the Plan states "the Railway Heritage Walk does not fall within the project area and therefore will not be impacted by the Project". However, Figure ES2 shows that some 2.4km of the walk trail alignment falls within the Project Area and 450m falls within the Development Envelope. The western toe of waste rock landform (north) is within 30-40 m of the alignment, any encroachment by waste rock would structurally compromise it and having a walk trail so close to a waste rock slope is certainly a safety issue. The present walk trail is within 70-80 m of the location indicated for Offices.	While the layout of the Project has been placed to the east of trail, the submission is correct and a section of the trail does indeed pass through the Development Envelope. Mitigation measures for the Project's interaction with the trail were included in Table 5-1 of the ERD but the statement included in section 5.1.5.1 was incorrect. The location of the trail in relation to the proposed Project is shown in **Figure 15**. In the ERD ACH committed to: • Warning signs where the trail crosses the main access road; and • Clearing of vegetation at the intersection to improve visibility for walkers. Also, ACH proposes to liaise with the Ravensthorpe Historical Society in relation to: • Establishment of a rest area with an interpretive display at the site of the Kundip Battery; and • The salvage any old mine infrastructure believed to be of value to the Historical Society and delivery of that infrastructure to a location of their choosing. ACH notes that it accompanied a representative of the Historical Society on a tour of the Kundip area on 30 October 2019 during which a large photographic catalogue of legacy mining infrastructure and artefacts was established.

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			In relation to the western toe of the northern waste rock landform, the footprint shown in the ERD shows the battered toe and not the 'as dumped' placement of waste rock which would be further to the east. Placement of waste rock at this location will be by paddock dumping and not through the use of a tiphead. This significantly reduces the risk of waste rock inadvertently reaching the trail.
71.	ANON-E5P7-Z8VP-S Group of 6 individuals.	The submitter has identified that the Kundip site is of heritage significance and that the Railway Heritage Trail runs through the Development Envelope which is contrary to the ERD (s 5.1.5.1).	See response to item 70.
72.	Department of Planning Lands and Heritage	It is considered that Aboriginal heritage matters have been appropriately dealt with by the proponent under *5.1.3.1 Aboriginal heritage*. Heritage surveys have been reviewed by the proponent with no Aboriginal heritage sites being identified and ACH Minerals has since entered into a Noongar Standard Heritage Agreement with the Wagyl Kaip Traditional Owners. It should be noted that any potential impacts to previously unidentified Aboriginal sites or Aboriginal heritage places from the proposal can be addressed through the mechanism in the provisions of the *Aboriginal Heritage Act 1972*. A review of historic heritage places identified as adjacent to the project area has confirmed that none are entered in the State Register or are on the	Noted. ACH acknowledges its ongoing responsibilities under the *Aboriginal Heritage Act 1972*. With regard to European heritage, ACH will work with DPLH on these matters and will adhere to the commitments made in the ERD.

No.	Submitter	Submission / Issue	Response
		Heritage Council's Assessment Program. To that end it is unlikely that the proposal will impact on places which are of State cultural heritage significance. It is noted that, other than P14027 Harbour View, none of the places will be subject to direct impact. If this were to change at any point in future, referral under the provisions of the Government Heritage Property Disposal Process should be considered. In relation to P14027 Harbour View it is noted that, while it will be directly impacted, the Heritage Council's Register Committee determined that it did not warrant full assessment for consideration for entry in the Register of Heritage Places, and that the proponent will commission an archive record, including an archaeological survey, for the place. A copy of this record and survey should be provided to the Department of Planning, Lands and Heritage for its records.	

12 Stakeholder Consultation

No.	Submitter	Submission / Issue	Response
73.	Shire of Ravensthorpe	ACH Minerals should develop and implement a community consultation/liaison group to facilitate views and concerns of the community to the company.	ACH agrees to form a community reference group, the Ravensthorpe Gold Project Community Reference Group (CRG). ACH is considering the model to be adopted but anticipates the group will comprise: • an independent chairperson; • 3 representatives from the local community; • 3 representatives from the mine; and • standing invitations for representatives from government agencies, SWALSC, the Jerdacuttup RNO Working Group and other groups, such as the Shire, Ravensthorpe and Hopetoun CRCs and the Fire Brigade. ACH proposes to develop a mission statement to which all members would be required to adhere. Quarterly meetings are proposed. ACH suggest two meetings at Ravensthorpe (CRC), one at the minesite and one at Hopetoun (CRC) over the course of each year but the details can be determined by the group.

No.	Submitter	Submission / Issue	Response
74.	ANON-E5P7-Z8SV-V	The submitter has commented that they are a resident within 10km of the proposal and have only received one direct call from the proponent in the past 10 years. They have also tried to make direct contact with ACH through the Perth office but have had no response. The submitter has suggested the formation of a representative community group similar to the Jerdacuttup RMO Working Group which has involved BHP and First Quantum Minerals.	ACH notes that it has only been the legal and beneficial owner of the Project since August 2016. The Company maintains a presence at its corporate office in Perth during business hours where phones are answered. If a call is missed there is a message service and the Company responds to all messages it receives. The Company can be contacted via email or through the message portal on the website: www.achminerals.com.au/contact-us/ ACH has consulted extensively with local stakeholders and would encourage any individuals who would like further information to again make contact. ACH proposes to form a community reference group (see item 73).
75.	Cocanarup Conservation Alliance Inc.	The submitter has indicated that they have not been consulted with during the preparation of the ERD. Given that the group is involved with the proposed Class A nature reserve adjacent to the project area it is reasonable to expect consultation to be undertaken with the group.	ACH met with the Cocanarup Conservation Alliance during 2019 prior to the public release of the ERD. At that meeting there was ample opportunity for the group to put forward any views they had specific to the proposal which has been in the public forum since December 2016.
76.	ANON-E5P7-Z8SE-B	The submitter has requested that all up to date information on the proposal be made publically available.	For review by the EPA – ACH assumes this refers to release of this document with the EPA's report.

No.	Submitter	Submission / Issue	Response
77.	Jerdacuttup Working Group	The Submitter would like it noted that the TSF is now in the Jerdacuttup River catchment area and hence is covered by the mining licence of First Quantum Minerals (FQM), to which Jerdacuttup Working Group is a party. This liaison between the two parties has been very successful, as a conduit between the local farming community and the mine. They recommend the inclusion of the JCA Working Group to be a party to the ACH mining licence. So that the area is covered in a common liaison body. If this liaison can be established they have no grounds against ACH's mining Plans.	As the RGP will primarily sit within the Steere River catchment and there is no direct relationship between the RGP and the Ravensthorpe Nickel Operations, ACH foresees the operations would be best served by a separate group (see item 73). However, representatives from the Jerdacuttup Working Group would be able to attend meetings.

No.	Submitter	Submission / Issue	Response
78.	South West Aboriginal Land and Sea Council	The South West Aboriginal Land and Sea Council (SWALSC) represents the Wagyl Kaip and Southern Noongar people (WKSN). On behalf of our clients we have reviewed the public comment material and taken instructions from our clients. The WKSN people request that further Aboriginal heritage survey is undertaken to take into account the proposed mining activities as opposed to previous exploration activity. The current heritage surveys are inadequate. The WKSN recognise that the proposed mining activity is located within an environmentally sensitive area and request Ravensthorpe Gold to form a joint management partnership with WKSN people to manage the mining activity in the mining area. Active and ongoing consultation is sought to ensure the area is protected.	ACH acknowledges the comments by SWALSC on behalf of WKSN and offers the following in response. ACH refers to the heritage surveys by Tamora Pty Ltd (December 2003) and Anthropos Australia Pty Ltd (July 2008). The Tamora survey and report was specific to M74/51, M74/53, M74/41, M74/135, P74/153 and M74/176 and concluded that the informants who undertook the ethnographic survey understood the extent of the leases and survey areas and cleared the leases for mining. The Anthropos survey and report was specific to L74/35, L74/45 and M74/180 and found that no ethnographic or archaeological sites were recorded in the survey area. The Tamora and Anthropos surveys together cover the entire proposed development envelope. It is noted that M74/176, L74/45 and (former) P74/153 do not form part of the proposed development. On that basis ACH's position is that no further Aboriginal heritage surveys are required and that the existing surveys are entirely adequate. ACH notes the Department of Planning Lands and Heritage considered that Aboriginal heritage matters have been appropriately dealt with by the proponent in the Environmental Review Document (see item 72).

No.	Submitter	Submission / Issue	Response
			With respect to WKSN's request that a joint management partnership be entered into with ACH to manage mining activity in the proposed development area, it is ACH's intention to form a Ravensthorpe Gold Project Community Reference Group (CRG). The CRG would meet on a quarterly basis with the aim of enhancing the relationship between the operators of the Ravensthorpe Gold Project and all sectors of the Shire of Ravensthorpe community. It is proposed that WKSN/SWALSC be provided with a standing invitation to attend and participate in CRG meetings.

13 Other

No.	Submitter	Submission / Issue	Response
79.	ANON-E5P7-Z8VP-S Group of 6 individuals.	The submitter has expressed concern over the management of traffic associated with the proposal. The transport route between RAV8 and Kundip for water supply is more than the 13 km suggested in the ERD and that the supply of water at 2 trucks per hour will have a significant impact on road safety and integrity and needs to be more fully explained and assessed for impact.	The distance of 13 km referred to in the ERD is the distance 'as the crow flies'. The route by road is indeed much longer – of the order of 40 km (see **Figure 1**). Main Roads WA has reviewed the proposal and did not raise any concerns about the impact either on road safety or on the road integrity. ACH notes that these roads are routinely used by trucks and other heavy vehicles and are designed accordingly. ACH acknowledges, however, that road modifications at entry and exit points at both RGP and RAV8 will be necessary to allow for the safe entry and exit of vehicles from the road system. This work will be undertaken in liaison with Main Roads WA (see also rezones to item 88).
80.	ANON-E5P7-Z8VP-S Group of 6 individuals.	The submitter believes that offsets are required for the proposal.	Offsets were considered against the current guidelines (Section 6 of the ERD). At that time, ACH concluded that the impacts were not of an extent that offsets were warranted. Following further discussions internally and with government, ACH would not oppose a requirement to provide offsets and would accept a Ministerial condition in this regard.

No.	Submitter	Submission / Issue	Response
81.	ANON-E5P7-Z8SV-V	The submitter considers that ACH should include offsets in their management plan to mitigate the emissions from diesel power and the loss of flora and fauna habitat.	See response to previous item regarding offsets. The EPA did not consider air quality / greenhouse gas emissions as a relevant environmental factor for this assessment. The relevant guideline sates that the EPA will consider "proposals that have the potential to significantly increase the State's greenhouse gas emissions" (EPA 2016). The RGP proposal does not fall into this category.
82.	ANON-E5P7-Z8SV-V	The submitter has raised several concerns over the amount and nature of the traffic proposed and questions the suitability of the road network for the increase in heavy haulage. They have also asked why Fremantle has been selected as the port when Esperance is closer. Specifically the submitter is concerned about the proposed route used for carting of water from RAV8 to the proposal site as this route has not been specified.	Main Roads WA has reviewed the proposal and did not raise any concerns about the impact either on road safety or on the road integrity. ACH notes that these roads are routinely used by trucks and other heavy vehicles and are designed accordingly. While the Esperance port is closer than the Fremantle port, the costs associated with transport and handling overall are lower if shipped through Fremantle. Fremantle also has a higher frequency of ships so is the preferred option. The route to be used to cart water from RAV8 to the RGP is shown in **Figure 1**. ACH proposes to use only public roads.

No.	Submitter	Submission / Issue	Response
83.	ANON-E5P7-Z8SV-V	The submitter has commended ACH for their commitment to train staff to fight fires on site and proposes that ACH commits to providing a fire fighting team to assist in local fire control if called upon by the Department of Fire and Emergency Response.	The commitment to training and the provision of local assistance is reiterated.
84.	ANON-E5P7-Z8SV-V	In regard to Mine Closure the submitter has asked what assurances ACH can give to ensure the closure plan is put into effect immediately following the 8 year Life of Mine?	See response to item 45 – depending on circumstances, immediate implementation of the MCP may not be in the interests of the all Project stakeholders. If a resource remains that has some potential to be economically extracted, a care and maintenance period would be warranted.
85.	DWER	DWER supports the water criteria objectives of the mine closure plan. The post closure water monitoring needs to be included in the surface and groundwater monitoring plan (Table 4-43).	The Mine Closure Plan includes provision for a minimum of two years monitoring after the cessation of operations.
86.	DBCA	The location of the project proposal is at the southern extent of the Ravensthorpe Range and the southern known extent of the known range for many conservation significant values. The DBCA's predecessor, the Department of Environment and Conservation, undertook a major program of biological investigations over the majority of the Ravensthorpe Range in 2007 and 2008, and this significant body of published research has now greatly increased the level of scientific understanding of the distribution and significance of the species and floristic communities (including short-range endemic species and communities) of the range (see attached Parks and Wildlife Science Division Information Sheet 30/2009).	The botanical values of the broader Ravensthorpe Range area are discussed in the ERD and the biological investigations referred to (Craig et al 2007; Craig et al 2008; Markey et al 2012) have been consulted and used to help assess potential impacts within the Project Area. It is ACH's view that the proposal's location in the foothills of the Ravensthorpe Range should not compromise future proposals to extend the conservation estate.

No.	Submitter	Submission / Issue	Response
		The Ravensthorpe Range is located within the greater Fitzgerald Biosphere area and represents a 'major biodiversity hotspot' (Markey (2012)[7]: see attached) within the internationally recognised South West Western Australia Biodiversity Hotspot. The Ravensthorpe Range supports floristic communities with high levels of floristic diversity and endemism, many geographically restricted species, species listed as threatened, and species being considered for listing. Despite the high conservation values of the range, the area currently reserved for conservation purposes is limited to two small other than class A nature reserves (Kundip Nature Reserve and Overshot Hill Nature Reserve) located off the main range that are not representative of the full diversity of flora and communities on the range. Several areas of unallocated Crown land within the Ravensthorpe Range and surrounding the proposal area are proposed within the department's South Coast Region Management Plan[8], for inclusion in the Kundip Nature Reserve to conserve values representative of the range. Based on available information, impacts in this location have the potential to be significant at both the local and regional scale for many of these conservation significant taxa, in particular those restricted to the Ravensthorpe Range.	Impacts to individual species of conservation significance were assessed in the ERD and are summarised in Table 4-12. Subsequent to the release of the ERD, further work has been undertaken to better inform the assessment (see response to item 36).

[7] Markey, A. (2012). "Floristic communities of the Ravensthorpe Range, Western Australia." Conservation Science Western Australia **8**(2): 187-239.

[8] https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/decarchive/south_coast.pdf

No.	Submitter	Submission / Issue	Response
87.	DBCA	**Recommendation 7:** That if the EPA is considering a favourable recommendation toward environmental approval of this proposal, DBCA is provided with the opportunity to comment on possible conservation offset measures aimed at mitigating the residual impacts of the project on conservation values related to the department's statutory responsibilities. **Discussion:** The proponent's assessment of the significance of residual impacts is presented in Table 4-12 (page 4-35) and elsewhere in the ERD and consideration of environmental offsets is presented in Section 6. The ERD suggests that offsets are not required (Table 6-1 page 6-1), however in the event that the EPA determines that the residual impacts of the proposal warrant the provision of environmental offsets for impacts on biodiversity values, DBCA would appreciate being consulted on offsets related to matters relevant to the department's BC Act related responsibilities.	Following further discussions internally and with government, ACH would not oppose a requirement to provide offsets and would accept a Ministerial condition in this regard.
88.	Main Roads	Main Roads has no in-principle objection to the proposed truck movements and transport arrangements associated with the proposal. To maintain road user safety and levels of serviceability and the road network however, Main Roads would seek to have the following design features incorporated in the mine access to the Ravensthorpe-Hopetoun Road, as a condition of approval: An acceleration/overtaking lane on the Ravensthorpe-Hopetoun Road is to be provided for northbound heavy vehicles leaving the mine site and traveling towards Ravensthorpe. The crossover is to be sealed and designed to accommodate the requested type of heavy vehicles. They shall be able to make all turn	Main Roads' requirements are noted. ACH will work with Main Roads to ensure required road upgrades are designed and implemented.

No.	Submitter	Submission / Issue	Response
		movements to and from the Ravensthorpe-Hopetoun Road, whilst remaining lane-correct and remaining on the sealed surface. All aspects of the proposed mine entrance shall be designed and constructed to Main Roads specifications and other relevant standards. All costs associated with the design and construction of the proposed mine entrance shall be at the proponents expense.	
89.	DMIRS	As previously stated the completion criteria are preliminary in nature and do not define quantifiable, measurable outcomes. Completion criteria will be required to be refined, and it is recommended the DMIRS endorsed, Western Australian Biodiversity Science Institute (WABSI) "Framework for development mine site completion criteria in Western Australia" https://wabsi.org.au/wpcontent/uploads/2019/09/Completion-riteria-Project-Report_updated-24.9.2019.pdf is employed in its development. The closure risk assessment identifies failure of water diversion infrastructure leading to impacts on the structural integrity of constructed landforms as an 'extreme' risk at closure. The residual risk is stated as being reduced to 'moderate' following the implementation of water infrastructure designed to withstand a 1 in 100 year rainfall event and implementation of monitoring and remediation where required. These management strategies appear insufficient to reduce the likelihood of the risk. There is insufficient information provided in the ERD and MCP on the surface water management for closure. It is DMIRS expectation that long term water diversion structures, that will be retained post closure, are designed in consideration of a probable maximum flood event. This information is required in order to	In the event that the Project receives Ministerial approval under the EP Act, ACH will be revising the draft Mine Closure Plan for submission to DMIRS and their review and approval under the Mining Act. ACH acknowledges the concerns in relation to post-closure water management and will provide additional information for the document submitted under the Mining Act. Completion criteria will also be reviewed and updated in line with the current guidelines.

No.	Submitter	Submission / Issue	Response
		determine if potential environmental impacts can be adequately managed post closure.	

14 References

Craig G.F. (2004b), *Kundip Mining Leases – Pultenaea and Melaleuca*. Unpublished report for Tectonic Resources NL.

Craig G.F. (2005), *Kundip Mining Leases – Waste Dumps and Haul Road – Declared Rare and Priority Flora Surveys*. Unpublished report for Tectonic Resources NL.

Eco Logical Australia (2018). Ravensthorpe Nickel Operations Flora and Vegetation Survey. Unpublished report prepared for FQM Australia Nickel. Dated 18 December 2018.

Environmental Protection Authority (2016). Environmental Factor Guideline – Air Quality, December 2016.

Environmental Protection Authority (2016). Technical Guidance Flora and Vegetation Surveys for Environmental Impact Assessment, December 2016.

Hickman, E. (2009), *Kundip Mining Leases Additional Monitoring Quadrat Survey*. Unpublished report for Tectonic Resources NL.

McQuoid, N. (2009), *Targeted and Regional Survey for Melaleuca sp. Kundip and Melaleuca stramentosa*. Unpublished report for Tectonic Resources NL.

Rathbone, DA. (2013) Flora Survey of the Coastal Catchments and Ranges of the Fitzgerald River National Park. Unpublished report. Department of Environment and Conservation, Western Australia.

15 Glossary

Term	Meaning
µm	Micrometre
µS/cm	Micro Siemen per centimetre
ACH	ACH Minerals Pty Ltd
Ag	Silver
AHD	Australian Height Datum
ALA	Atlas of Living Australia
ANCOLD	Australian National Committee on Large Dams
ANZECC	Australian and New Zealand Environment and Conservation Council
APM	Animal Plant Mineral Pty Ltd
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
Au	Gold
Battery	An ore crushing facility.
BCM	Bank cubic metres
Berm	Horizontal shelf or ledge within a wall slope left to enhance the stability of the slope and intercept run-off.
BGL	Below ground level
Biota	Biota Environmental Sciences
BoM	Bureau of Meteorology
CIL	Carbon in leach
Clearing Area	Disturbance area that requires native vegetation clearing i.e. does not include existing cleared areas.
CO	Completely oxidised
Concentrate	Precious metals concentrate
Cu	Copper
DBCA	Department of Biodiversity, Conservation and Attractions
DBF	Dieback-free
DER	Department of Environmental Regulation
Development Envelope	Envelope within which all ground disturbance and clearing for the Project will occur. The area is greater than the required disturbance in order to allow for a degree of flexibility and to ensure that the area captures indirect impacts in addition to direct impacts.

Term	Meaning
Disturbance Footprint	Defined area of ground disturbance for the Project within the Development Envelope. Includes new clearing and existing disturbed areas associated with the Project footprint.
DMA	Decision making authority
DMIRS	Department of Mines, Industry Resources and Safety
DMP	Department of Mines and Petroleum
dmt	Dry Metric Tonne
DoEE	Department of the Environment and Energy (Cth)
Doré	Gold doré, a bar that is a semi-pure allow of gold and silver.
DPaW	Department of Parks and Wildlife
DWER	Department of Water and Environmental Regulation
EC	Electrical conductivity
EIA	Environmental impact assessment
EIL	Ecological Investigation Level
EMP	Environmental Management Plan
EP Act	*Environmental Protection Act 1986*
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
ERD	Environmental Review Document
ESD	Environmental Scoping Document
FIFO	Fly in fly out
FoS	Factor of safety
FRNP	Fitzgerald River National Park
g/m^2/mth	Grams per square metre per month
g/t	Grams per tonne
GCA	Graeme Campbell and Associates
GHG	Greenhouse Gas
GL	Gigalitre
GL/y	Gigalitre per year
Gold doré	A semi-pure alloy of gold and silver.
Greenbase	Greenbase Environmental Accountants
ha	Hectare
kg	Kilogram

Term	Meaning
km	Kilometre
km/h	Kilometre per hour
kPa	kilopascal
LG	Low grade
LOM	Life of mine
m	Metre
m/d	Metres per day
m^3	Cubic metre
MCP	Mine Closure Plan
mg/kg	Milligrams per kilogram
mg/l	Milligram per litre
mg/m3	Milligram per cubic metre
mm	Millimetre
mm/y	Millimetres per year
MRWA	Main Roads Western Australia
MS	Ministerial Statement
Mt	Million tonnes
MW	Megawatt
NAF	Non-acid forming
NEPM	National Environmental Protection Measure
PAF	Potentially acid-forming
PAF_{LC}	Potentially acid forming (low capacity)
NO_x	Oxides of nitrogen, usually nitric oxide (NO) or nitrogen dioxide (NO_2).
PEC	Priority Ecological Community
Phreatophyte	A plant with a root system that draws its water supply from near the water table.
PO	Partially oxidised (transition zone)
Project	Ravensthorpe Gold Project
Project Area	A group of tenements in which the Development Envelope occurs. Most surveys assessed the whole Project Area and not just the Development Envelope.
PRP	Phillips River Project
RAV8	RAV8 Nickel Project

Term	Meaning
Regolith	The layer of unconsolidated solid material covering bedrock.
ROM	Run-of-mine
RRA	Ravensthorpe Range Area
Shire	Shire of Ravensthorpe
Silver Lake	Silver Lake Resources Ltd
SO	Strongly oxidised
Soilwater	Soilwater Consultants
SRE	Short range endemic
Stope	An open space remaining after extraction of ore from an underground mine.
t	Tonne
t/m³	Tonne per cubic metre
t/y	Tonne per year
tCO_2-e	Tonnes of carbon dioxide equivalent
TDS	Total dissolved solids
TEC	Threatened Ecological Community
Telemetry	An automated communications process that can be used to detect leakage in pipelines.
TSF	Tailings Storage Facility
UO	Unoxidized (fresh zone)
Vug	Rock cavity
WA	Western Australia
WAM	Western Australian Museum
wmt	Wet Metric Tonne
WRL	Waste Rock Landform
WSF	Water Storage Facility
w/w	“Weight for weight", the proportion of particular substances within a mixture, e.g. mine tailings and process water.

Figures

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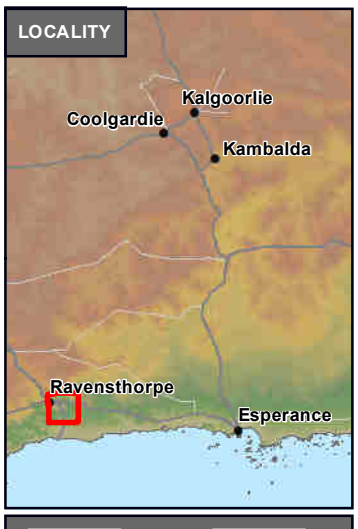
790000
800000
6280000
6270000
6260000

RAVENSTHORPE
Hopetoun-Ravensthorpe Rd
South Coast Highway
DESMOND
KUNDIP
RAV8 Project
Ravensthorpe Gold Project

Data source: Tenements - DMIRS, 2019. Roads - MRWA, 2019. Imagery: Landgate, 2016.

- ACH Project Area
- Water Route (40.5km)
- ACH Tenement
- Minor Road
- Major Road

LOCALITY



WATER HAULAGE ROUTE

Ravensthorpe Gold Project ERD
Response to Submissions
ACH Minerals Pty Ltd

N
0 1 2 3 4 5 km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator, Datum: GDA 1994
Scale @ A3: 1:100,000

Prepared:	F Walker
Reviewed:	G Barrett
Project No:	TE19017
Revision:	A
Date:	7/04/2020

Figure 01

ACHMINERALS

Document Path: \\server\Talis\SECTIONS\Environment\Projects\TE2019\TE19017 - Ravensthorpe Gold Project\GIS\Maps\ERD_RtS\TE19017_01_WaterRoute_RevA.mxd

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AQUIFER CHARACTERISTICS

- Fissured aquifer, locally fractured and jointed - moderate supplies from fracture zones, minor groundwater resources
- Fractured and weathered rocks - local aquifer, minor groundwater resources
- Fractured and weathered rocks - local aquifer, very minor or no groundwater resources
- Fractured and weathered rocks - local aquifers, with large suplies from fracture zones, minor groundwater resources

239000 240000 241000 242000

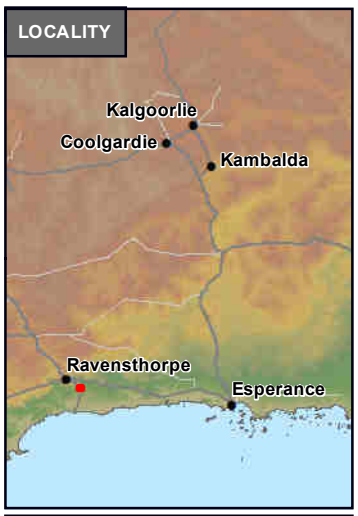
6272000 6271000 6270000 6269000

P5 G1 P4 KMB5a P1,S6 G2 G4 G3 KMB6a G8 G12 VWP2 VWP1 VWP4 G13 VWP3 P3 VWP7 VWP8 G9 G10 VWP5 G6 VWP6 G11 P2, S5 G7

Data source: Imagery: Landgate, 2016.

- Ravensthorpe Gold Project Area
- Proposed Groundwater Monitoring Location
- Proposed Surface Water Photo Monitoring Location
- Proposed Surface Water Photo & Surface Water Quality Monitoring Location
- Vibrating Wire Peizometer
- Mining Void
- Tailings storage facility
- Waste Rock Landform

LOCALITY



INDICATIVE SURFACE WATER PHOTO AND GROUND WATER MONITORING LOCATIONS

Ravensthorpe Gold Project
Water Monitoring and Management Plan
ACH Minerals Pty Ltd

N
0 200 400 600 800 metres

Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator, Datum: GDA 1994
Scale @ A3: 1:13,000

Prepared:	F Walker
Reviewed:	G Barrett
Project No:	TE19017
Revision:	A
Date:	14/04/2020

Figure 2

ACHMINERALS

Document Path: \\server\talis\SECTIONS\Environment\Projects\TE2019\TE19017 - Ravensthorpe Gold Project\GIS\Maps\WaterMonitoringMgmtPlan\TE19017_2-2_ProposedGroundMonitoringLocs_RevA.mxd

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239000 240000 241000 242000

6272000 6271000 6270000 6269000

239000 240000

Data source: Imagery: Landgate, 2016. Hydrogeology: Water and Rivers Commission, 1998.

Ravensthorpe Gold Project Area

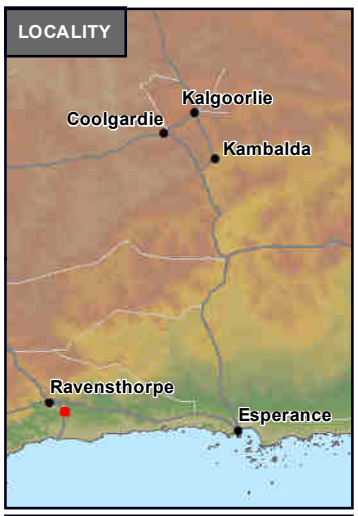
RGP Mine Activities

- Site Access Roads
- Ancilliary Support Infrastructure
- Fire Break (DBCA)
- Mine Pit
- Processing Plant
- Tailings Storage Facility
- Waste Rock Landform

AQUIFER CHARACTERISTICS

- Fissured aquifer, locally fractured and jointed - moderate supplies from fracture zones, minor groundwater resources
- Fractured and weathered rocks - local aquifer, minor groundwater resources
- Fractured and weathered rocks - local aquifer, very minor or no groundwater resources
- Fractured and weathered rocks - local aquifers, with large suplies from fracture zones, minor groundwater resources

LOCALITY



0 100 200 300 km

AQUIFERS
Ravensthorpe Gold Project ERD
Response to Submissions
ACH Minerals Pty Ltd

N

0 200 400 600 800 m

Coordinate System: GDA 1994 MGA Zone 51,
Projection: Transverse Mercator, Datum: GDA 1994
Scale @ A3: 1:13,000

Prepared:	F Walker
Reviewed:	G Barrett
Project No:	TE19017
Revision:	A
Date:	7/04/2020

Figure 03

ACHMINERALS

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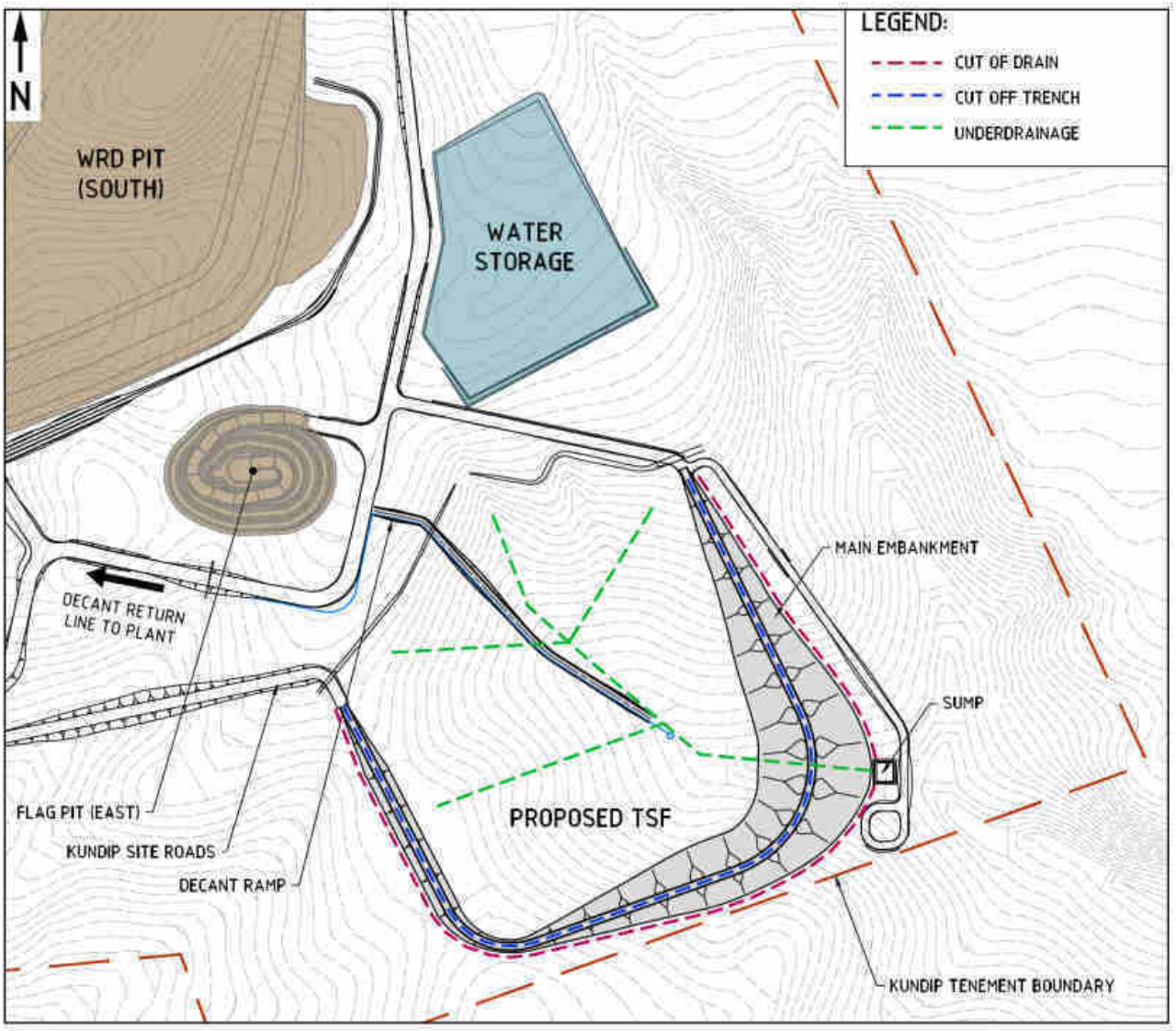

Figure 4: Tailings storage facility – proposed seepage controls (from Appendix A).

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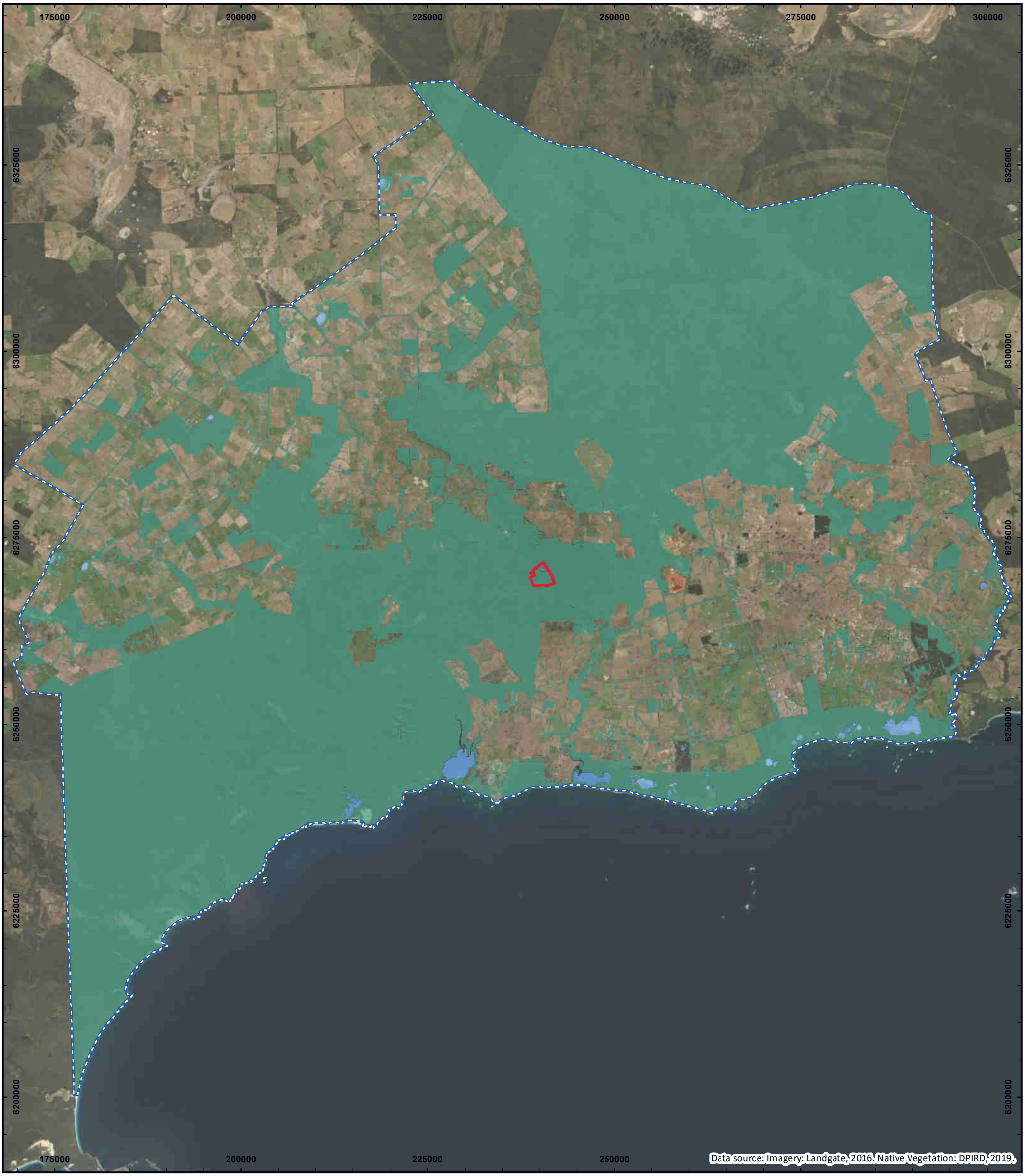
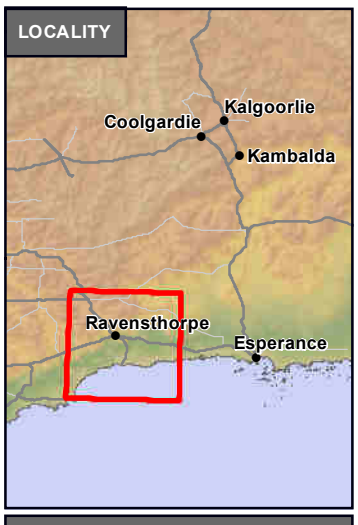


Ravensthorpe LGA
Ravensthorpe Gold Project Area
Native Vegetation Extent
Waterbody



REMNANT VEGETATION
Ravensthorpe Gold Project ERD
Response to Submissions
ACH Minerals Pty Ltd

N
0 5 10 15 20 25 30 km
Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator, Datum: GDA 1994
Scale @ A3: 1:500,000

Prepared:	F Walker
Reviewed:	G Barrett
Project No:	TE19017
Revision:	A
Date:	4/02/2020

Figure 05

ACHMINERALS

Document Path: \\server\Talis\SECTIONS\Environment\Projects\TE2019\TE19017 - Ravensthorpe Gold Project\GIS\Maps\ERD_RtS\TE19017_05_RavensthorpeClearing_RevA.mxd

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239000 240000 241000 242000

6273000 6272000 6271000 6270000 6269000

M 74/63

1 1250 isolated plants 1060 21 25 30 790 6 50

M 74/51

0 50 100 150 200 metres

Inset

M 74/53 M 74/180 Magazine North WRL M 74/41 M 74/135 Kaolin Mine Pit

L 74/34

Offices Site Support Harbour View Mine Pit South WRL Water Storage Facility

Site Support Water Transfer Facility Topsoil Stockpile M 74/51

Processing Plant Area ROM Pad Flag East Mine Pit

Flag West Mine Pit Tailings Storage Facility

See Inset

L 74/45

239000 240000 241000

Data source: Tenements - DMIRS, 2019. Roads - MRWA, 2019. Imagery: Landgate, 2016.

- Ravensthorpe Gold Project Area
- RGP Development Envelope
- Tenement Boundary
- Tailings Storage Facility
- Waste Rock Landform
- Exclusion Zone *(Calothamnus roseus)*

RGP Mine Activities

- Site Access Roads
- Ancilliary Support Infrastructure
- Fire Break (DBCA)
- Mine Pit
- Processing Plant

LOCALITY

Kalgoorlie Coolgardie Kambalda Ravensthorpe Esperance

0 100 200 300 km

PROPOSED EXCLUSION ZONE

Ravensthorpe Gold Project ERD
Response to Submissions
ACH Minerals Pty Ltd

N

0 190 380 570 760 metres

Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator, Datum: GDA 1994
Scale @ A3: 1:15,000

Prepared:	F Walker
Reviewed:	G Barrett
Project No:	TE19017
Revision:	A
Date:	7/04/2020

Figure 06

ACHMINERALS

Document Path: \\server\Talis\SECTIONS\Environment\Projects\TE2019\TE19017 - Ravensthorpe Gold Project\GIS\Maps\ERD_RtS\TE19017_06_ExclusionZone_RevA.mxd

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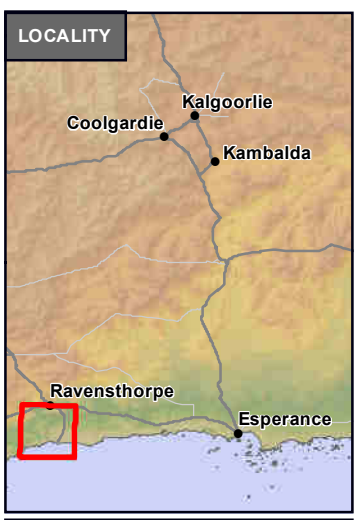
Ravensthorpe Gold Project Area

RGP Development Envelope

Kundip Quartzite Outcrop

Calothamnus roseus known location (WA Herb, TPFL and Current Survey)

Calothamnus roseus plant patch



KUNDIP QUARTZITE

Ravensthorpe Gold Project ERD
Response to Submissions
ACH Minerals Pty Ltd

N
0 2 4 6 8 10 km

Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator, Datum: GDA 1994
Scale @ A3: 1:180,000

Prepared:	F Walker
Reviewed:	G Barrett
Project No:	TE19017
Revision:	A
Date:	4/02/2020

Figure 07

ACHMINERALS

Document Path: \\server\Talis\SECTIONS\Environment\Projects\TE2019\TE19017 - Ravensthorpe Gold Project\GIS\Maps\ERD_RtS\TE19017_07_KundipQuartzite_RevA104.mxd

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239000 240000 241000 242000

6272000 6271000 6270000 6269000

Data source: Imagery: Landgate, 2016. Ecological Communities: APM, 2018 and Craig, 2004.

- Ravensthorpe Gold Project Area
- Development Envelope
- Melaleuca sophisma dense heath (P1) (Craig, 2004)
- Kwongkan Shrublands (P3) (APM, 2018)
- RGP Mine Activities

LOCALITY

0 100 200 300 km

PRIORITY ECOLOGICAL COMMUNITIES (BASED ON VEGETATION MAPPING)

Ravensthorpe Gold Project ERD
Response to Submissions
ACH Minerals Pty Ltd

N

0 150 300 450 600 metres

Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator, Datum: GDA 1994
Scale @ A3: 1:13,000

Prepared:	F Walker
Reviewed:	G Barrett
Project No:	TE19017
Revision:	A
Date:	7/04/2020

Figure 8

ACHMINERALS

Document Path: \\server\Talis\SECTIONS\Environment\Projects\TE2019\TE19017 - Ravensthorpe Gold Project\GIS\Maps\ERD_RtS\TE19017_10_APM_TECSandPECS_RevA.mxd

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R073
Less than 10% cover.

R135
10-30% cover.

R178
isolated plants.

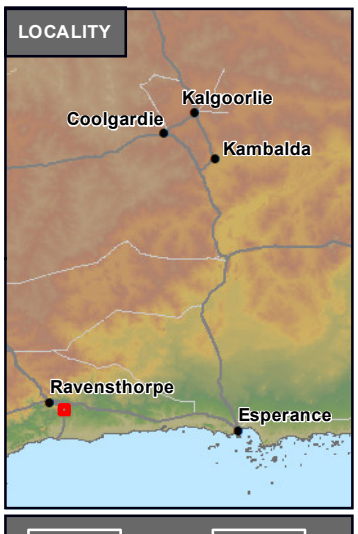
236000 237000 238000 239000 240000 241000 242000

6275000 6274000 6273000 6272000 6271000 6270000 6269000

Data source: Imagery: Landgate, 2016.

- Ravensthorpe Gold Project Area
- Development Envelope
- *Lepidosperma* sp. Elverdton (R. Jasper et al. LCH 16844)
- Annabelle Volcanics
- Manyutup Tonalite

LOCALITY



LEPIDOSPERMA SP. ELVERDTON (R. JASPER ET AL. LCH 16844)

Ravensthorpe Gold Project ERD
Response to Submissions
ACH Minerals Pty Ltd

N
0 300 600 900 1,200 1,500 metres

Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator, Datum: GDA 1994
Scale @ A3: 1:25,000

Prepared:	F Walker
Reviewed:	G Barrett
Project No:	TE19017
Revision:	A
Date:	31/03/2020

Figure 9

ACHMINERALS

Document Path: \\server\Talis\SECTIONS\Environment\Projects\TE2019\TE19017 - Ravensthorpe Gold Project\GIS\Maps\ERD_RtS\TE19017_08_LepidospermaElverdton_RevA.mxd

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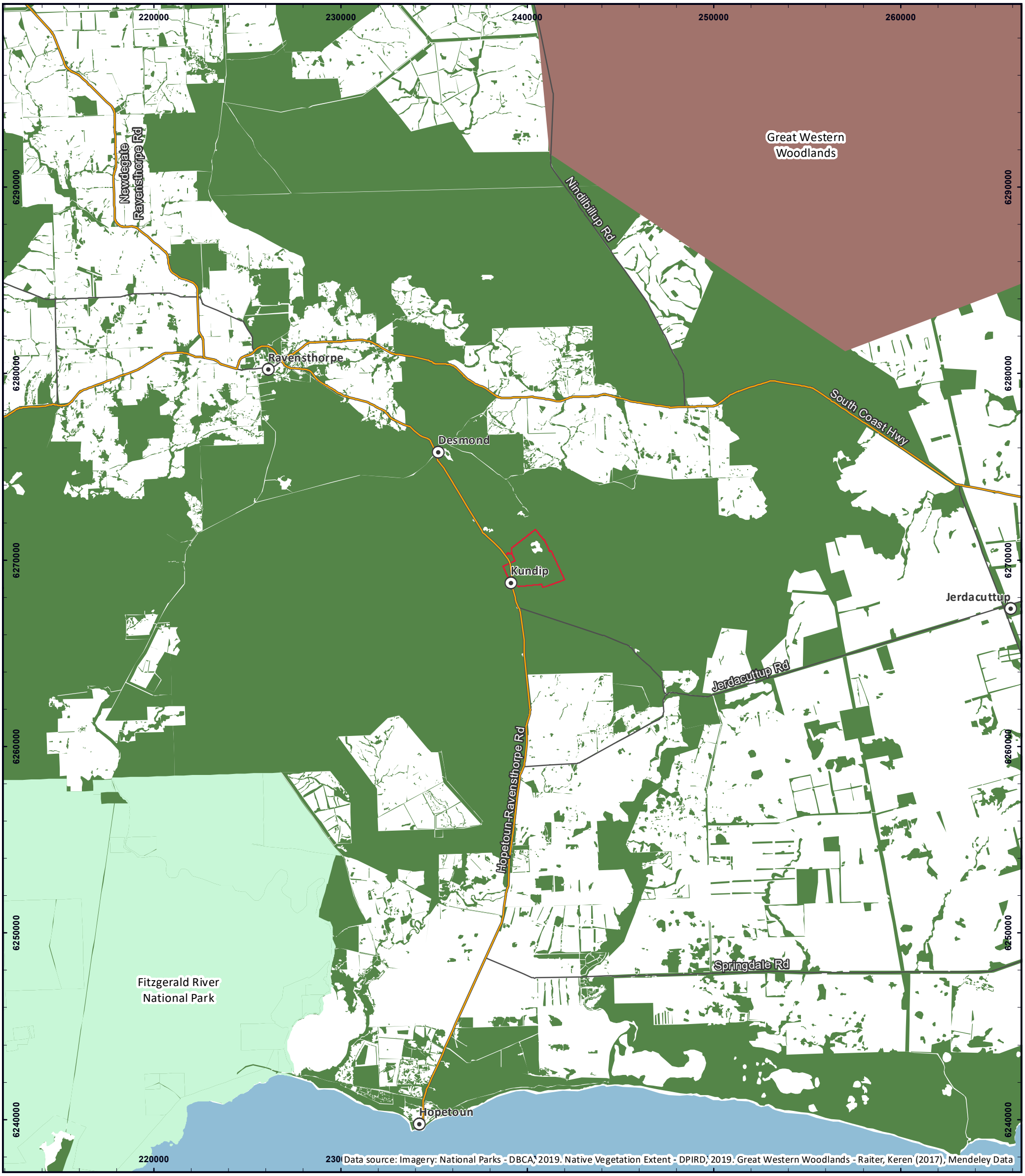
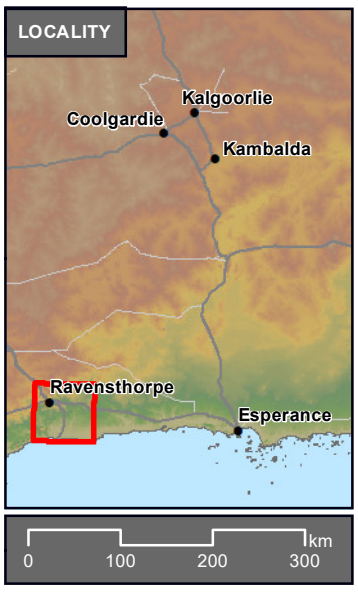


Ravensthorpe Gold Project Area
Great Western Woodlands
Native Vegetation Extent
Fitzgerald River National Park



ECOLOGICAL LINKAGES BETWEEN COASTAL VEGETATION AND INLAND WOODLANDS

Ravensthorpe Gold Project ERD
Response to Submissions
ACH Minerals Pty Ltd

N
km
0 2 4 6 8 10

Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator, Datum: GDA 1994
Scale @ A3: 1:200,000

Prepared:	F Walker
Reviewed:	G Barrett
Project No:	TE19017
Revision:	A
Date:	7/04/2020

Figure 10

ACHMINERALS

Document Path: \\server\Talis\SECTIONS\Environment\Projects\TE2019\TE19017 - Ravensthorpe Gold Project\GIS\Maps\ERD_RtS\TE19017_13_EcologicalLinkage_RevA.mxd

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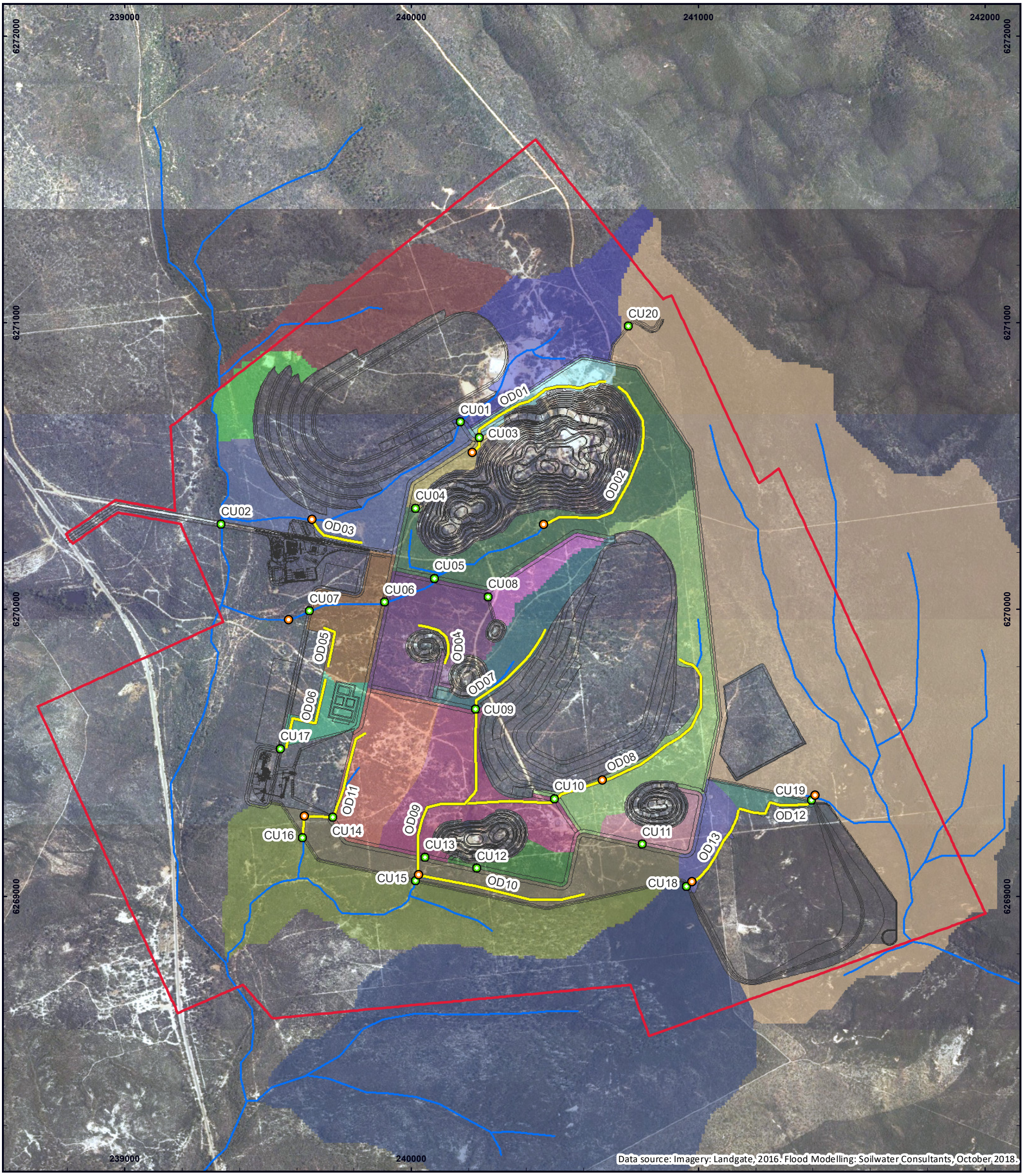
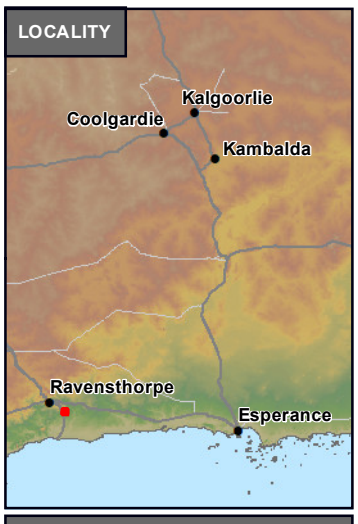


- Ravensthorpe Gold Project Area
- Infrastructure
- Stream Flows
- Culvert
- Sediment Settling Pond
- Open Drains

Operational Catchments

- C02a
- C03a
- C04a
- C04b
- C04c
- C04d
- C05a
- C05b
- C05c
- C05d
- C06a
- C07a
- C07b
- C07c
- C07d
- C07e
- C07f
- C07g
- C07h
- C08a
- C08b
- C09a
- C10a



OPERATIONAL WATER MANAGEMENT MEASURES

Ravensthorpe Gold Project ERD
Response to Submissions
ACH Minerals Pty Ltd

N
0 100 200 300 400 500 metres
Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator, Datum: GDA 1994
Scale @ A3: 1:13,000

Prepared:	F Walker
Reviewed:	G Barrett
Project No:	TE19017
Revision:	A
Date:	7/04/2020

Figure 11

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239000 240000 241000

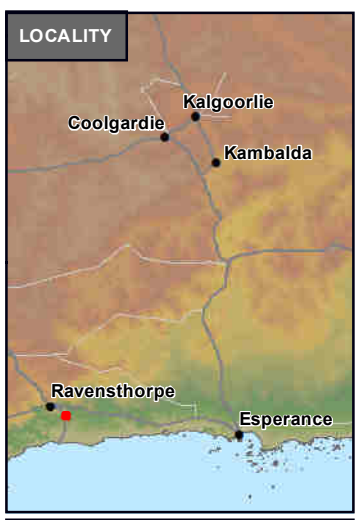
6271000 6270000 6269000

Data source: Imagery: Landgate, 2016.

- Ravensthorpe Gold Project Area
- RGP Development Envelope
- Exclusion Zone *(Bothriembryon)*
- *Bothriembryon*

RGP Mine Activities

- Site Access Roads
- Ancilliary Support Infrastructure
- Fire Break (DBCA)
- Mine Pit
- Processing Plant
- Tailings Storage Facility
- Waste Rock Landform



BOTHRIEMBRYON EXCLUSION ZONE

Ravensthorpe Gold Project ERD
Response to Submissions
ACH Minerals Pty Ltd

N
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Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator, Datum: GDA 1994
Scale @ A3: 1:12,000

Prepared:	F Walker
Reviewed:	G Barrett
Project No:	TE19017
Revision:	A
Date:	7/04/2020

Figure 12

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239000 240000 241000 242000

6272000 6271000 6270000 6269000

Spatial Extent of Habitat Mapping

Ravensthorpe

0 3 6 9 12 Km

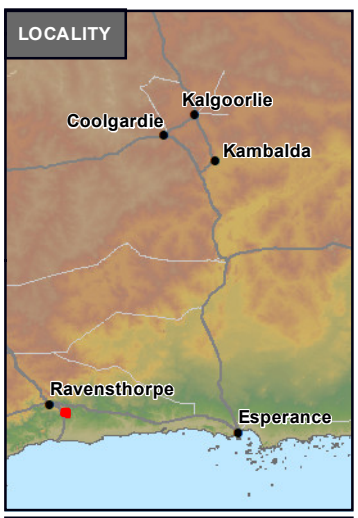
Data source: Imagery: Landgate, 2016. Habitat Mapping: Craig et al (2008).

- Ravensthorpe Gold Project Area
- RGP Development Envelope
- RGP Mine Activities

Fauna Habitats

- Completely Degraded
- Damplands and Drainage Habitat
- Low Dense Forest / Forest Habitat
- Low Woodland Mallee and Heath Habitat

LOCALITY



FAUNA HABITATS
Ravensthorpe Gold Project ERD
Response to Submissions
ACH Minerals Pty Ltd

N 0 150 300 450 600 metres

Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator, Datum: GDA 1994
Scale @ A3: 1:15,000

Prepared:	F Walker
Reviewed:	G Barrett
Project No:	TE19017
Revision:	A
Date:	7/04/2020

Figure 13

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240000

6270000

6270000

240000

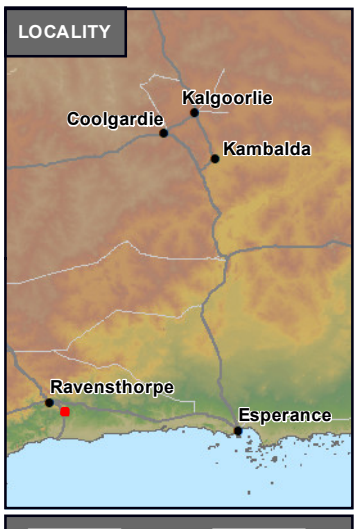
Data source: Imagery: Landgate, 2016.

Ravensthorpe Gold Project Area

Potential Stygofauna Habitat

Proposed Open Pit

LOCALITY



ALLUVIAL FORMATIONS

Ravensthorpe Gold Project ERD
Response to Submissions
ACH Minerals Pty Ltd

N

0 200 400 600 800 m

Coordinate System: GDA 1994 MGA Zone 51,
Projection: Transverse Mercator, Datum: GDA 1994
Scale @ A3: 1:13,000

Prepared:	F Walker
Reviewed:	G Barrett
Project No:	TE19017
Revision:	A
Date:	7/04/2020

Figure 14

ACHMINERALS

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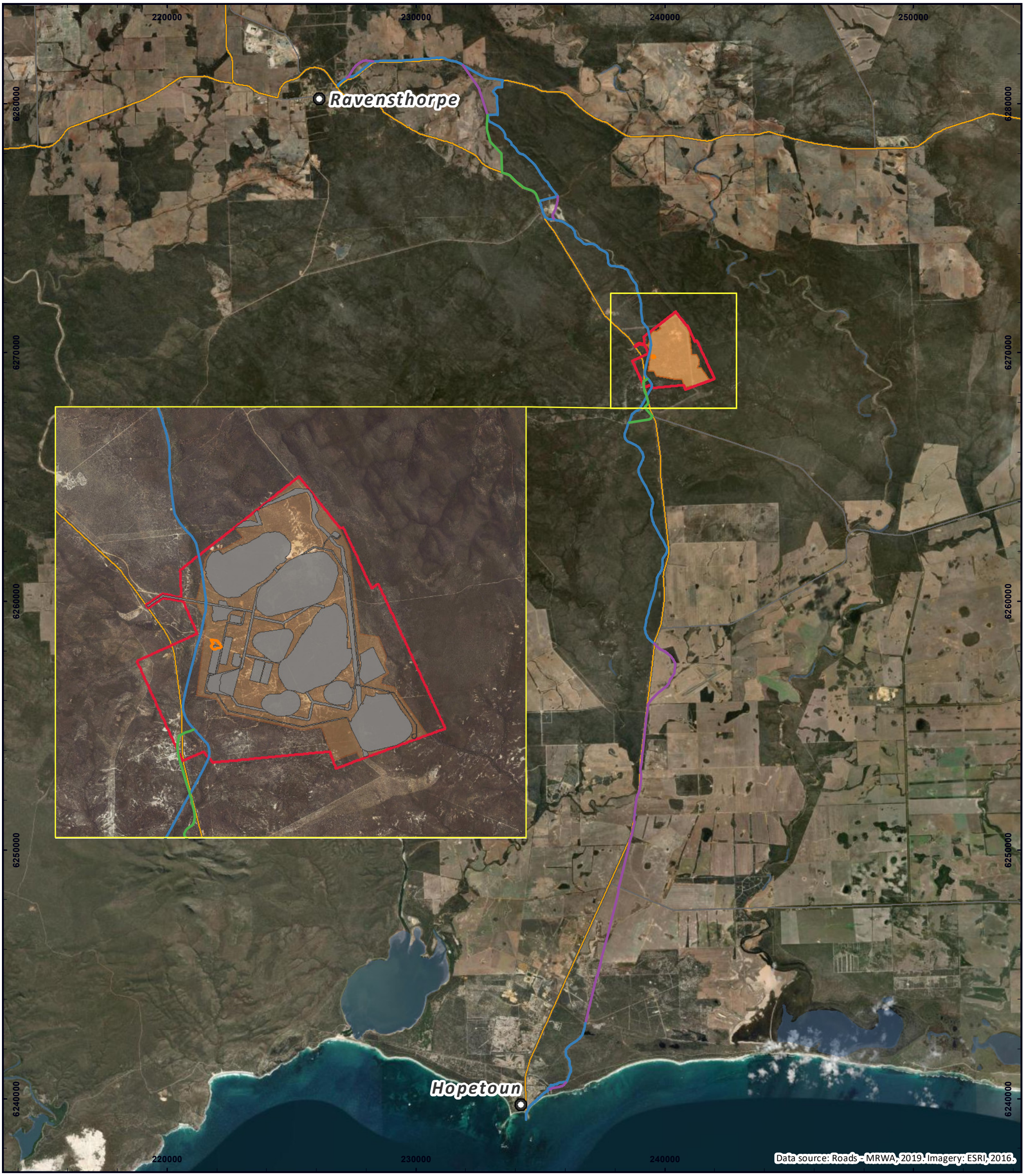
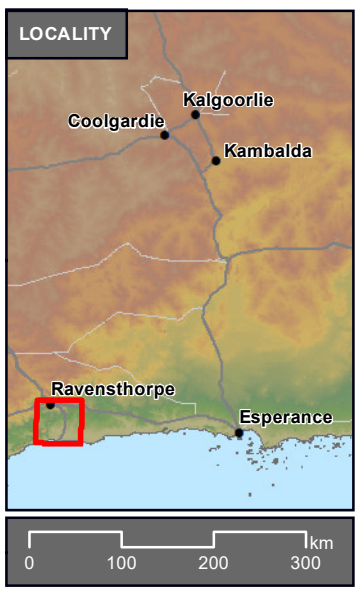


Ravensthorpe Gold Project Area
RGP Development Envelope
Proposed Footprint

Hopetoun - Ravensthorpe Railway Heritage Walk

Rail Trail
Other Trail
Former Railway
Kundip Battery

Minor Road
Major Road



HOPETOUN - RAVENSTHORPE RAILWAY HERITAGE WALK

Ravensthorpe Gold Project ERD
Response to Submissions
ACH Minerals Pty Ltd

N
0 2 4 6 8 km

Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator, Datum: GDA 1994
Scale @ A3: 1:150,000

Prepared:	F Walker
Reviewed:	G Barrett
Project No:	TE19017
Revision:	A
Date:	7/04/2020

Figure 15

ACHMINERALS

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Tables

Table 1: RGP Project Area – dam water quality samples (2018-2019)

Analyte	Units	Measured range	DER (2014) fresh water assessment level
EC	mS/cm	1.26 – 18.03	-
pH		6.8 – 7.7	6.5-8.5
Total N	mg/L	0.04 – 9.11	1 (long term) 2 (Short term)
Hg	mg/L	0.00005 – 0.00056	0.00006
Al	mg/L	0.07 – 3.3	0.055
Cu	mg/L	0.03 – 2.14	0.0014
Mn	mg/L	0.03 – 3.95	1.9
Ni	mg/L	0.003 – 0.024	0.011
Zn	mg/L	0.01 – 0.048	0.008
Bo	mg/L	0.2 – 2.1	0.37
Fe	mg/L	0.263 – 27.3	0.3
Pb	mg/L	0.001 – 1.4	0.0034
Cd	mg/L	0.0001 - 0.0047	0.0002
As	mg/L	0.001 – 0.027	0.013

Table 2: RAV8 Nickel Project - pit groundwater quality (May 2018)

Parameter	Unit	Limit of Reporting	Value
pH	pH units	0.01	8.14
Total Dissolved Solids	mg/L	10	20,200
Major Cations			
Calcium	mg/L	1	200
Magnesium	mg/L	1	864
Sodium	mg/L	1	3210
Potassium	mg/L	1	103
Total Metals			
Aluminium	mg/L	0.01	0.02
Arsenic	mg/L	0.001	0.001
Beryllium	mg/L	0.001	<0.001
Barium	mg/L	0.001	0.030
Cadmium	mg/L	0.0001	0.0004
Chromium	mg/L	0.001	<0.001
Cobalt	mg/L	0.001	0.040
Copper	mg/L	0.001	0.002
Lead	mg/L	0.001	<0.001
Lithium	mg/L	0.001	0.138
Manganese	mg/L	0.001	0.191
Molybdenum	mg/L	0.001	0.002
Nickel	mg/L	0.001	3.39
Selenium	mg/L	0.01	<0.01
Tin	mg/L	0.001	<0.001
Uranium	mg/L	0.001	0.001
Vanadium	mg/L	0.01	<0.01
Zinc	mg/L	0.005	<0.005
Boron	mg/L	0.05	1.86
Iron	mg/L	0.05	0.14

Table 3: RGP Project Area and surrounds- indicative surface and groundwater monitoring program

Sampling points	Timing/frequency	Target analytes
Surface water		
Steere River monitoring points: • 2 upstream • 4 downstream (Figure 4-38, Figure 2) (Points: S1-4, P1 -2)	Hand sample ephemeral flows opportunistically during runoff events, during operation.	Field: • Temperature; • pH; • Dissolved oxygen (DO); and • Electrical conductivity (EC). Laboratory: • pH; • Total Dissolved Solids (TDS); • Turbidity; • N and P; • Ionic balance; • Metals (total and dissolved); and • Total recoverable hydrocarbons (TRH).
Jerdacuttup River monitoring points: • 1 upstream • 2 downstream (Figure 4-38) (Points: J1-3)		
TSF cut-off drain		
Mine void water quality: • All pit lakes	Annually, at cessation of dewatering when pits fill with water.	Laboratory: • pH; • TDS; • Ionic balance; and • Metals (total and dissolved).
Photo monitoring points: • 5 points along local creeklines (Figure 2) (Points: P1-5)	Six monthly.	Photo monitoring.
Groundwater		
TSF: • An array of 8 monitoring bores (upstream and downstream)[9] (Figure 2) (Points: G6-12)	During operation quarterly sampling and monthly standing water levels.	Laboratory: • pH; • Salinity; • Ionic balance; • Metals (total and dissolved); • Depth to water; and • WAD CN.
Pit voids: • An array of 7 monitoring bores (upstream and downstream) (Figure 2) (Points: G1-4, G8, KMB5a, KMB6a)	During operation annual sampling and monthly standing water levels.	

[9] A mine tenure change will be necessary to establish some groundwater monitoring bores south of the Project Area.

Sampling points	Timing/frequency	Target analytes
Notes on metals Metal suite for dissolved and total metals should include the following: Aluminium (Al), silver (Ag), arsenic (As), boron (B), barium (Ba), beryllium (Be), calcium (Ca), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), mercury (Hg) , potassium (K), lithium (Li), magnesium (Mg), manganese (Mn), molybdenum (Mo), sodium (Na), nickel (Ni), lead (Pb), antimony (Sb), selenium (Se), tin (Sn), titanium (Ti), uranium (U), vanadium (V) and zinc (Zn).		
Notes on post-closure monitoring Groundwater and surface water monitoring will continue post closure until such a time as the completion criteria are met as per an approved Mine Closure Plan (MCP) under the *Mining Act 1978.* The current completion criteria in the draft MCP in regards to water quality states that water quantity and quality will be on a trajectory to baseline levels within two years of cessation of mining and processing. This will likely be subject to change at the time of submission to DMIRS.		
Notes on trigger levels Trigger levels for groundwater and surface water quality will be established once sufficient baseline data has been collected. Trigger levels for water quality are proposed to be set to 80th (or 20th) percentile of baseline data and confirmed in consultation with DMIRS and DWER. Should the trigger levels be exceeded for three consecutive sampling periods for groundwater (or two for surface water), investigations will take place and management strategies will be implemented. Management strategies may include: • Determine whether the changes observed are a results of the Project e.g. undertake a comparison with any control sites up-gradient or upstream; • Increase monitoring frequency; • Investigate reason for any change including which activities may have caused the change; • Review of management measures and controls; and • Undertaken further studies.		

Table 4: RGP Project Area - groundwater quality samples

Analyte	Units	Measured range	DER (2014) non-potable groundwater use assessment level
EC	mS/cm	16.33 – 69.7	-
pH		6.18 – 7.37	-
Sulfate as SO_4	mg/L	**910** - 3600	1000
Cl	mg/L	**4634** - **20667**	250
Ammonia as N	mg/L	0.02 – **7.19**	0.5
Al	mg/L	0.01 – **0.41**	0.2
Fe	mg/L	0.001 – **3.633**	0.3

Note: The values highlighted denote changes since incorporating the latest monitoring results. The only significant change of note was the presence of elevated 'ammonia as N' in one monitoring location (KMB2) as the previous maximum recorded value was 1.24 mg/L. Possibly attributable to historic blasting residue.

Table 5: Summary of population counts for five Priority species (December 2019)

Taxon	Conservation status	Total known plants	Abundance in Development Envelope and 20 m buffer	% of total known plants	Abundance in Development Envelope less abundance in Exclusion Zone (inc. 20 m buffer)	% of total known plants (with Exclusion Zone applied)
Calothamnus roseus	P1	4,700	3,200	68	220	4.7
Melaleuca sophisma	P1	58,347	347	0.6		
Hydrocotyle tuberculata	P2	237	-[10]	-		
Thomasia sp. Hopetoun (K.R. Newbey 4896)	P2	243	44	18		
Dampiera sp. Ravensthorpe (G.F. Craig 8277)	P3	36,893	-[11]	-		

[10] Annual plant not found in Dec 2019 survey; c. 60 plants in 2011; previously 110 plants in 2005.

[11] Not found in Dec 2019 survey; 1,500 plants in 2009.

Appendix A: Tailings Storage Facility: Feasibility Study (Resource Engineering Consultants)

Tailings Storage Facility Feasibility Study

Ravensthorpe Gold Project, Western Australia
ACH Minerals Ltd

Rev. 5
January 2020

REC
RESOURCE ENGINEERING CONSULTANTS

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Report

Title:	TSF Feasibility Study, Ravensthorpe Gold Project
File:	P17-02/TSF/FS/5
Author(s):	Mitch Hanger
Client:	ACH Minerals Ltd
Contact:	Paul Bennett
Synopsis:	This document details the findings of a Feasibility Study pertaining to the proposed Tailings Storage Facility at ACH Minerals' Ravensthorpe Gold Project.

Document Control

Revision No	Date	Author(s)	Reviewer(s)
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0	January 2018	MH; JW	JW
1	January 2018	MH	-
2	July 2018	MH	CL
3	August 2018	MH	-
4	October 2018	MH	-
5	January 2020	MH	-

Distribution

Revision No	Date	Approved	Recipient(s)	No of Copies
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5	January 2020	MH	PB	1.

Revision

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A	December 2017	Draft for Comment – MHA GEOTECHNICAL	MH
0	January 2018	Final Draft Report – MHA GEOTECHNICAL	MH
1	January 2018	Final Report – MHA GEOTECHNICAL	MH
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3	August 2018	Revised Final Draft Report – MHA GEOTECHNICAL	MH
4	October 2018	Revised Final Report – MHA GEOTECHNICAL	MH
5	January 2020	Revised Final Report	MH
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Appendix E: Geotechnical Field Investigation Laboratory Test Results and Certificates
Appendix F: TSF Feasibility Study Drawings

Terminology and Abbreviations

The following terminology and abbreviations have been used in this document:

AEP	Annual exceedance probability
ANCOLD	Australian National Committee on Large Dams
BOM	Bureau of Meteorology
DFL	Deflector Mining Limited
DMIRS	Department of Mines, Industry Regulation and Safety
DWERS	Department of Water and Environmental Regulation
LOM	Life of mine
IFD	Intensity frequency duration
m/a	Metres per annum
m^3/d	Cubic meters per day
Mm^3	Million cubic meters
Mt	Million tonnes
Mtpa	Million tons per annum
NAF	Non-acid forming
OD	Outside diameter
RL	Reduced level
SG	Specific gravity
tpa	Tonnes per annum
tpd	Tonnes per day
t/m^3	Tonnes per cubic metre
TSF	Tailings Storage Facility
TSM	Tailings storage management

1. TSF Proposal Summary

MHA Geotechnical Pty Ltd (MHA) prepared the original Feasibility Study (FS) level design of the Kundip Mine Site tailings storage facility (TSF) at the ACH Minerals Pty Ltd (ACH) Ravensthorpe Gold Project (RGP) to support the overall project Feasibility Study into the technical and commercial viability of RGP. This report was originally prepared in December 2017 and in July 2019 MHA was rebranded to operate as Resource Engineering Consultants Pty Ltd (REC).

This revised FS report has been prepared by REC following the format recommended in the Government of Western Australia Department of Mines and Petroleum's (DMP) Guide to the Preparation of a Design Report for Tailings Storage Facilities. This report is not intended to serve as the detailed design report for submission to the Department on Mines, Industry Regulation and Safety (DMIRS); further design development is required to advance from a FS level design to detailed design with issued for construction (IFC) documentation.

The Kundip Mine Site is situated approximately 20 km by road south-east of the town of Ravensthorpe and can be accessed from the Hopetoun-Ravensthorpe Road. The RGP site layout, Kundip mining tenement and location of the TSF relative the main project features is shown on Figure 1.

The Project schedule envisages total tailings production of 3.1 Mt. At an assumed average dry density of 1.5 t/m^3 for the stored tailings, the required tailings storage capacity is 2.0 Mm^3.

The proposed RGP TSF is a side-hill paddock-style facility. An engineered embankment will provide containment on three sides (east, south and west) whilst the natural topography will provide containment on the north side. The proposed TSF configuration is shown in plan and profile on Figure 6 and Figure 7. In accordance with the DMP Code of Practice (CoP) (DMP, 2013), the RGP TSF attracts a Medium hazard rating.

Construction of the RGP TSF will be undertaken in accordance with IFC drawings and earthworks specification. Furthermore, construction and operation will be in general accordance with the design intent of the final detailed design report.

Tailings are to be deposited from the main embankment in a sub-areal manner in thin lifts and beaching towards the northwest corner of the facility to form a decant pond away from the main embankment. The configuration and location of the decant pond provides capacity for the 1:100 annual exceedance probability (AEP) 72-hour storm event and DMP required freeboard.

It is envisaged that a detailed closure plan will be developed at a later stage in conjunction with an RGP site wide closure plan. The proposed RGP TSF has been developed with closure in mind, taking into consideration the DMP's principal closure objectives for rehabilitated mines and the Environmental Protection Authority's (EPA) objective for Rehabilitation and Decommissioning to ensure that premises are decommissioned and rehabilitated in an ecologically sustainable manner.

2. TSF Design Considerations

2.1 Introduction

MHA was engaged by ACH to provide engineering design services as part of a Feasibility Study (FS) level design of the Kundip Mine Site tailings storage facility for the Ravensthorpe Gold Project. This work was carried out between December 2017 and October 2019. MHA was rebranded in July 2019 to operate as REC.

As part of this study, REC have developed a TSF concept through to a FS level. The output of this work will be incorporated into the overall project Feasibility Study (undertaken by others) assessing the technical and commercial viability of the RGP.

2.2 Background

RGP is larger in scale than the previously approved Phillips River Project, which was to be developed at the same site. Mining of gold and copper bearing ore will be focused on a combination of open-pits and underground mining at Kundip. Processing and tailings storage will also be contained within the Kundip mining leases.

The Kundip Mine Site is situated approximately 20 km by road south-east of the town of Ravensthorpe and can be accessed from the Hopetoun-Ravensthorpe Road. Regional features include the Bandalup Corridor, the buffer zone for the Fitzgerald Biosphere Reserve and areas of uncleared vacant Crown Land as well as private property that supports agricultural land uses.

2.3 Standards, Guidelines and Regulations

The FS level design of the RGP TSF shall follow the recommendations of the following;

- Government of Western Australia Department of Mines and Petroleum (DMP): Guide to Departmental requirements for the management and closure of tailings storage facilities (TSFs), 2015a;
- Government of Western Australia Department of Mines and Petroleum (DMP) Code of Practice (CoP): Tailings Storage Facilities in Western Australia, 2013;
- Australian National Committee on Large Dams (ANCOLD): Guidelines on Tailings Dams Planning, Design, Construction, Operation and Closure, 2012.

2.4 Storage Capacity

The RGP ore processing route is gravity/flotation/CIL; design slurry density of CIL (Carbon-in-leach) is 50 % solids w/w (no tailings thickener). After the final adsorption tank the slurry will pass through a detox tank before being pumped to the TSF at 50 % solids w/w.

Base case tailings production of 3.1 Mt has been adopted for this study. At an assumed average dry density of 1.5 t/m^3 for the stored tailings, the required tailings storage capacity is 2.0 Mm^3. Annual production rates may vary from 0.3 Mtpa to 0.4 Mtpa however the required tailings storage capacity will remain constant.

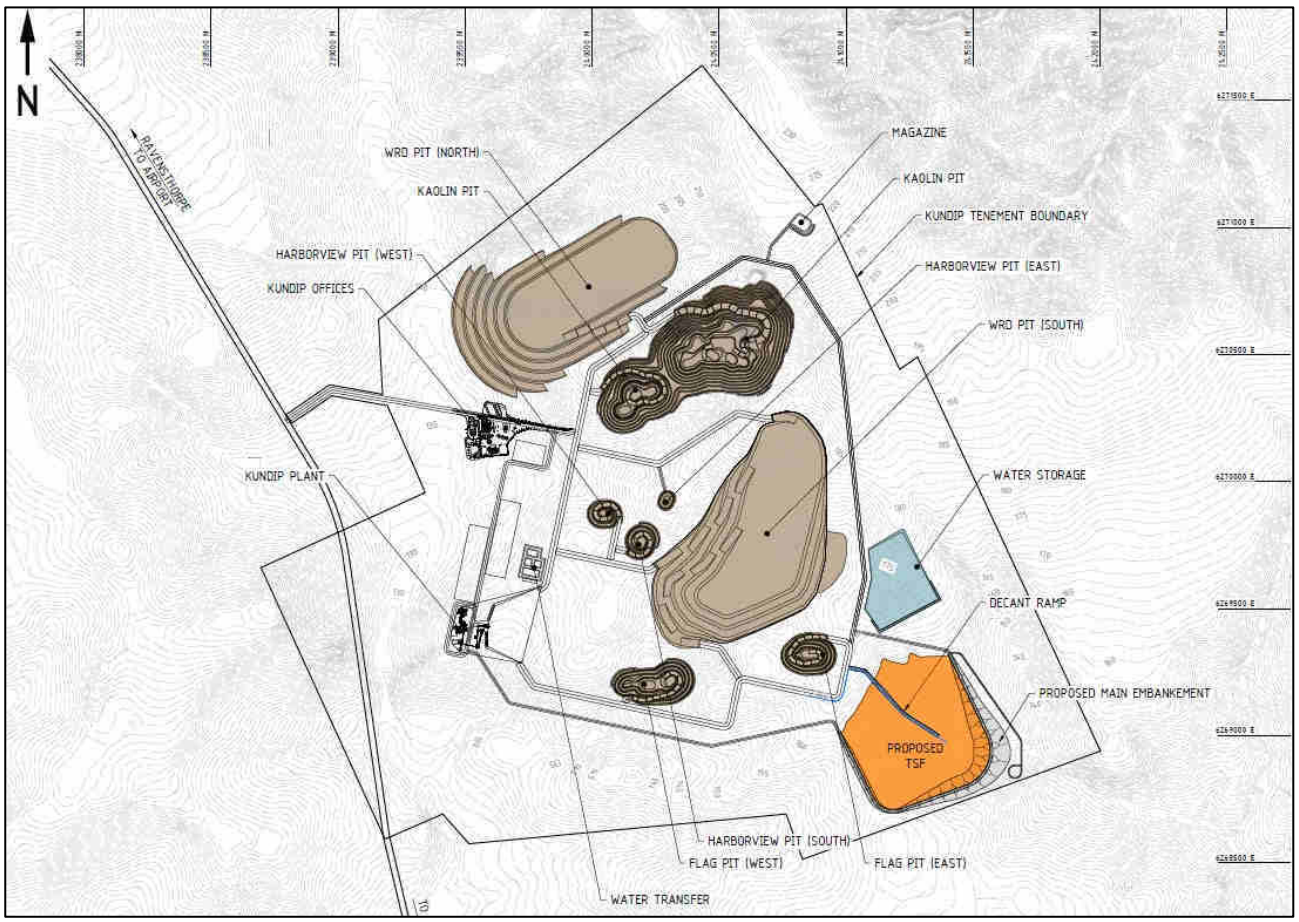
Should additional storage capacity be required, either from increased production or extending the life of the project, the TSF could be raised. However, design of a future raise is outside the scope of this document.

2.5 Tenure and Site Conditions

2.5.1 Location

The Kundip Mine Site is situated approximately 20 km by road south-east of the town of Ravensthorpe and can be accessed from the Hopetoun-Ravensthorpe Road. The RGP site layout, Kundip mining tenements and location of the TSF relative the main project features is shown on Figure 1.

Figure 1: RGP Site layout



2.5.2 Climate

Data from the Bureau of Meteorology (BOM) weather station nearest to the TSF will be used to evaluate the climate of the project area (BoM, 2017). Presented in Table 1 are the long-term temperature and rainfall data (1901-2017) for Ravensthorpe (BoM Site 010633).

Mean monthly rainfall at Ravensthorpe ranges from 24.2 mm in December to 47.3 mm in July, with a mean annual rainfall of 429.5 mm.

Mean daily evaporation at Munglinup Melaleuca (BoM site 012281), approximately 60km from the Kundip mine site, ranges from 2.5 mm in July to 8.3 mm in January; mean annual daily evaporation of 5.0 mm (1,825 mm annual).

Table 1: Long-term Rainfall & Temperature and Evaporation Data - Ravensthorpe 010633.

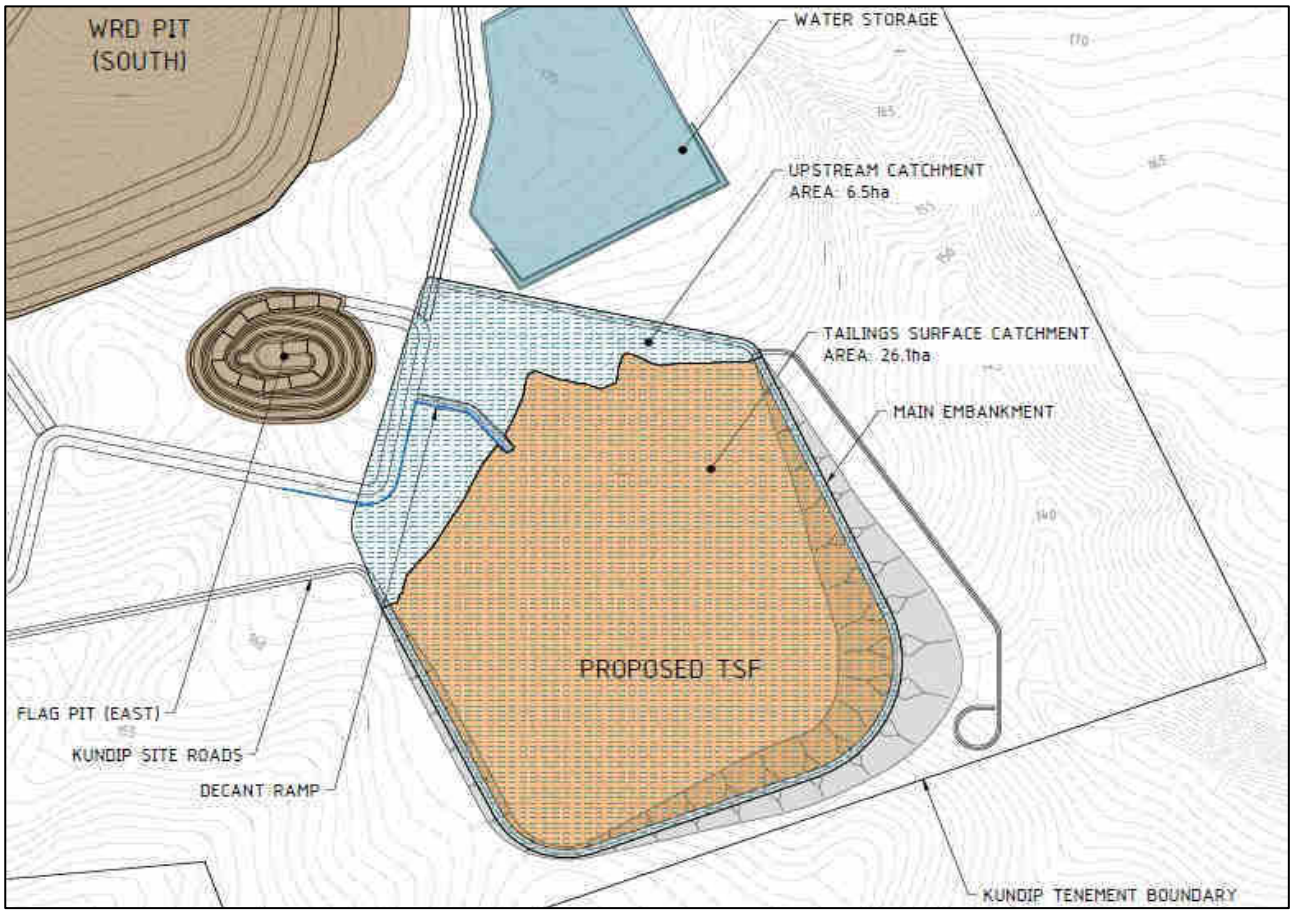
Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Mean Max Temp (ºC)*	29.0	28.3	26.6	23.7	20.0	17.3	16.3	17.3	19.5	22.5	25.1	27.2	22.7
Mean Minimum Temp (ºC)*	14.1	14.6	13.6	11.8	9.6	7.9	6.7	6.7	7.4	9.1	11.1	12.8	10.4
Mean Rainfall (mm)**	24.9	26.5	32.8	32.8	44.1	43.6	47.3	45.1	42.3	38.0	30.6	24.2	429.5 (total)
Highest Rainfall (mm)**	223.2	249.2	163.0	144.7	127.0	117.9	129.6	136.6	144.8	121.4	189.4	140.1	734.5 (total)
Mean Daily Evaporation (mm)***	8.3	7.7	6.3	4.7	3.2	2.6	2.5	2.9	3.7	4.8	6.0	7.7	1825 (total)
* 1962-2017; **1901-2017; ***1975-2001 Munglinup Melaleuca (BoM site 012281)													

2.5.3 Hydrology

2.5.3.1 Catchment

The proposed location of the RGP TSF has been chosen to limit the upstream catchment which would report to the TSF. The final TSF disturbance footprint is approximately 29.3 ha (main embankment and maximum tailings extent at year 10). The total tailings surface catchment is 26.1 ha with an upstream catchment of 6.5 ha for a total catchment of 32.6 ha as shown on Figure 2.

Figure 2: TSF Catchment. (TSF catchment and upstream catchment areas)



2.5.3.2 Runoff

The catchment upstream of the proposed TSF location is densely vegetated as shown on Figure 3.

Figure 3: Proposed TSF location - upstream catchment.

An appropriate rational method runoff coefficient for heavily vegetated areas with loamy soil such as those observed for the TSF catchment would be in the range of C = 0.05 to 0.25. Data gathered from the Australian Rainfall & Runoff Data Hub (accessed 6 November 2017) for the proposed TSF location indicate storm initial losses and continuing losses at 28.0 mm and 1.5 mm/hr respectively; roughly equating to a rational method runoff coefficient of C = 0.21 for a 1:100-yr 72-hr event. A conservative runoff coefficient of C = 1.0 and C = 0.25 for the tailings surface (18.9 ha) and upstream catchment (18.6 ha) respectively has been adopted.

A runoff coefficient of C = 1.0 for the upstream catchment was checked for sensitivity in the TSF storm water storage (freeboard) calculation in Section 3.4.4.

2.5.3.3 Design Storm Events

Design rainfall depths (mm) for the project site obtained from the BoM 2016 Rainfall IFD (Intensity Frequency Duration) Data System are shown on Table 2. The design storm storage requirement under DMP (2015a) and ANCOLD (2012) guidelines is for a 1:100 year 72-hour duration rainfall event (highlighted) in Table 2. DMP and ANCOLD design storm storage requirements are discussed further in Section 3.2.3 & 3.3.6 respectively.

Table 2: Rare design rainfall depth (mm) – (BoM 2016 Rainfall IFD data system)

	Annual Exceedance Probability (1 in x)				
Duration	**1 in 100**	**1 in 200**	**1 in 500**	**1 in 1000**	**1 in 2000**
24-hour	136	159	193	222	255
48-hour	162	189	229	263	301
72-hour	172	200	243	279	319
96-hour	177	206	249	286	327
120-hour	178	209	252	290	331
144-hour	179	211	254	292	334
168-hour	179	212	256	293	335

2.5.4 Geology

2.5.4.1 Regional Geology

There are three regional geological units in the area:

- Yilgarn Craton (Archaean) to the north comprising granitoid, granitic gneiss and migmatitic rocks with some greenstone rafts, overlain to the south by;
- Mount Barren Group (Proterozoic) comprising metasedimentary rocks of shale, arenite, dolostone and intruded gabbro-diorite sills; and
- The southeast portion of the region is occupied by Munglinup Gneiss (Proterozoic), which forms part of the Biranup Complex.

The northeast trending Jerdacuttup Fault separates the Munglinup Gneiss from both the Mount Barren Group and the Archaean granite-greenstone terrane. Tertiary sediments of the Plantagenet Group in turn unconformably overlie all Precambrian tectonic units.

2.5.4.2 Local Geology

The Kundip mining area lies in a region of steeply dipping mafic to intermediate volcanic rocks of Archaean age (Annabelle Volcanics) (Witt, 1997). The volcanic rocks have been intruded to the west by granitic rocks, also of Archaean age. The upper reaches of the Steere River follow the contact between the granitic and the volcanic rocks.

Immediately south of the Kundip mining area, the Archaean rocks are overlain by the Proterozoic Mount Barren Group, including sediments of the Kundip Quartzite and the Kybulup Schist. The quartzite dips at about 15 degrees to the south-south-west.

2.5.4.3 Sub-surface Conditions and Foundations

A geotechnical site investigation was carried out by REC November 17th to 23rd 2017 (Appendix A). The purpose of the geotechnical investigation was to:

- Develop ground profiles for the TSF location,
- Determine the geotechnical properties for foundation and borrow materials,
- Provide comment on the suitability of the site for the proposed development.

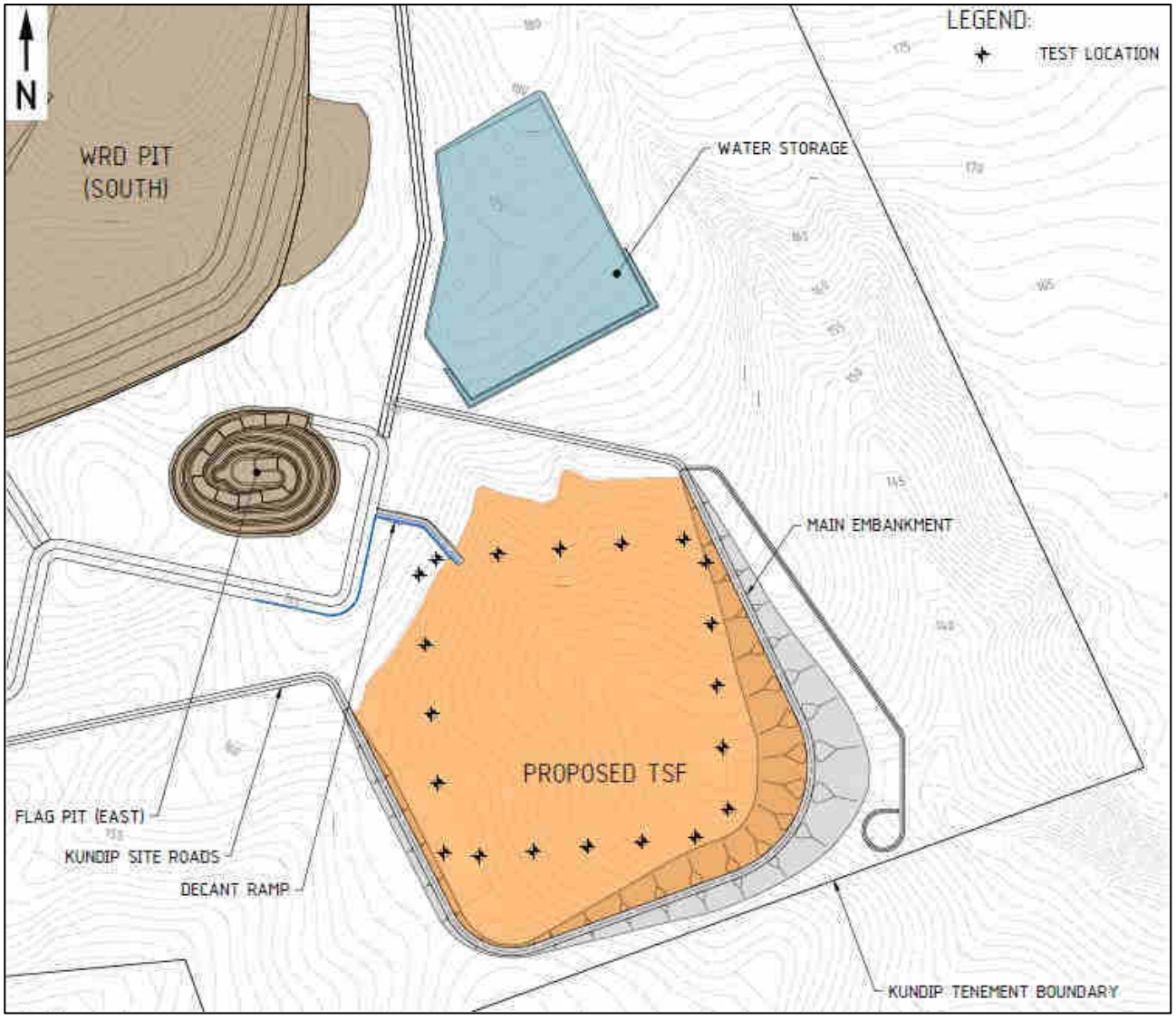
The typical regolith profile at the TSF site comprises a surficial cover of an unconsolidated sandy silt TOPSOIL underlain by sandy gravelly SILT, underlain by SILTSTONE (see Appendix B – Geotechnical Field Investigation Test Pit Logs and Photographs).

The material encountered can be broadly summarised as:

- 0 m – 0.2 m: SILT; sandy, gravelly TOPSOIL with roots and organic matter;
- 0.2 m – 0.6 m: SILT; red brown, sandy with gravel (transitional zone);
- 0.6 m – 1.0 m: SILTSTONE; red brown, conglomeritic;
- 1.0 m – 3.0 m: SILTSTONE, white sandy/gravelly (considered competent bedrock).

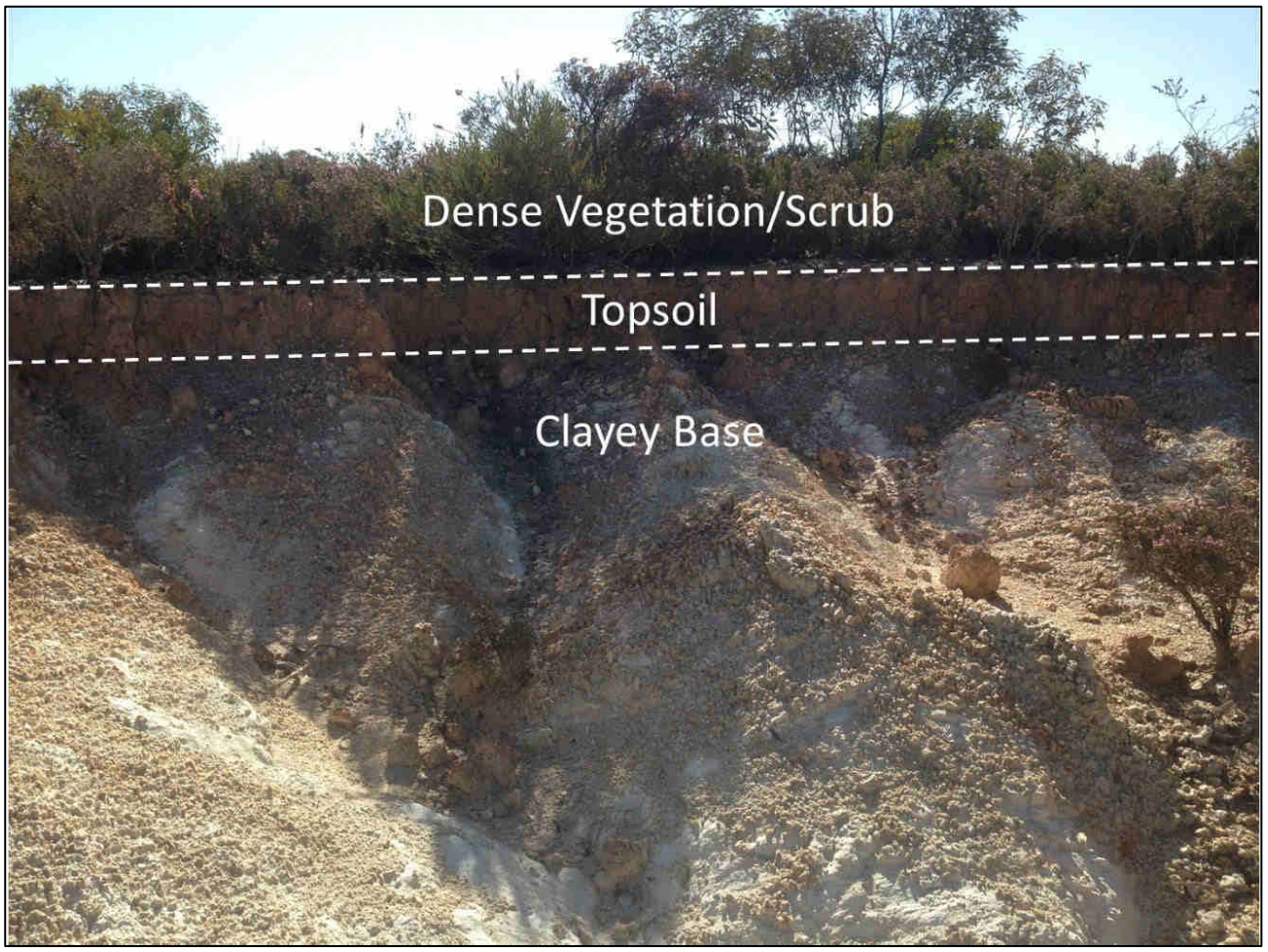
Geotechnical test locations relative to the proposed TSF configuration are shown on Figure 4.

Figure 4: Geotechnical Investigation Setout



Additionally, during a site visit undertaken on 19 October 2017, a portion of the TSF basin was accessible from an existing access track. In an area disturbed by previous prospecting activities a glimpse into the shallow subsurface conditions was gained by viewing the disturbed areas within the TSF basin. The exposed profile captured in Figure 5 shows dense vegetation/scrub underlain by 300 to 500 mm of topsoil with a clayey base below.

Figure 5: TSF basin - shallow subsurface conditions



The geotechnical investigation undertaken by REC further confirmed the general shallow subsurface stratigraphy. The foundation directly beneath the proposed TSF main embankment was not accessible during the site visit. At this stage it is assumed that the subsurface conditions beneath the main embankment are similar to the test locations immediately upstream of the embankment. Assumed geotechnical parameters for the embankment foundation are presented in Section 3.4.1.3.

2.5.5 Seismic Risk

The seismic hazard risk assessment contained in GA (2012) is used to quantify the seismic setting for the site. This is a relatively recent and detailed assessment and provides peak ground accelerations (PGAs) for earthquakes of return period 500 years and greater (c.f. the project Operating Basis Earthquake (OBE) and Maximum Design Earthquake (MDE) return periods of 50 years and 100 years respectively). As such its use is conservative but it directly relates to PGAs of interest to the design of earth structures as opposed to use of AS1170.4 Structural design actions – Earthquake actions in Australia that is strictly only applicable to steel, concrete and timber structures.

The PGA is estimated to be 0.06 g for the project. Mining induced ground motion, such as blast induced shaking, is expected to result in relatively minor PGA and for very short durations (cycles). A blast risk assessment will be covered as part of the detailed design process if required.

2.5.6 Current and After Closure Land Use

Post mining land use options and closure objectives have been broadly identified at the project planning phase and will be further defined during the stakeholder consultation process. The identified post mining land use aim is to return the land to the pre-mining land use of native vegetation at Kundip.

2.6 Retaining Structure Properties

The geotechnical investigation undertaken by REC (Appendix A) included collection of samples from stockpiles located on the Kundip site as well as samples taken from the TSF basin. The results of the laboratory test work and the geotechnical properties of retaining structure are presented in Appendix E. The geotechnical properties of the proposed embankment construction material sources are presented in Section 3.4.1.2.

2.7 Tailings Properties

2.7.1 Laboratory Testing

At the time of writing this report, preliminary representative oxide and primary ore tailings samples were available for laboratory test work. Assumed engineering design parameters are based on these results and our experience with similar tailings projects. This is considered acceptable for FS level design, particularly so because the proposed design does not rely on the geotechnical properties of the tailings for stability or containment, as would be the case with an upstream raised embankment configuration.

The laboratory test schedule for the tailings samples included:

- Particle Size Distribution with Hydrometer;
- Atterberg limits test;
- Air drying test;
- Settling tests (drained and undrained); and
- Oedometer test.

2.7.1.1 Oxide Tailings Test Results

Preliminary test results indicate that the oxide ore will potentially form a low permeability layer at the base of the TSF. An in-situ dry density of 1.34 t/m^3 is achieved within 24 hours.

Table 3: Oxide Ore Tailings test results

Test/Parameter	Value
Percent passing 0.075 mm (SILT)	82 %
Percent passing 0.002 mm (CLAY)	14 %
Liquid Limit	33 %
Plastic Limit	28 %
Plasticity Index	8 %
Linear Shrinkage	2 %
Moisture Content	143.6 %
Particle Density	2.82 t/m^3

2.7.1.2 Primary Ore Test Results

The results of the primary ore air-drying tests indicate that the evaporation rate form the tailings beach is expected to be low. The primary ore tailings are non-plastic and settle quickly given the high Specific Gravity (SG) and lack of plasticity. The settling tests also indicate that water recovering from the TSF is expected to be high given that an in-situ dry density of 1.46 t/m^3 is achieved within 4 hours.

Table 4: Primary Ore Tailings test results

Test/Parameter	Value
Percent passing 0.075 mm (SILT)	77 %
Percent passing 0.002 mm (CLAY)	7 %
Liquid Limit	NOT OBTAINABLE
Plastic Limit	NOT OBTAINABLE
Plasticity Index	NON-PLASTIC
Linear Shrinkage	NOT OBTAINABLE
Moisture Content	59.6 %
Particle Density	2.91 t/m^3

The tailings test results are presented in Appendix E.

2.7.2 Tailings Design Parameters – Civil Infrastructure and Planning

The RGP TSF embankment will provide tailings storage capacity for the currently projected life of asset tailings production, as set out in Section 2.4. The embankment does not rely on the strength of the tailings for stability and no future raises are currently planned. Assumed parameters for FS level design of the TSF are shown in Table 5.

Table 5: Assumed tailings design parameters

Parameter	Value
In situ dry density	1.5 t/m^3
Shear Strength for slope stability assessment	zero
Hydraulic permeability	1x10^{-3} to 1x10^{-7}
Slurry density	50 % (w/w)

2.7.3 Tailings Design Parameters – Civil Infrastructure and Planning

Tailings samples for rheological test work were not available at the time of preparing this report. Furthermore, design of mechanical infrastructure is not within the scope of this study.

2.7.4 Geochemical Characterisation of Tailings

A preliminary review of the Phillips River Project: Geochemical Characterisation of Tailings-Slurry Samples (Trilogy Deposit) - Implications for Process-Tailings Management (GCA, 2011) indicates the “Cu/Au-Tailings” are potentially acid forming (PAF). It is understood that additional geochemical test work and characterisation will be undertaken prior to or as part of the detailed design process.

3. TSF Design

3.1 Introduction

The proposed RGP TSF is a side-hill paddock-style facility. An engineered embankment will provide containment on three sides (east, south and west) whilst the natural topography will provide containment to the north. The proposed TSF configuration is shown in plan and profile on Figure 6 and Figure 7. FS level design drawings are included in Appendix F.

Figure 6: TSF General arrangement (plan)

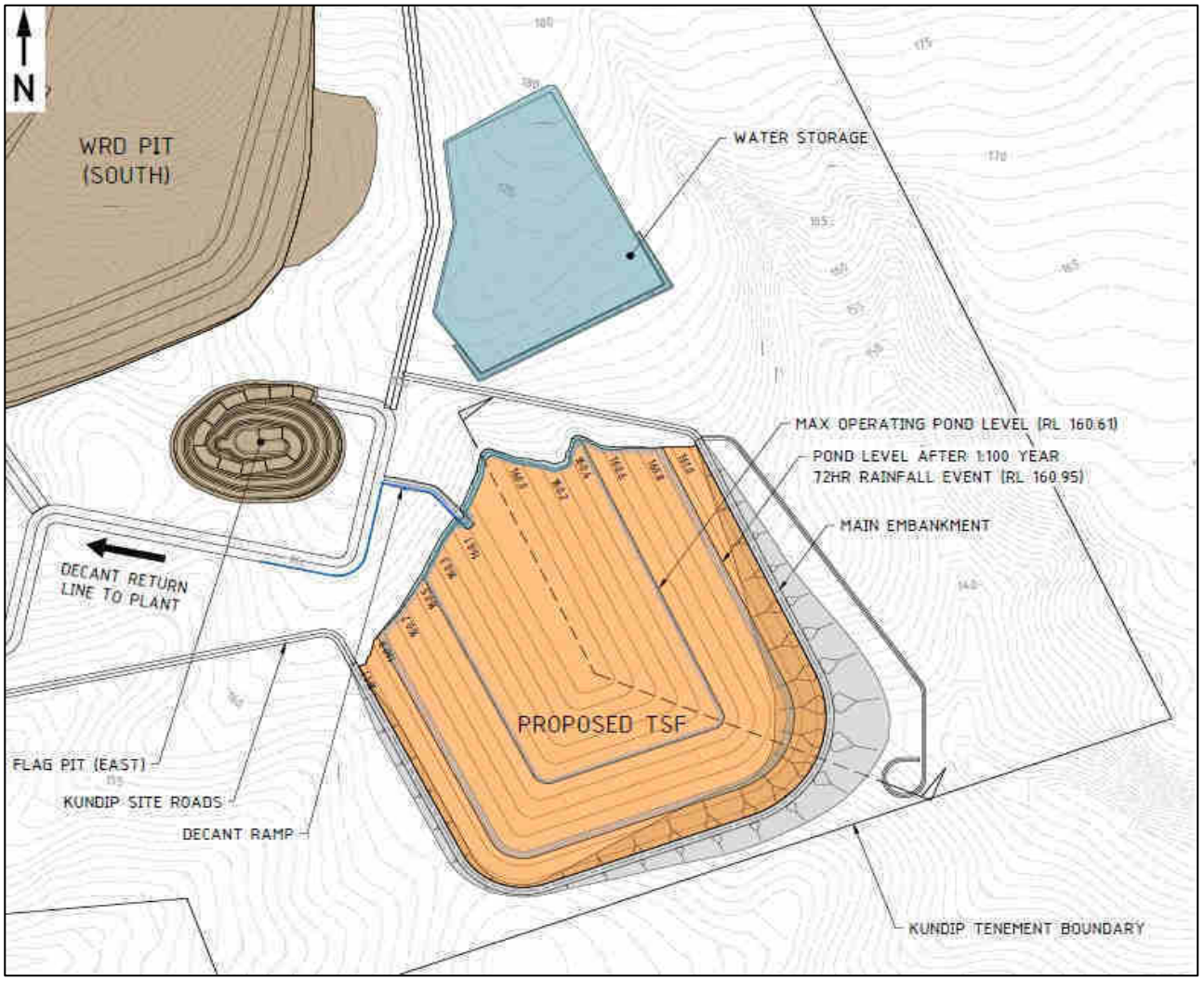
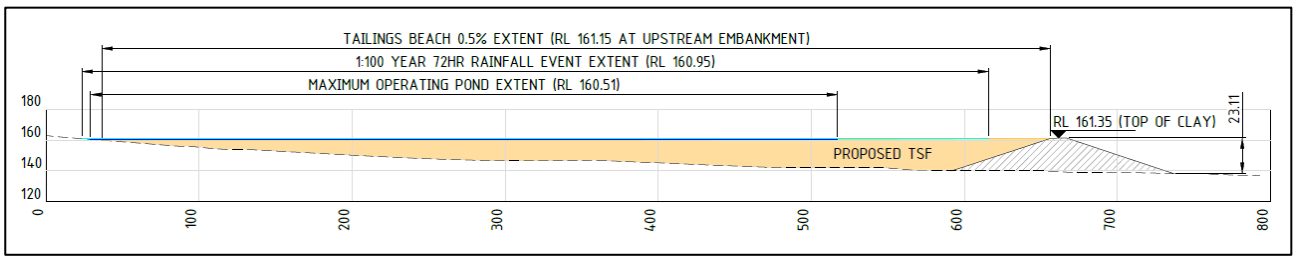


Figure 7: TSF General arrangement (profile)



3.2 DMIRS Classification

3.2.1 Hazard Rating

In accordance with the DMP CoP (DMP, 2013), the RGP TSF attracts a Medium hazard rating as demonstrated in Table 6.

Table 6: Hazard rating system applicable to TSFs in Western Australia

Type of impact or damage	Hazard rating	Extent or severity of impact or damage Embankment or Structural Failure Controlled or uncontrolled release of tailings/water, or seepage
Loss of human life or personal injury	Low	For the proposed location of the TSF the potential population at risk (ANCOLD terminology) is <1.
Adverse human health due to direct physical impact or contamination of the environment	Low	For the proposed location of the TSF there is no potential for human exposure due to direct physical impact. Potential human exposure due to contamination of the environment is low, but the possibility is acknowledged.
Loss of assets due to direct physical impact or contamination of the environment	Low	Livestock will not be present locally, hence there is no potential for loss of livestock from failure. The impact to stock water supply downstream is acknowledged but considered to be minimal; nearest farm is approximately 9km south.
	Low	There are no infrastructure or other mining, public or pastoral assets immediately downstream of the TSF.
	Medium	Loss of TSF storage capacity is possible and repair is practicable.
Damage to items of environmental, heritage or historical value due to direct physical impact or contamination of the environment	Medium	*The Kundip leases are surrounded by an area of the Ravensthorpe Range recommended by the EPA Red Book (Recommendation 3.8) to become a nature reserve (Proposed Nature Reserve 56).* *Kundip lies within the eastern sector of the Fitzgerald Biosphere Reserve, in the zone of cooperation. The Biosphere Reserve is a part-tenured management concept recognised by UNESCO as well as State and Commonwealth governments. The concept includes a core area (the Fitzgerald River National Park) a buffer zone (Crown land and some unvested reserves) and a zone of cooperation (private freehold farmland including 557,000ha cleared and 160,000ha uncleared). Mining, subject to sound environmental management practices, is one of many human impacts considered to be acceptable in the zone of cooperation. Kundip is outside of all defined zones.* (Tectonic, 2011). The Kundip Mine Site is in close proximity to areas of significant environmental value (nature reserve). Temporary damage to the natural environment is possible.
	Medium	Temporary adverse effects on flora and fauna are possible
	Low	Limited or no potential for damage of items of heritage or historical value

3.2.2 TSF Category

In accordance with the DMP Code of Practice (DMP, 2013), the RGP TSF would be classified as a **Category 1** facility as the TSF attracts a hazard rating of **Medium** and the embankment will be greater than 15 m in height.

3.2.3 DMP Recommended Freeboard (DMP, 2015a)

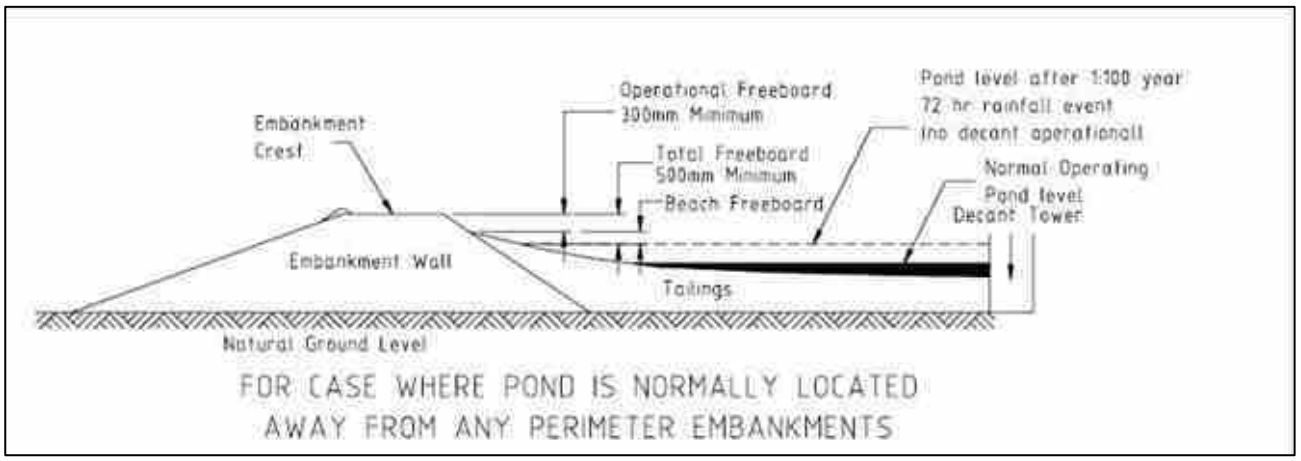
Total Freeboard is defined as the vertical height between the lowest point on the crest of the perimeter embankment of the TSF and the normal operating pond level plus an allowance for an inflow corresponding to the 1:100 year 72-hour duration rainfall event falling in the catchment of the pond, assuming that no uncontrolled discharge takes place for the duration of the rainfall event (Total Freeboard also corresponds to the sum of the “Operational Freeboard” and the “Beach Freeboard” as shown on Figure 8).

Operational Freeboard is defined as the vertical height between the lowest elevation of the perimeter embankment and the tailings beach immediately inside the embankment.

The operational freeboard varies over the course of a deposition cycle as the storage is raised and fills with tailings. The operational freeboard becomes critically important at the end of a deposition cycle, particularly to minimise the potential for back flow and overtopping as a result of mounding of tailings at discharge points.

Beach Freeboard is defined as the vertical height between the normal operating pond level plus an allowance for an inflow corresponding to the 1:100 year 72-hour duration rainfall event falling in the catchment of the pond, assuming that no uncontrolled discharge takes place for the duration of the rainfall event, and the point on the beach where the wall freeboard is measured. The Beach Freeboard can vary significantly during the life of the storage and depends upon beach length, slurry/tailings characteristics, deposition methodology etc. Beach Freeboard is not applicable where the pond is normally located against a perimeter embankment.

Figure 8: Freeboard definition (DMP, 2015a)



3.3 ANCOLD Consequence Category

3.3.1 General

There are two Consequence Categories that need to be assessed as part of Tailings Dam design. These are the Dam Failure Consequence Category and the Environmental Spill Consequence Category. These are used to determine various design and operational requirements including design of spillways and for flood storage requirements.

3.3.2 Dam Failure Severity Level

In accordance with ANCOLD (2012) Guidelines there are seven (7) damage type categories (infrastructure, business importance, public health, social dislocation, impact area, impact duration and impact on natural environment) that need to be assessed in order to determine the severity level/impact (Minor, Medium, Major and Catastrophic) of a potential facility failure or spill.

The severity levels of impacts associated with failure of the RGP TSF embankment are:

- Infrastructure – Minor: less than $10 M production losses and repair costs;
- Business importance – Medium: significant impacts to operations, including reduced or suspended operations whilst repairs are made;
- Public health – Minor: no person's health is affected (see Table 4);
- Social dislocation – Minor: no persons impacted;

- Impact area – Medium: potential impact area greater than 1 km2 but less than 5km2;
- Impact duration – Minor: less than 1 year;
- Impact on natural environment – Medium: (see Table 4).

3.3.3 Dam Failure Population at Risk

The population at risk (PAR) is defined as all people who would be directly exposed to floodwaters assuming they took no action to evacuate. No homes, businesses, recreational areas, offices, workshops or laydowns are located downstream of the embankment, and operational personnel would not be present in low lying areas downstream of the embankment. Based on this, the PAR for the TSF is considered to be 0 (ANCOLD PAR category of <1).

3.3.4 Dam failure Consequence Category

Based on a dam failure severity level of '**Medium**' and a PAR <1, the ANCOLD guidelines recommend adoption of a '**Low**' Dam Failure Consequence Category rating for purpose of design.

3.3.5 Environmental Spill Consequence Category

The Environmental Spill Consequence Category is assessed by considering the effect of spilling dam water to the downstream environment (typically through the dam spillway during a flood event). The aerial extent of the spill impact will be significantly smaller than the area which would be affected in the event of dam failure.

The effect of spilling dam water to the environment is primarily driven by the geochemistry of the tailings solids and supernatant; see Section 2.7.4. Water spilled from the dam under extreme weather events, will be significantly diluted, and further diluted again given the downstream environment of the dam is also likely to be flooded.

Therefore, the severity of impact on the natural environmental from environmental spills through a TSF spillway would be 'Minor'.

The PAR assigned to a dam spill is <1.

The combined Dam Spill Consequence Category is assessed as 'Very Low' at this stage of the design.

3.3.6 ANCOLD Design Criteria

ANCOLD recommended design criteria for a 'Low' consequence category facility have been adopted, including;

Minimum freeboard comprising:

- 1:100 annual exceedance probability (AEP), 72-hr flood;
- Contingency freeboard – nil;
- Additional freeboard – nil.

Earthquake loadings:

- Operating Basis Earthquake (OBE) – 1:50 AEP; and
- Maximum Design Earthquake (MDE) – 1:100 AEP.

3.4 Modelling and Design Studies

3.4.1 Stability Assessment

3.4.1.1 Embankment Compaction

The maximum height of the tailings dam embankment is 21.8 m and would be classified as a large height dam embankment. On this basis the compaction criterion for embankment materials is based on the Modified Compaction test method, with a minimum required dry density of 95 % MMDD (Maximum Modified Dry Density).

3.4.1.2 Embankment Material Foundation Material Slope Stability Assessment Methodology

Based on the results of the laboratory test work, the embankment material is likely to comprise low plasticity clay with silt, sand and gravel, and is likely to encompass the following material types in Table 7 under the Unified Soil Classification System (USCS). Table 7 presents expected values for maximum unit wet density, effective stress cohesion and friction angle for these materials after Hunt (1986). Design density and strength values adopted for the embankment material are also presented.

Table 7: Embankment Material Geotechnical Parameters

USCS	Description	Maximum Wet Density (σ)	Saturated Effective Cohesion (c')	Effective Stress Friction Angle (ϕ')
		kN/m^3	kPa	degrees
SM-SC	Sand-silt clay mix with slightly plastic fines	19.9 – 22.7	14	33
SC	Clayey sand, poorly graded sand-clay mix	19.6 – 21.8	11	31
ML	Inorganic silts and clayey silts	18.5 – 21.2	9	32
ML-CL	Mixture of inorganic silt and clay	19.2 – 21.1	22	32
CL	Inorganic clays of low to medium plasticity	18.5 – 21.1	13	28
DESIGN	Embankment Material	21.0	10	30

3.4.1.3 Foundation Material

The foundation material is likely to comprise pallid clayey soil with an expected minimum undrained shear strength of 100 kPa. This affords a suitable founding material for the proposed 21.8 m high embankment (applied bearing pressure of about 400 kPa, maximum, and 250 kPa, average).

3.4.1.4 Slope Stability Assessment Methodology

Slope stability assessment was undertaken assuming a uniform slope of 1V:3H upstream and downstream batters. The target static stability factor of safety (FoS) is 1.50, and the maximum allowable degree of saturation in the slope to achieve this was assessed.

The following analysis techniques were used:

- Hoek & Bray (1981)
- Michalowski (2002)
- Cousins (1979)

The embankment material is unlikely to be susceptible to seismic liquefaction, given its high fines content and well-compacted state. Seismic stability was assessed by considering:

- What percent reduction in soil strength was required in order to achieve a post seismic FoS of unity;
- What coefficients of horizontal (kh) and vertical (kv=+/-0.5kh) acceleration were required to achieve a FoS of unity.

3.4.1.5 Results

3.4.1.5.1 Static Stability

Results of static stability analyses are presented in Table 8 for target factor of safety (FoS) value of 1.50. These results indicate adequate stability even for the case of a part-saturated embankment.

Table 8: Static Stability Results

Analysis Method	Static FoS	Embankment Percentage Saturation
Hoek & Bray (1981)	1.50	50 %
Michalowski (2002)	1.50	90 %
Cousins (1978)	1.50	60 %

3.4.1.5.2 Seismic Stability

Results of seismic stability analyses are presented in Table 9 for a target factor of safety (FoS) value of unity.

The strength reduction results point to a robust embankment even if marked strength reduction occurs post seismic shaking.

Simplistic pseudo-static assessment using k_h and k_v indicate adequate seismic stability. The peak ground acceleration (PGA) for the site is <0.06 g for the Operating Basis Earthquake (OBE) and Maximum Design Earthquake (MDE) events. The k_h and k_v for FoS of unity are 0.10 g and +/- 0.055 g respectively.

Table 9: Seismic Stability Results

Assessment Method	Seismic FoS	Result
Strength Reduction	1.0	30 % reduction in c' and ϕ'
	1.0	100 % reduction in c' No reduction in ϕ'
Lateral Acceleration	1.0	k_h = 0.10g k_v = +/- 0.5k_h

3.4.2 Erosion Control

The proposed TSF embankment configuration incorporates 1V:3H upstream and downstream batters to help manage batter erosion. The shallow downstream batter will serve as both an operational and final closure slope, envisaged to be vegetated shortly after construction in order to mitigate batter erosion. A shallow upstream batter has been adopted for the upstream batter due to the length of time the batter will be exposed prior to being covered with tailings.

The embankment will be constructed of non-dispersive material and includes a protective wood chip/mulch sheeting layer for further protection of the batter from erosion.

3.4.3 Seepage

Design measures and operational controls aimed at minimising seepage include;

- Design measures
    - Underdrainage and collection sump;
    - Cut-off trench and cut-off drain;
    - Small TSF catchment;
    - Location of the decant pond;
    - Low rate of rise;
    - Low permeability floor.
- Operational controls
    - Sub-areal deposition to promote air-drying (evaporation) whilst continually depositing in thin lifts to minimise dust generation;
    - Maintaining a small decant pond away from the embankment against natural topography;
    - Monitoring of pore pressure development within and downstream of the main embankment;
    - Monitoring of groundwater levels and groundwater quality downstream of the main embankment.

These measures are discussed in the following sections.

3.4.3.1 Design Measures

3.4.3.1.1 Underdrainage and collection sump

An underdrainage system and collection sump are proposed to intercept seepage through the tailings stack. The underdrainage system comprises finger drains within the floor of the TSF (typically wrapped with geotextile) that are covered with coarse aggregate. The finger drains report to a collection sump at the downstream toe of the TSF embankment.

Seepage reporting to the collection sump can either be pumped back to the TSF operating pond or to the water storage dam. The volume of water removed should be correlated against the TSF water balance to determine whether the underdrainage system is working efficiently and restricting seepage.

3.4.3.1.2 Cut-off trench and cut-off drain

A cut-off trench is proposed beneath the TSF embankment. This trench acts to key the embankment into the natural ground and restrict lateral seepage beneath the embankment wall. A cut-off drain is also proposed on the downstream toe of the TSF embankment.

The drains act to prevent and collect seepage driven through or under the embankment. The cut-off drain also acts to manage surface water and prevent ponding on the downstream toe of the embankment. This is important for TSF monitoring and stability.

3.4.3.1.3 TSF Catchment

The location of the proposed TSF has been optimised to provide the required storage capacity whilst minimising the catchment runoff that reports to the facility i.e. seepage is minimised by minimising TSF inflows, see Section 2.5.3.1.

3.4.3.1.4 Decant Pond Location

The TSF is designed such that tailings will be discharged from the embankment and beaching towards the natural topography. This will facilitate the decant pond being located substantially away from the embankment, reducing the potential for phreatic conditions (pore pressures) from developing beneath and with the main embankment. Decant pond development and location are described in Section 3.6.2.

3.4.3.1.5 Rate of Rise

The TSF will benefit from a low rate of rise (RoR) of <2 m/yr (year 3 to year 10) which will allow for deposition of tailings in thin lifts. Sub-areal deposition in thin lifts will promote consolidation through air-drying resulting in a reduced permeability of the deposited tailings and thus reduced seepage potential (compared to other deposition strategies such as sub-aqueous deposition or deposition in thick lifts i.e. high RoR). The RoR is shown graphically on Figure 13.

3.4.3.1.6 Low Permeability Floor

The in-situ TSF floor material is assumed to be of low permeability based on preliminary field observations during the site visit and geotechnical investigation undertaken by REC, see Appendix C and D. Further test work will be undertaken in the main embankment footprint to confirm this assumption is valid throughout the TSF. In the event that areas of the TSF floor are found to be more permeable than expected (>1x10-9), clay borrow material sourced from the Kundip mine site may be used to construct a compacted clay liner.

3.4.3.2 Operational Controls

3.4.3.2.1 Sub-aerial Deposition

As discussed above, sub-areal deposition in thin lifts will serve to increase evaporative losses (reducing water available for seepage) and decrease permeability of the deposited tailings. Preliminary tailings test work indicates that the primary ore tailings settle quickly given the high Specific Gravity (SG) and lack of plasticity. The settling tests also indicate that water recovering from the TSF is expected to be high given that an in-situ dry density of 1.46 t/m^3 is achieved within 4 hours

3.4.3.2.2 Decant Pond Management

Maintaining a small decant pond away from the embankment will reduce (if not eliminate) the potential for embankment seepage. Furthermore, a small decant pond both in depth and areal extent against natural topography will minimise hydraulic head driving seepage.

3.4.3.2.3 Pore Pressure monitoring

Pore pressure development within and downstream of the main embankment will be monitored via vibrating wire piezometers (VWPs) as shown in Section 4.5. A total of 16 VWPs are proposed at 4 sections. Each section comprises 3 nested VWPs within the embankment and 1 VWP near the downstream toe.

3.4.3.2.4 Groundwater Monitoring

A network of groundwater monitoring bores and VWPs will be installed downstream of the main embankment to monitor groundwater levels and groundwater quality (against background groundwater quality) downstream of the main embankment as shown in Section 4.5. A total of 4 monitoring bores are proposed downstream of the embankment.

3.4.3.3 Seepage Quality

Seepage quality and background groundwater quality in the area of the proposed TSF location has yet to be quantified. At this stage in the design development process the primary seepage management strategy is to limit the amount of seepage.

3.4.4 Surface Water Flow and Storage

Assessment of freeboard has been conducted taking into consideration the *ANCOLD Guidelines on Tailings Dams – Planning, Design, Construction, Operation and Closure (ANCOLD, 2012)* and the Code of Practice (CoP): Tailings Storage Facilities in Western Australia (DMP, 2013). The TSF catchment is shown on Figure 2.

The freeboard was assessed as shown on Figure 9 (top down approach); the figure shows that based on a maximum operating pond level of RL 160.61 m, there is sufficient freeboard to contain a 1:100 AEP 72-hour storm event whilst maintaining 500 mm total freeboard. A very conservative runoff coefficient (C=1.0) was adopted for the entire catchment to demonstrate the robustness of the TSF storm water storage capacity.

The storm water storage capacity is dependent upon the actual beach slope achieved during operation. The volume estimate presented in Figure 9 is based on a 0.5 % beach slope. The freeboard limits are presented graphically in Figure 10.

These freeboard requirements are only applicable at the end of the operation of the facility (i.e. dam full tailings). During the operational life of the facility the risk of overtopping is significantly reduced as the incidental rainfall and upstream catchment rainfall is contained within the TSF and should not be allowed to pond on the tailings surface. Removal of stormwater is managed by designing the decant pumps to extract not only the volume of water required for the target dry density, but also the volume of water expected from the PMP/PMF.

It should be noted that the maximum operating pond level (RL 160.61 m) could be a combination of small storm events prior to a 1:100 AEP 72-hour storm event; i.e. the maximum operating pond level at a dam full (tailings) scenario should not be viewed as a maximum operating level under normal circumstances. The freeboard assessment should be revisited prior to reaching dam full of tailings to assess if the above assumptions regarding beach slopes are correct.

Figure 9: TSF Freeboard Assessment

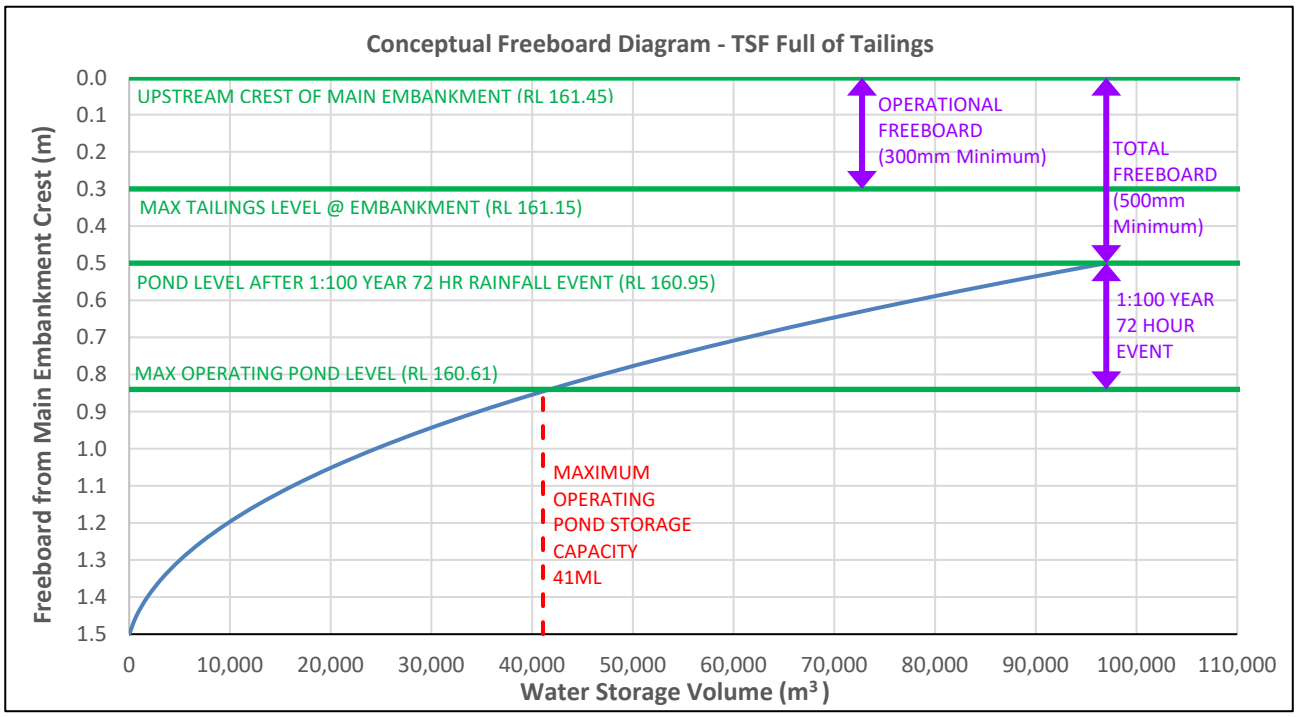
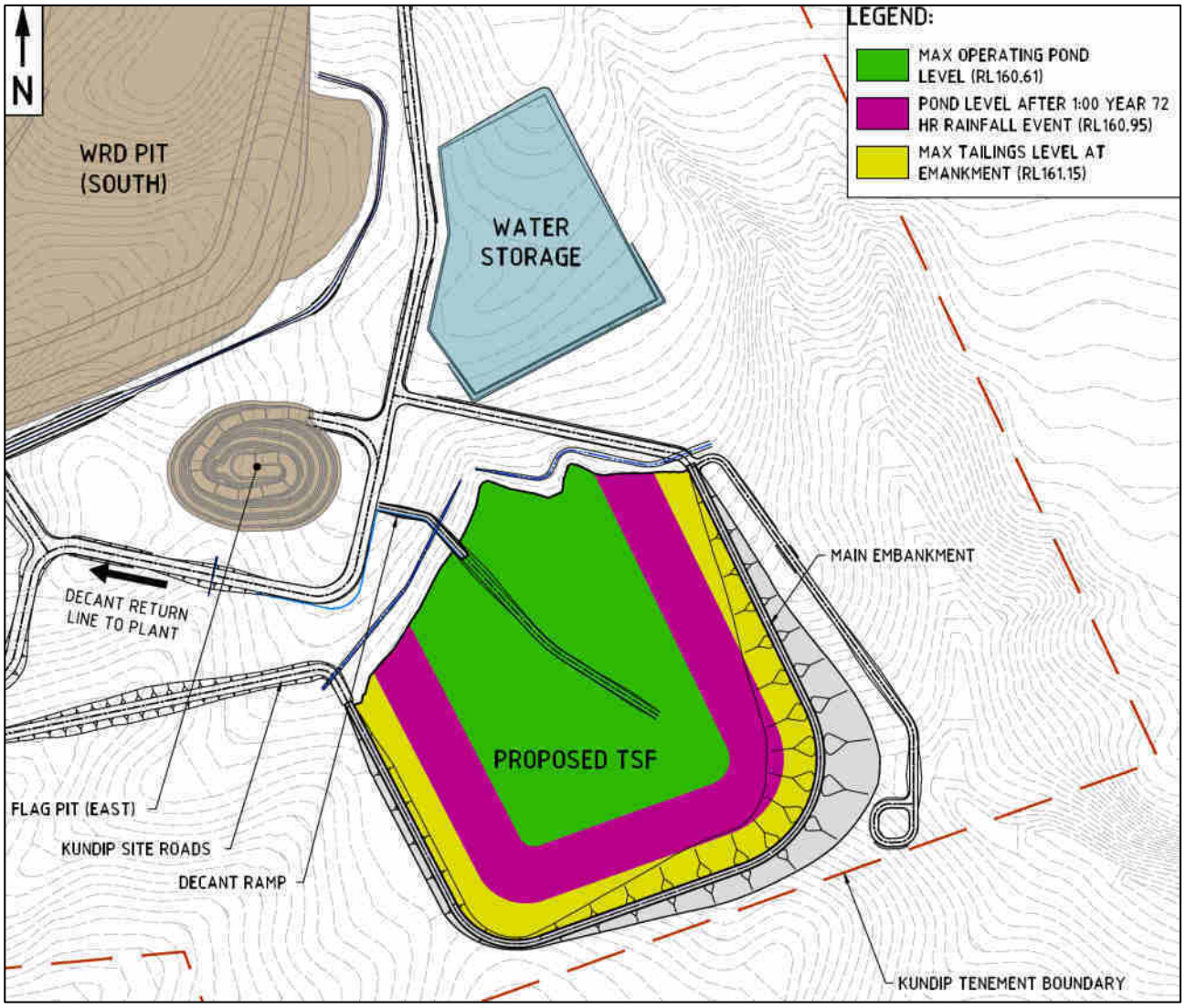


Figure 10: TSF Freeboard Limits



3.5 Design and Construction Details

3.5.1 General

Construction of the RGP TSF will be undertaken in accordance with issued for construction (IFC) drawings and earthworks specification. Furthermore, construction and operation will be in general accordance with the design intent of the final detailed design report.

This report and the drawings included in Appendix F present a FS level design of the RGP TSF which may serve as the basis for subsequent development of a detailed design report and IFC drawings.

3.5.2 Bill of Quantities

A preliminary earthwork bill of quantities (BOQ) is provided in Table 10. A more detailed BOQ will be developed during detailed design based on issued for construction (IFC) drawings.

Table 10: Preliminary bill of quantities

Item #	Item description	Quantity	Unit
1	Clear and grub TSF footprint (may be done in stages over the 10-year operational life of the facility to limit the cleared surface area to minimise dust generation and erosion). Trees cleared as part of this item to be chipped/mulched and stockpiled for later use as batter protection (ACH's dieback management plan will be implemented to ensure that any dieback affected vegetation is not utilised as woodchip cover for the embankment batters).	295,000	m^2
2	Prepare main embankment footprint - Immediately prior to construction, trimming of all loose material, ripping to a depth of 200 mm, moisture conditioned and compact as per the Earthworks Specification.	77,500	m^2
3	Place clay main embankment - Win, load, haul from within 2km of embankment and place, condition onsite and compact as per the Earthworks Specification and design profile. The construction is to allow for compaction out to the design batters and include removal of excess material to a location directed by ACH.	527,500	m^3 (CCM)
4	Install crest roads geofabric - Install geofabric for crest edge detail including supply of steel pins to secure fabric from wind uplift.	1300	m
5	Crest road - Win, load, haul, place and compact crest road gravel 200 mm thick on the embankment; includes windrow construction and supply of gravel from onsite stockpiles.	13,000	m^2
6	Guide posts - Prepare location by survey, supply and install Main Roads standard wooden guide posts with delineator (50m intervals on straights and 10m on curves <200m radius).	130	#
7	Woodchip batters - Win, load, haul and place wood chip 100 mm thick on the downstream batter slope.	34,000	m^2
8	Supply and install vibrating wire piezometers – Direct push installation with cone penetration test (CPT) rig. Includes supply and installation of cabling, data logger, and lightning protection box.	4	#
9	Install downstream monitoring bore – Depth and specifications to be determined during detailed design.	1	#
10	Prepare decant access ramp – Cut and fill as shown on the drawings.	3,000	m^3 (CCM)
11	Decant ramp road - Win, load, haul, place and compact gravel 200 mm thick on the decant access ramp; includes windrow construction and supply of gravel from onsite stockpiles.	4,550	m^2

3.6 Tailings Discharge and Water Management

3.6.1 Tailings Deposition

Tailings are expected to be delivered from the Kundip Plant at a production rate of 300,000 tonnes of solids per annum (tpa) for 10 years (base case production scenario). At times throughout the mine plan, the rate of deposition may increase as softer weathered ores are processed. The solids content (% solids) is expected to be approximately 50 %.

A tailings delivery pipeline will be routed to the crest of the embankment and connect to a single ring main with 62 discharge spigots positioned approximately 20 m apart, as shown on Figure 11.

The Kundip TSF has been designed to provide 10 years of tailings storage capacity. The proposed TSF configuration and tailings deposition methodology results in a tailings surface (beach) area of approximately 7.6 ha after 1 year of tailings deposition.

However, the incremental tailings surface (beach) area for each subsequent year is relatively small as shown on Figure 11. Initially 23 of the 62 spigots should be installed on the embankment with 4 additional spigots installed in each subsequent year up to year 6. At this point the remaining spigots should be installed.

Development (filling) of the TSF is shown graphically on Figure 12 and Figure 13 in terms of storage volume, tailings surface area and rate of rise.

Figure 11: Tailings surface (beach) development

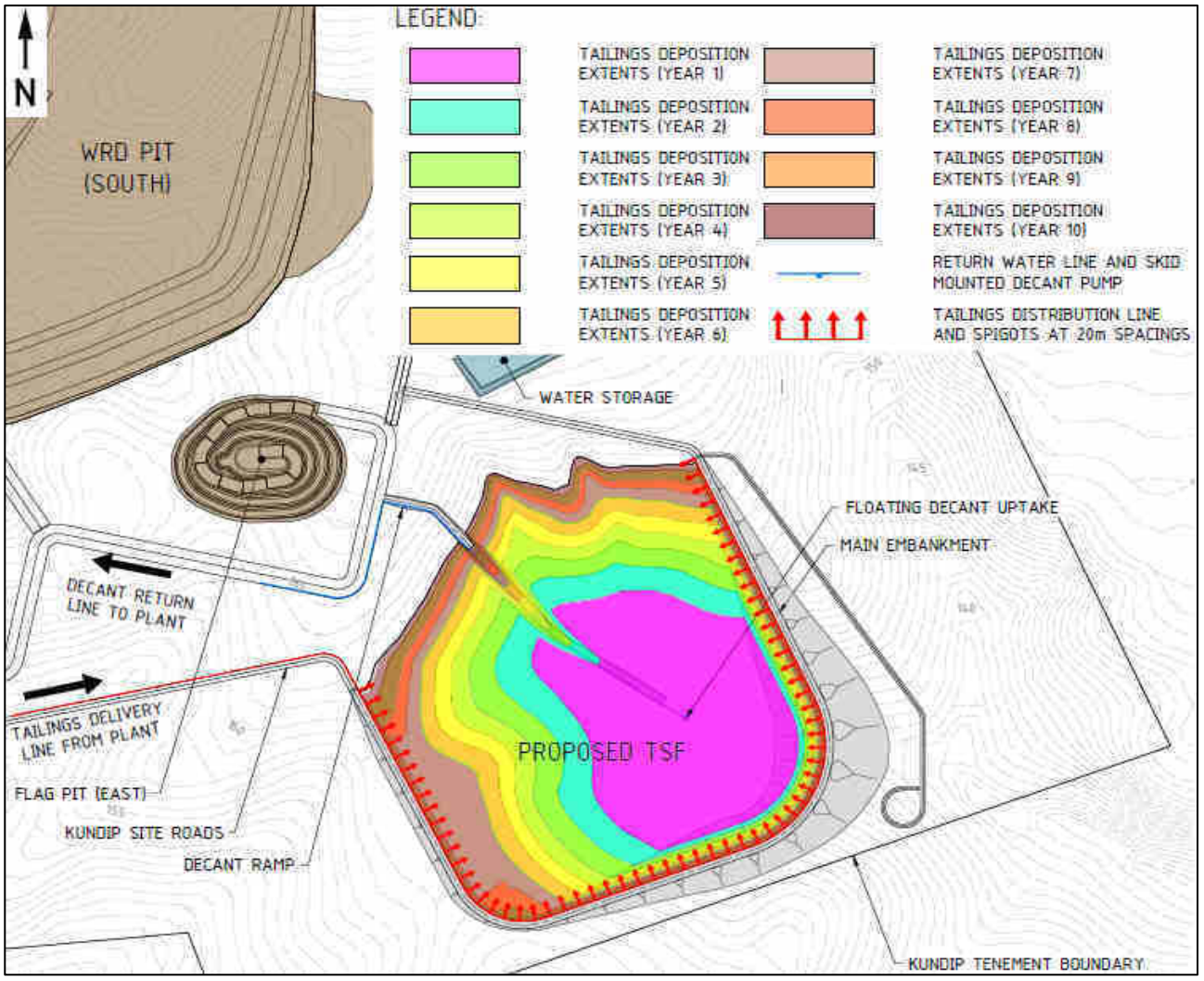


Figure 12: Tailings storage capacity curve

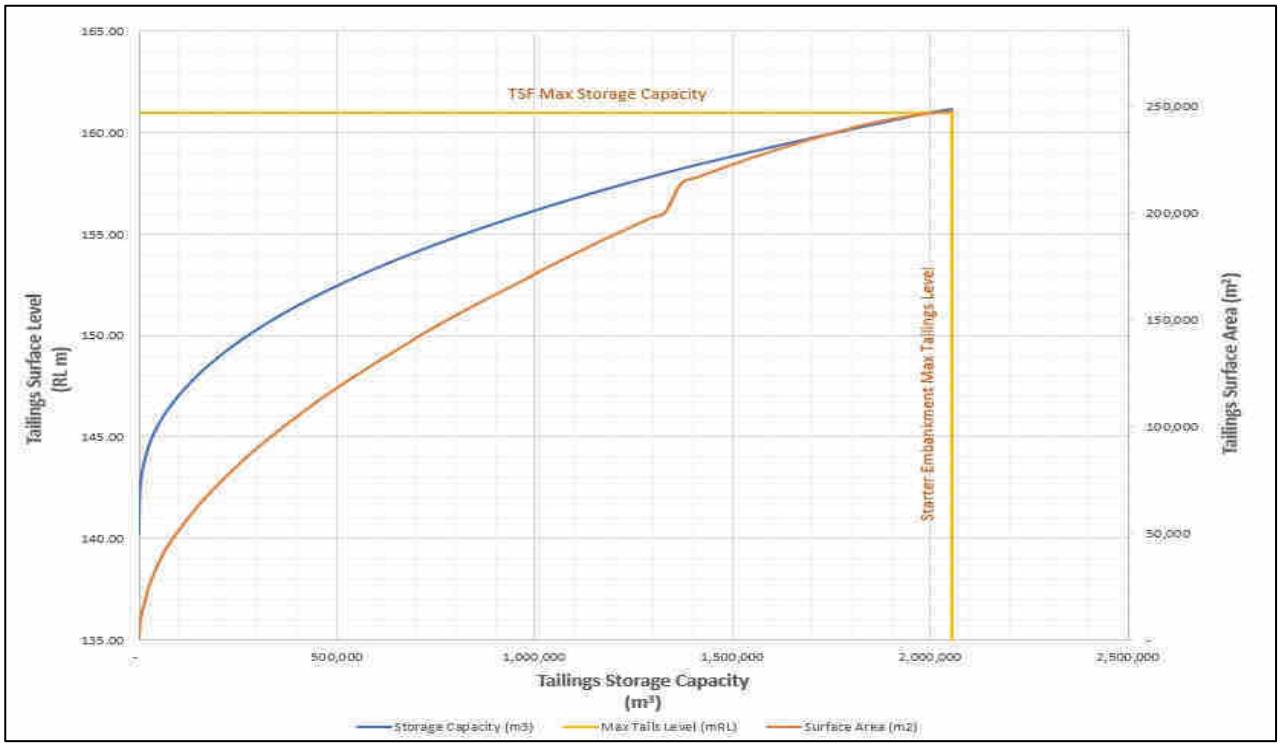
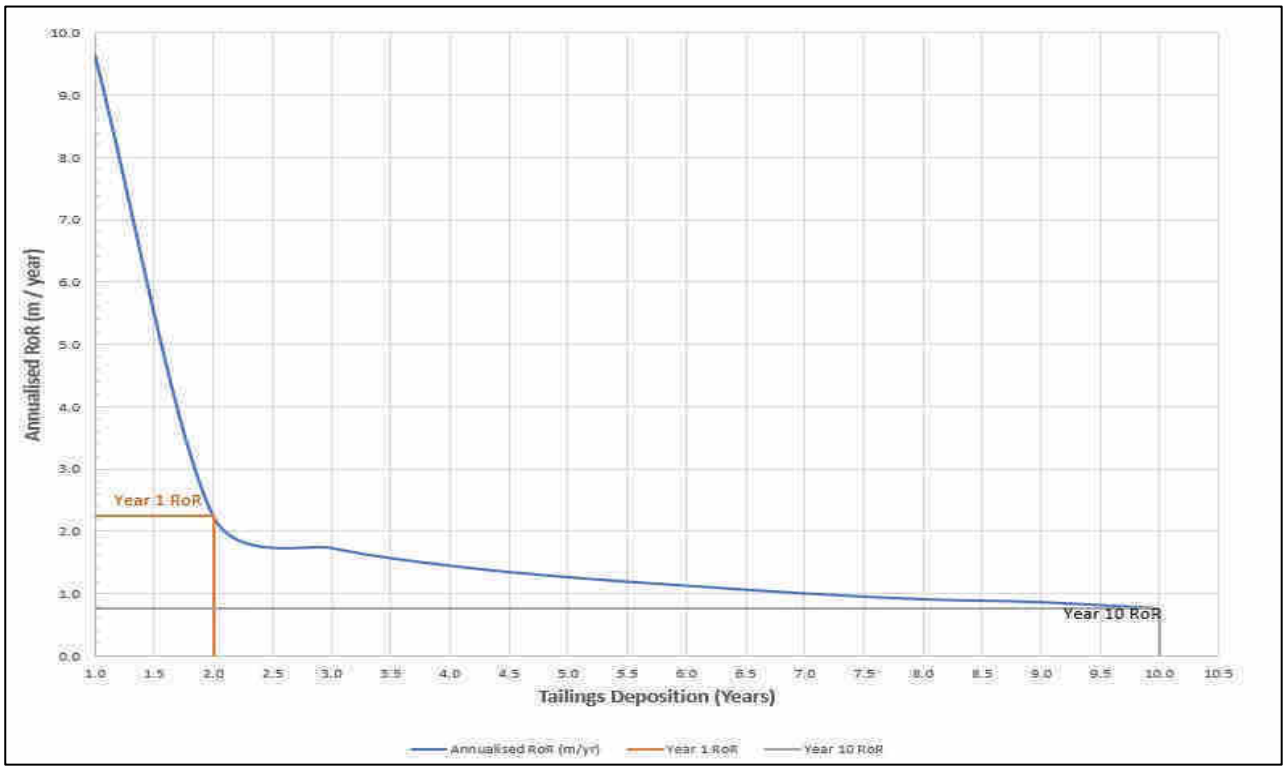


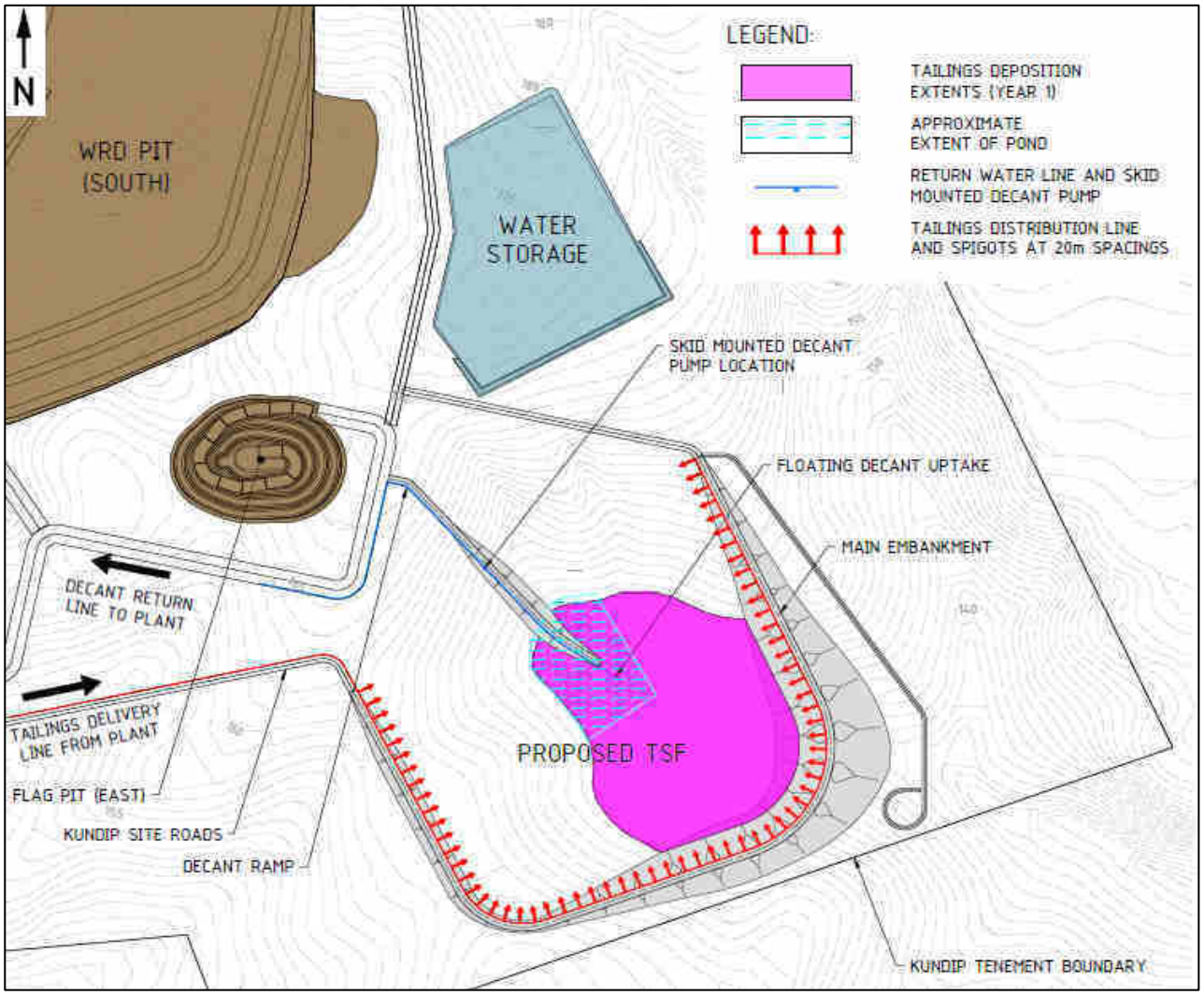
Figure 13: Tailings Rate of Rise



3.6.2 Decant Pond Management

The RGP TSF has been configured to manage the decant pond away from the embankment. Tailings discharged from the embankment will beach towards the natural surface where the decant pond will form in the north-west corner of the facility.

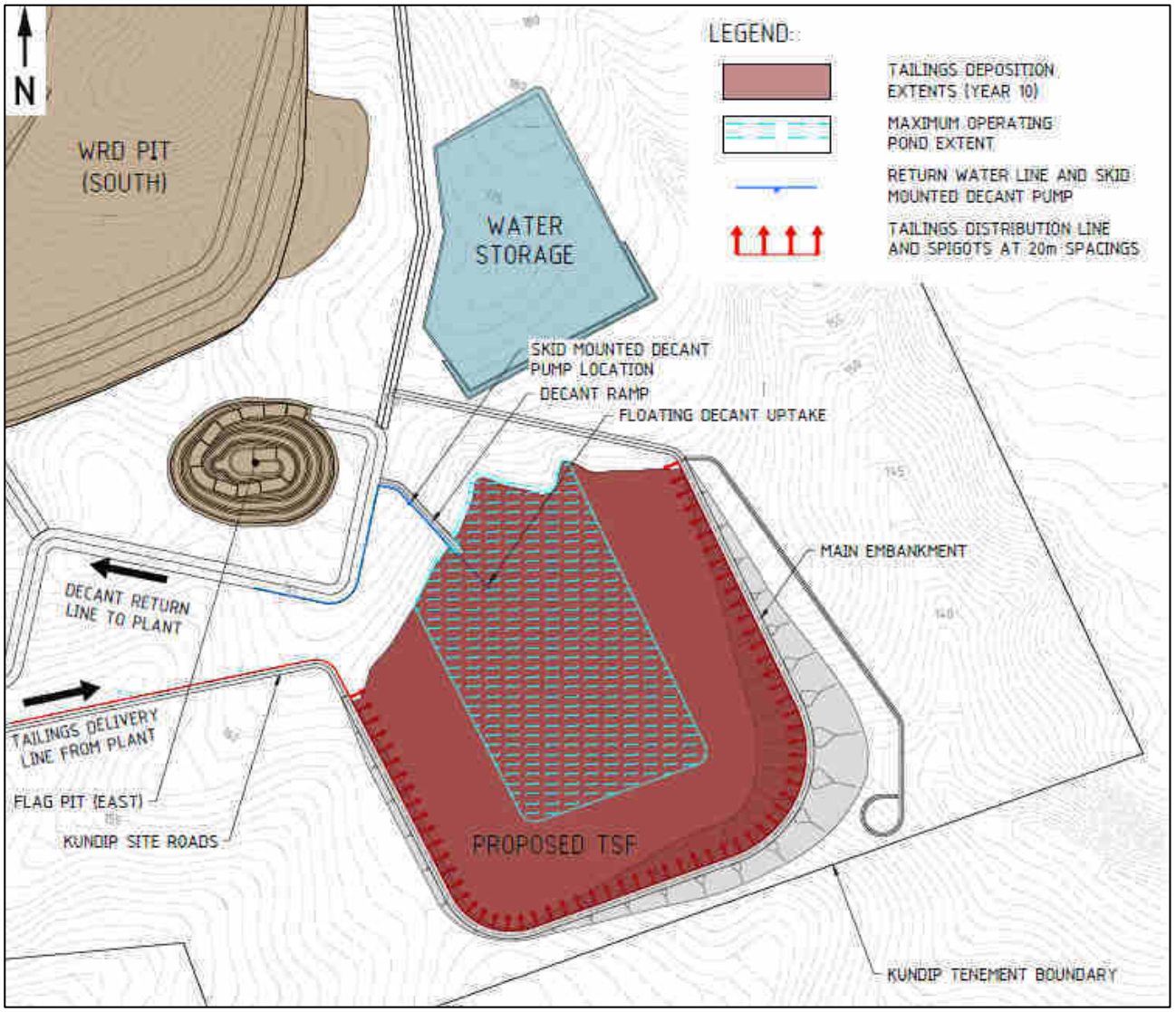
Figure 14: Decant configuration (initial pump and floating uptake location – Year 1)



A ramp will be constructed from the north-west corner towards the middle of the TSF basin. A skid-mounted pump will be located on the ramp with a floating uptake located in the pond.

As the tailings (beach) surface area continues to expand, the skid mounted pump will be relocated up the ramp to ensure that the pump does not become submerged. Pump specification and sizing are expected to be undertaken during detailed design.

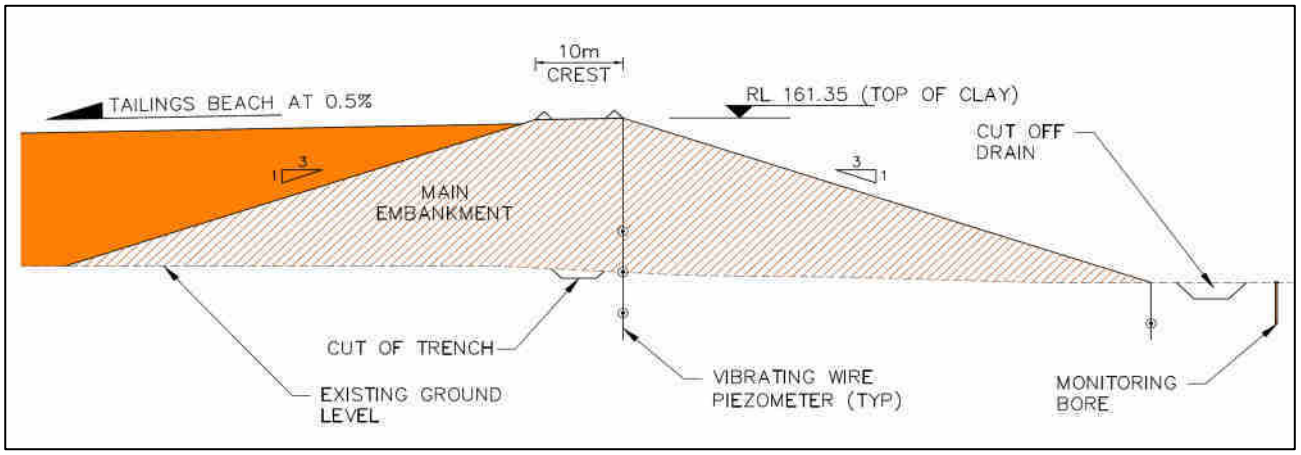
Figure 15: Progressive relocation of decant pump (pump and floating uptake location – Year 10)



3.6.3 Seepage Management

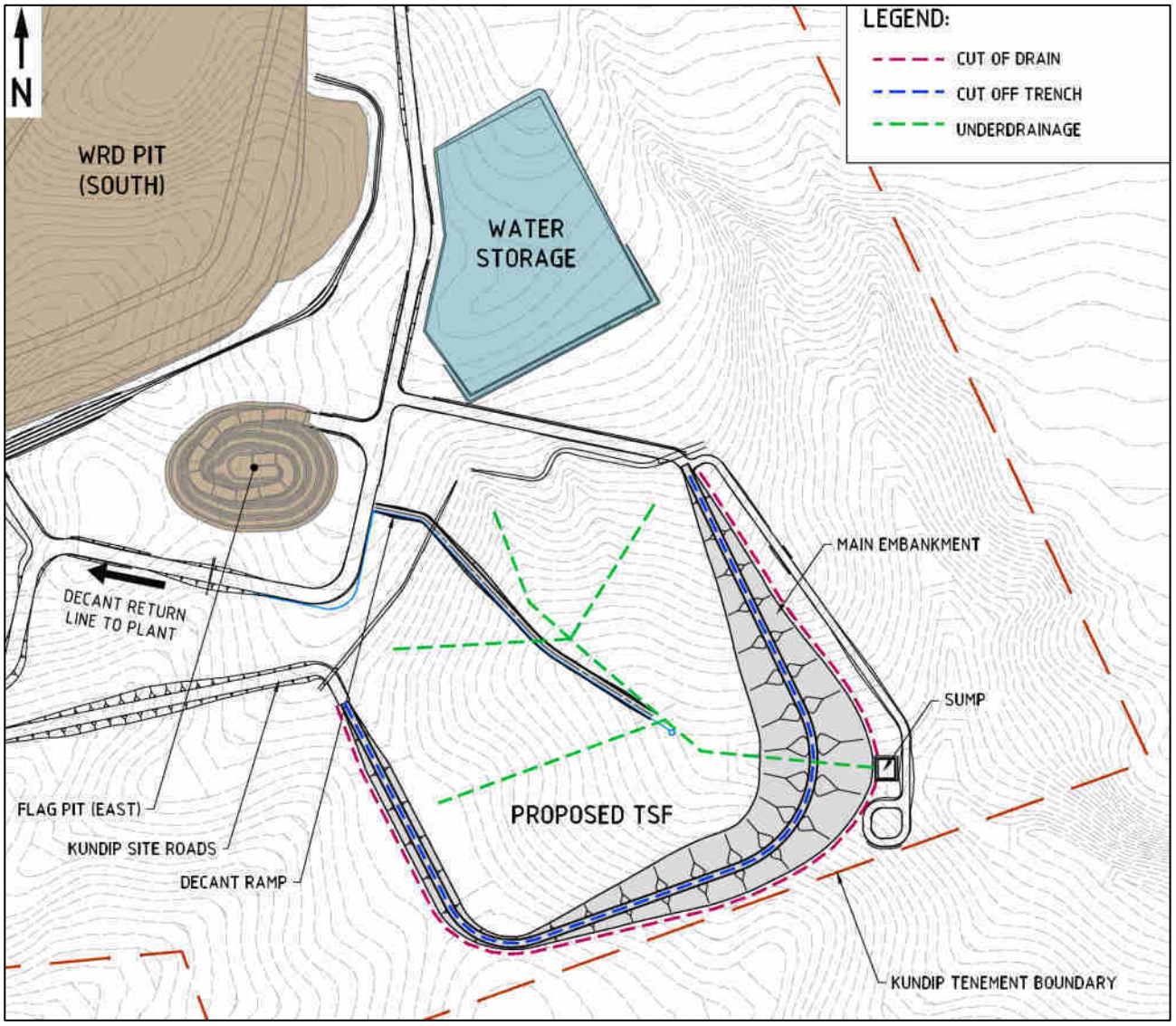
A cut-off trench and cut-off drain are proposed as part of the construction of the TSF embankment. Both the trench and the drain aim to intercept lateral seepage through and beneath the embankment. The configuration of the trench and drain relative to the embankment is shown in Figure 17.

Figure 16: Cut-off trench and cut-off drain



The floor of the TSF and foundation of the TSF embankment is expected to comprise weather siltstone or sandstone, tending to a low permeability pallid clay. This is expected to provide a low-permeability floor for the TSF. In order to efficiently collect and manage seepage, an underdrainage system and collection sump are proposed. The configuration of the system is shown in Figure 16.

Figure 17: Underdrainage and Collection Sump configuration



3.7 Covers and Liners

The Kundip TSF design does not call for a liner. However, the design has taken into consideration the low permeability of the existing subsurface material to assist in managing seepage from the TSF basin.

The proposed closure concept outlined in Section 5.0 includes the provision of a vegetation soil cover. Specification of the cover is envisaged to be undertaken during final closure planning and design.

3.8 Quality Assurance

An Earthworks Specification will be developed as part of detailed design development. The specification will include a construction quality assurance (CQA) plan and requirements for on-site third-party quality assurance (QA) monitoring. A construction completion report will be prepared by a Competent Person (typically the design engineer) following substantial completion of TSF construction; in line with the requirements of the CoP: Tailings Storage Facilities in Western Australia (DMP, 2013) and Guide to Departmental requirements for the management and closure of tailings storage facilities (TSFs) (DMP, 2015a).

3.9 Spillways

The CoP: Tailings Storage Facilities in Western Australia (DMP, 2013) states that in Western Australia, the use of spillways is not encouraged. As such, no spillway has been allowed for as part of the design.

4. Operational Requirements

4.1 General

An operating manual will be developed as part of detailed design in accordance with the DMPs Guide to Departmental requirements for the managements and closure of tailings storage facilities (TSFs) and Code of Practice (CoP): Tailings Storage Facilities in Western Australia.

4.2 Management of Tailings Deposition and Water

Tailings are to be deposited from the main embankment in a sub-areal manner in thin lifts and beaching towards the northwest corner of the facility to form a decant pond away from the main embankment. The size of the normal operating pond should be as small as practical to minimise seepage potential whilst providing sufficient depth for operation of the decant pump. The maximum normal operating pond level for a dam full (tailings) scenario which still provides capacity for the 1:100 AEP 72-hour storm event and DMP required freeboard is RL 160.51 m. The maximum normal operating pond level represents the storage of 41 ML, highlighting the robustness of the proposed TSF design arrangement to prevent overtopping. However, it is not the intent of the TSF design that such a large amount of water is stored within the facility.

4.3 Seepage Management

Seepage management is achieved by the presence of a low permeability floor, sub-areal deposition in thin lifts to promote air-drying (evaporation) and maintaining a small decant pond away from the main embankment as described in Section 4.2.

4.4 Erosion Control

Erosion mitigation features are described in Section 3.4.2. The main embankment batter, upstream and downstream should be inspected on a regular basis and following heavy rainfall events for signs of excessive erosion and repairs made accordingly. Sub areal tailings deposition on thins lifts across the entire tailings beach will ensure the tailings surface is kept sufficiently moist to prevent excessive wind erosion and dusting of the tailings surface.

4.5 Embankment Instrumentation

Monitoring instrumentation will be installed in the TSF embankment as shown in plan and section on Figure 18 and Figure 19, including;

- Vibrating wire piezometers (VWP) – to monitor the development of pore pressures (phreatic surface) within the embankment and embankment foundation for assessment of embankment stability (in line with Section 3.4.1),
- Monitoring bores w/VWP – to monitor groundwater levels immediately downstream of the facility for comparison with pore pressures (phreatic surface) measured within the embankment VWP's.

Figure 18: Embankment instrumentation (Plan)

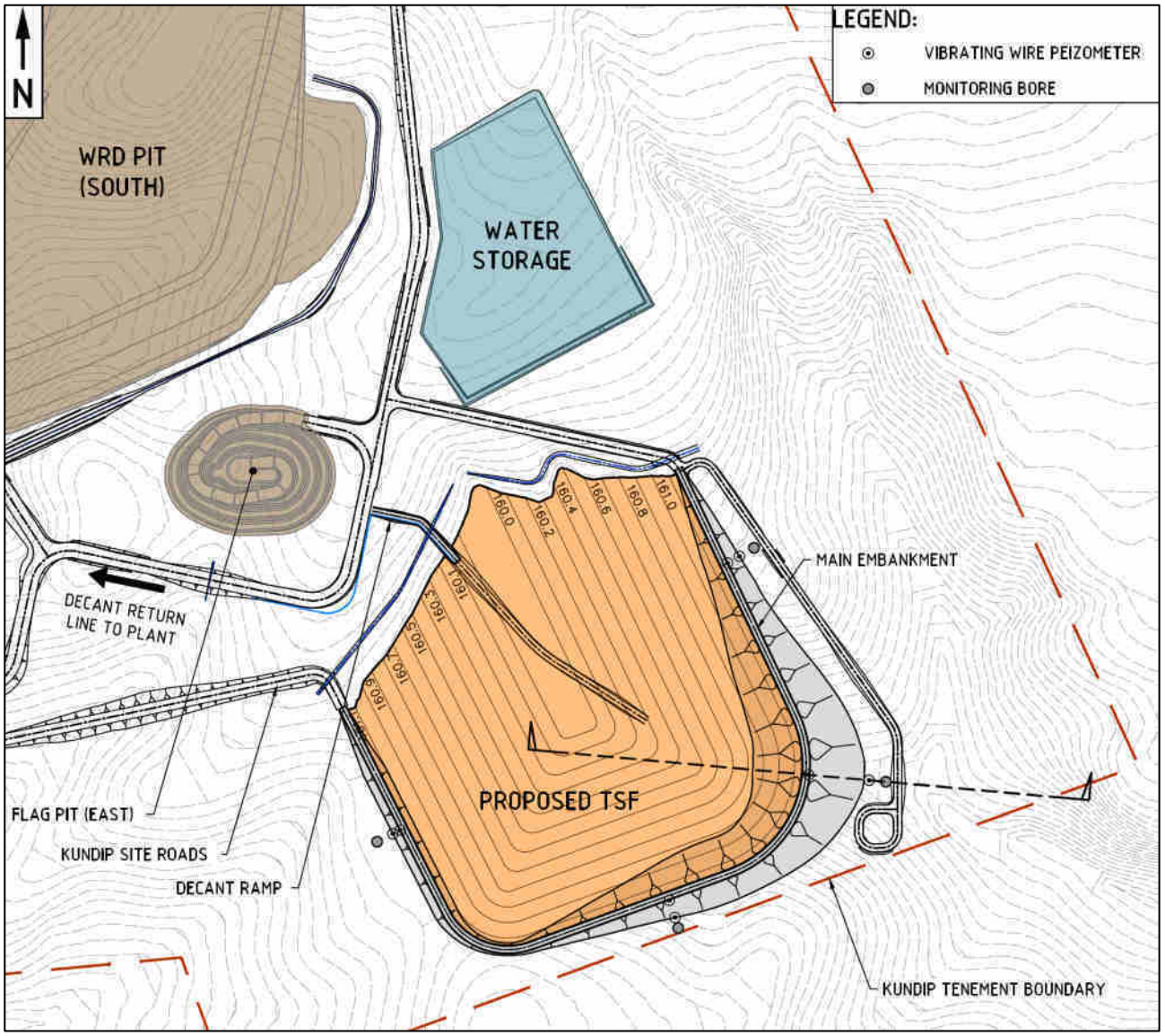
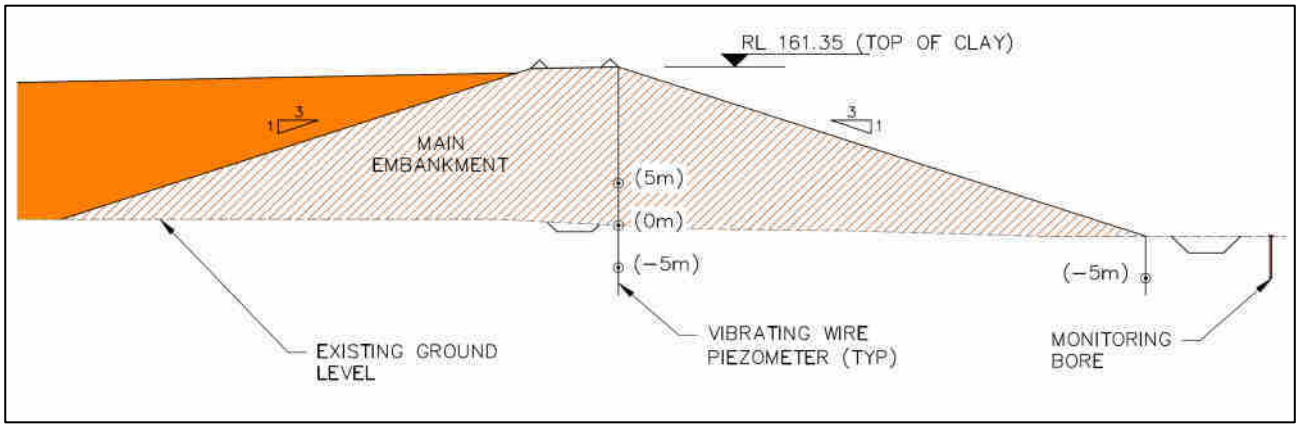


Figure 19: Embankment instrumentation



5. Closure Requirements

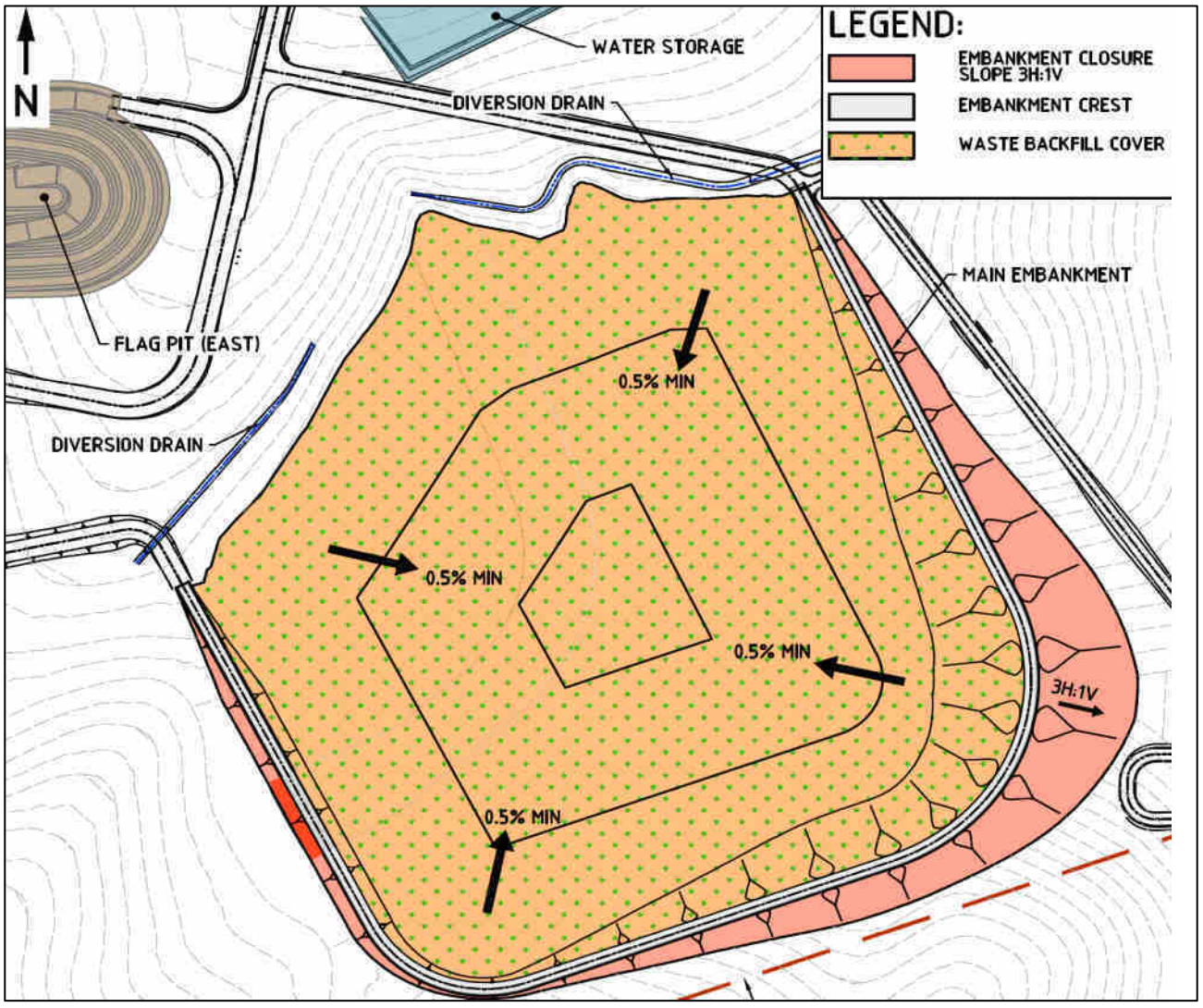
5.1 General

An RGP Closure Plan has not yet been developed. It is envisaged that a detailed closure plan will be developed at a later stage in conjunction with an RGP site wide closure plan. The proposed RGP TSF has been developed with closure in mind, taking into consideration;

- The DMP's principal closure objectives for rehabilitated mines - Guidelines for Preparing Mine Closure Plans (DMP, 2015b);
    - (physically) safe to humans and animals,
    - (geo-technically) stable,
    - (geo-chemically) non-polluting/non-contaminating, and
    - capable of sustaining an agreed post-mining land use.
- The Environmental Protection Authority's (EPA) objective for Rehabilitation and Decommissioning to ensure that premises are decommissioned and rehabilitated in an ecologically sustainable manner.

The proposed closure concept for the RGP TSF is shown on Figure 20.

Figure 20: RGP TSF closure concept



The closure concept utilises the tailings beach formed during deposition and the natural topography to divert surface water away from the highest part of the embankment. Surface water from the upstream catchment will be diverted away from the TSF by means of diversion drains. The tailings surface will be shaped to direct incidental rainfall to the centre of the TSF. The downstream embankment batter at 1V:3H will serve as a final closure surface.

5.2 Decommissioning

Once the TSF has reached capacity and no further deposition is to occur, the tailings delivery line and distribution system will be removed from the main embankment. The decant system may remain in place or on standby until the tailings surface cover has been installed; to provide an interim means of surface water removal. Further detail around decommissioning of the TSF should be coordinated with the project-wide decommissioning and closure plan.

5.3 Tailings Surface Cover

The tailings surface will be covered with waste and topsoil to provide long term containment and erosion protection of the tailings, as well as providing a suitable medium for re-establishment and sustenance of vegetation. The cover will be 2.0 m in thickness (minimum) depending on the location of the tailings surface and estimated surface water flow velocities. The tailings surface cover will make use of the tailings beach slope and grade towards the centre of the facility.

5.4 Diversion Drains

Diversion drains will be constructed in the general area shown on Figure 18. The drains will allow for controlled discharge of surface water collecting within the upstream TSF catchment. The drains will discharge away from the embankment, providing protection from erosion.

5.5 Rehabilitation

A rehabilitation plan will be developed at a later stage in conjunction with an RGP site wide closure plan. Rehabilitation should involve respreading collected topsoil on the downstream slopes of the final embankments and on top of the capping layer. Topsoil surfaces may require ripping and seeding with native species in order to promote revegetation, and consequently blend the TSF into the natural landscape and promote evapotranspiration.

It's important that batter slopes function as erosion resistant water shedding structures. Rocky mantle scree of competent oversize material (+10 mm to > 1 tonne) should be spread on the downstream batter surfaces with a thin layer of topsoil mixed in between the particles to promote revegetation.

The outer slopes should have no berms, banks, moonscapes or rip lines as these pond water which inevitably result in piping failure or off-contour rip line breakout gullying.

5.6 Performance Monitoring against Closure Criteria

Closure criteria and a post closure monitoring plan will be developed at a later stage in conjunction with an RGP site wide closure plan.

6. References

1. ANCOLD 2012, Australian National Committee on Large Dams: Guidelines on Planning, Design, Construction, Operation and Closure of Tailings Dams
2. BoM 2016/17, Bureau of Meteorology Website
3. DMP 2013, Code of Practice (CoP): Tailings Storage Facilities in Western Australia
4. DMP 2015a, Guide to Departmental requirements for the management and closure of tailings storage facilities (TSFs)
5. DMP 2015b, Guidelines for Preparing Mine Closure Plans
6. DMP 2015c, Guide to the preparation of a design report for tailings storage facilities (TSFs)
7. Geoscience Australia 2012, The 2012 Australian Earthquake Hazard Map
8. Golder 2016, Concept Design for Waste Landform and Tailings Storage Facility Kundip Gold Project
9. Golder 2017, Updated Concept Design for Tailings Storage Facility at ACH Global Ravensthorpe Gold/Copper Project
10. GCA 2011, Phillips River Project: Geochemical Characterisation of Tailings-Slurry Samples (Trilogy Deposit) - Implications for Process-Tailings Management (DRAFT)
11. Tectonic 2011, Phillips River Project Definitive Feasibility Study

7. Limitations

Resource Engineering Consultants Pty Ltd (REC) has prepared this feasibility study (FS) level design of the Kundip Mine Site tailings storage facility (TSF) at the ACH Mineral's Ltd (ACH) Ravensthorpe Gold Project (RGP) to support the overall project Feasibility Study into the technical and commercial viability of RGP. This report is provided for the exclusive use of ACH Minerals Pty Ltd and their consultants for this project only and for the purposes as described in the report. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of REC, does so entirely at its own risk and without recourse to REC for any loss or damage. In preparing this report REC has necessarily relied upon information provided by the client and/or their agents.

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Any such risk assessment would, however, be necessarily restricted to the geotechnical components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Appendix A

Geotechnical Field Investigation Report
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MHA GEOTECHNICAL

Geotechnical Site Investigation Tailings Storage Facility

Ravensthorpe Gold Project

ACH Minerals Pty Ltd

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Report

Title:	Geotechnical Site Investigation
File:	P02-17-RF
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Client:	ACH Minerals Pty Ltd
Contact:	Paul Bennett
Synopsis:	This document details the findings of a geotechnical site investigation pertaining to the proposed Tailings Storage Facility at ACH Minerals' Ravensthorpe Gold Operation.

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Abbreviations

AHD	Australian Height Datum
CBR	California Bearing Ratio
DCP	Dynamic Cone Penetrometer
HDPE	High Density Polyethylene
MDD	Maximum Dry Density
OMC	Optimum Moisture Content
QA/QC	Quality Assurance/Quality Control
PI	Plasticity Index
PSD	Particle Size Distribution
SP	Poorly graded sand (USCS)
UU	Undrained Unconsolidated
USCS	The Unified Soil Classification System

d	day
ha	hectare
hr	hour
km	kilometre
m	metre
mm	millimetre
min	minute
yr	year
s	second
t	ton

Executive Summary

Background

MHA Geotechnical (MHA) has prepared this Geotechnical Report as part of a Feasibility Study (FS) level design of the Kundip Mine Site tailings storage facility (TSF) at ACH's Ravensthorpe Gold Project (RGP), to support the overall project Feasibility Study into the technical and commercial viability of RGP. A geotechnical investigation of the proposed site was carried out by MHA Geotechnical (MHA) between the 17th and 23rd of November 2017.

The work has been undertaken at the request of Paul Bennett (Managing Director – ACH Minerals).

The purpose of the geotechnical investigation was to:

- Develop ground profiles for the TSF location,
- Determine the geotechnical properties for foundation and borrow materials,
- Provide comment on the suitability of the site for the proposed development.

The general sub-surface profile is consistent across the site, except for variation in the thickness of alluvial surficial cover and depth to competent bedrock. The sub-surface profile is summarised below:

- The regolith is comprised of a sandy to silty alluvial detrital sediment, with a consistent weathered profile. The horizon was dominantly alluvial and comprised an unconsolidated grey to brown, silty SAND with gravel to sandy SILT with gravel, with roots and organic matter;
- Inconsistently, across the TSF site, immediately underlying the top soil horizon, a transition material comprising a sandy to silty GRAVEL, more consolidated pale brown to white, gravelly horizon. This horizon was locally cemented and diagenetically altered;
- A red brown soil horizon underlies the transition material and where this transition phase was not present, the red brown silty clay layer was present immediately below the top soil. This layer was consistently observed to be indurated and gravelly, with local instances showing a lateritic and conglomeritic texture. This unit was excavated as rock and had been diagenetically altered;
- The material found at the base of all the test pit locations was described as a white, sometimes grey to mottled red, sandy SILTSTONE.

TSF Assessment

Detailed geotechnical analysis of the TSF footprint and materials identified for construction have been performed using data obtained from the site investigation and succeeding lab tests. The foundation and embankment conditions and soil types have been determined from the test pit logs with additional data derived from laboratory testing and previous investigations.

Borrow Material Assessment

An assessment of the borrow material has been undertaken to assess the suitability of both the in-situ and proposed borrow material for construction of the TSF. This includes an assessment of the subsurface conditions and the suitability of blended in-situ and borrow material for embankment construction.

1. Introduction

This report presents the findings of a geotechnical site investigation of the proposed Tailings Storage Facility (TSF) and assessment of proposed construction borrow material. The investigation forms part of a Feasibility Study (FS) level design of the Kundip Mine Site tailings storage facility (TSF) at ACH's Ravensthorpe Gold Project (RGP), to support the overall project Feasibility Study into the technical and commercial viability of RGP, located approximately 25 km by road south-east of the town of Ravensthorpe, Western Australia.

The investigation was carried out by MHA Geotechnical (MHA) between the 17th and 23rd of November 2017. The work has been undertaken at the request of Mr. Paul Bennet (Managing Director – ACH Minerals).

The purpose of the geotechnical investigation was to:

- Develop ground profiles for the TSF location,
- Determine the geotechnical properties for foundation and borrow materials,
- Provide comment on the suitability of the site for the proposed development.

The proposed TSF footprint and test locations are shown on **Figure 1**.

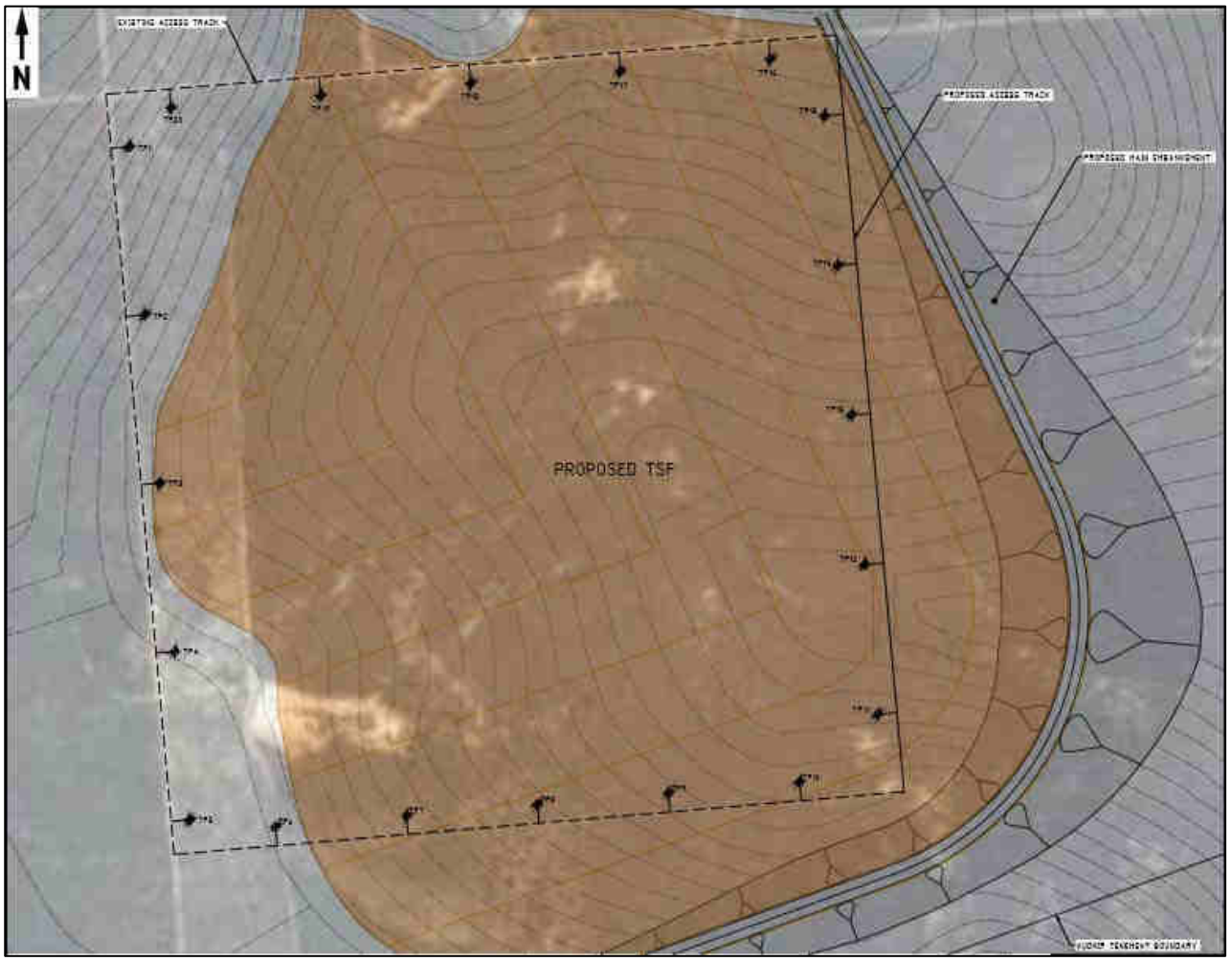

Figure 1 Proposed TSF footprint with associated Test Pit locations.

This report details the results of the geotechnical investigation (test pits, in situ testing, and laboratory test results) that have been carried out at the proposed TSF location. Descriptions of in situ ground conditions are presented, together with interpretation of founding conditions for the TSF and associated structures.

Interpretations, site conditions and design parameters in this report are based on in-situ testing, test pit excavations and laboratory test results from recovered samples, in addition to information gathered as part of previous site investigations.

2. Site Characteristics

2.1 Site location

The Ravensthorpe Gold Project (RGP) is hosted within the north-west trending Archaean Ravensthorpe Greenstone Belt. Nelson (1995) and Savage et al. (1995) have constrained the age of the greenstone belt in this area to 2950-3000 Ma.

2.2 Regional Geology

There are three regional geological units in the area:

- Yilgarn Craton (Archaean) to the north comprising granitoid, granitic gneiss and migmatitic rocks with some greenstone rafts, overlain to the south by;
- Mount Barren Group (Proterozoic) comprising metasedimentary rocks of shale, arenite, dolostone and intruded gabbro-diorite sills; and
- The southeast portion of the region is occupied by Munglinup Gneiss (Proterozoic), which forms part of the Biranup Complex.

The northeast trending Jerdacuttup Fault separates the Munglinup Gneiss from both the Mount Barren Group and the Archaean granite-greenstone terrane. Tertiary sediments of the Plantagenet Group in turn unconformably overlie all Precambrian tectonic units.

2.3 Local Geology

The Kundip mining area lies in a region of steeply-dipping mafic to intermediate volcanic rocks of Archaean age (Annabelle Volcanics) (Witt, 1997). The volcanic rocks have been intruded to the west by granitic rocks, also of Archaean age. The upper reaches of the Steere River follow the contact between the granitic and the volcanic rocks.

Immediately south of the Kundip mining area, the Archaean rocks are overlain by the Proterozoic Mount Barren Group, including sediments of the Kundip Quartzite and the Kybulup Schist. The quartzite dips at about 15 degrees to the south-south-west.

2.4 Typical TSF Regolith Profile

A geotechnical site investigation was carried out by MHA between the 17th and 23rd of November 2017. The purpose of the geotechnical investigation was to:

- Develop ground profiles for the TSF location,
- Determine the geotechnical properties for foundation and borrow materials,
- Provide comment on the suitability of the site for the proposed development.

The typical regolith profile at the TSF site comprises a surficial cover of an unconsolidated sandy silt TOPSOIL underlain by sandy gravelly SILT, underlain by SILTSTONE.

The material encountered can be broadly summarised as:

- 0 m – 0.2 m: SILT; sandy, gravelly TOPSOIL with roots and organic matter;
- 0.2 m – 0.6 m: SILT; red brown, sandy with gravel (transitional zone);
- 0.6 m – 1.0 m: SILTSTONE; red brown, conglomeritic;
- 1.0 m – 3.0 m: SILTSTONE, white sandy/gravelly (considered competent bedrock)

2.5 Seismic Assessment

A seismic hazard assessment of the project site was carried out by MHA to determine design ground acceleration for the RGO area.

The seismic hazard risk assessment contained in GA (2012) is used to quantify the seismic setting for the site. This is a relatively recent and detailed assessment and provides peak ground accelerations (PGAs) for earthquakes of return period 500 years and greater (c.f. the project Operating Basis Earthquake (OBE) and Maximum Design Earthquake (MDE) return periods of 50 years and 100 years respectively). As such its use is conservative but it directly relates to PGAs of interest to the design of earth structures as opposed to use of AS1170.4 Structural design actions – Earthquake actions in Australia that is strictly only applicable to steel, concrete and timber structures.

The PGA is estimated to be 0.06g for the project.

Mining induced ground motion, such as blast induced shaking, is expected to result in relatively minor PGA and for very short durations (cycles). A blast risk assessment will be covered as part of the detailed design process if required.

3. Geotechnical Investigation

3.1 Introduction

A site investigation was undertaken between 17th and 23rd of November 2017. The investigations aimed to assess the ground conditions and evaluate the suitability of the in-situ and borrow material for construction of the proposed TSF.

3.2 Scope of Work

The field work for the investigation comprised:

- Excavation of 20 test pits broadly tracing the internal embankment of the proposed TSF design footprint (arranged in a square configuration with 5 test pits on each side);
- Dynamic Cone Penetrometer testing alongside each test pit location to a maximum depth of 3.0 m.
- Cone Penetrometer Testing (CPT) at 7 locations;
- Dissipation Testing at 4 specified locations;
- Falling head permeability tests at 6 locations;
- Recovery of disturbed soil samples for laboratory testing.

Fieldwork was carried out by two experienced senior geotechnical engineers. The test pit locations were set out using a hand-held Global Positioning (GPS) instrument and were based on the proposed layout of the TSF. No additional tracks cleared throughout the investigation site due to clearing and access restrictions.

The geotechnical fieldwork was undertaken in accordance with the guidelines presented in AS1726-1993, Geotechnical Site Investigations (Ref. 3) and samples were collected for laboratory testing.

3.3 Test Pitting

A total of twenty (20) test pits were excavated across the proposed TSF investigation area using a backhoe excavator to depths of up to 3.1 m. All test pits were logged and photographed by the investigating engineers and samples were collected from selected horizons in each pit for laboratory testing. All the test pits were backfilled with excavated soil on completion of sampling.

A summary of the test pitting is presented in Table 1.

Table 1: Summary of Test Pits

Site	Test Pits	No. of Pits	Max Depth (m)
TSF North track	16, 17, 18, 19 & 20	5	2.8
TSF East track	11, 12, 13, 14 & 15	5	2.8
TSF South track	6, 7, 8, 9 & 10	5	2.9
TSF West track	1, 2, 3, 4 & 5	5	3.1

Logs, photographs and the locations of the test pits are presented in Appendix B. The proposed test pit locations are shown in **Figure 1**.

3.4 Field Permeability Testing

Field permeability tests were conducted in 6 auger boreholes adjacent to selected Test Pits in order to estimate the permeability of the surficial ground profile across the project site. A summary of these tests and their locations are presented below in Table 2.

Table 2: Summary of Field Permeability Tests

Test No.	Test Depth (m)	Target Material	Reason for Termination
TP 3	0.6	SILTSTONE	Target Depth
TP 7	0.4	SILTSTONE	Target Depth
TP 12	0.6	SILTSTONE	Target Depth
TP 13	0.7	SILTSTONE	Target Depth
TP 16/17	0.8	SILTSTONE	Target Depth
TP 19	0.6	SILTSTONE	Target Depth

The detailed calculations for the permeability tests are presented in Appendix C

3.5 Cone Penetrometer Testing

Both Cone Penetration Tests (CPT) and Piezocone Tests (CPTU) were conducted across the site to characterise the sub-surface ground profile and estimate in-situ permeability of target materials. A summary of these tests and their locations are presented below.

3.5.1 Electric Friction Cone Penetrometer Testing

A total of seven (7) Electric Friction Cone Penetrometer Tests (CPTs) were conducted at selected Test Pit locations in order to characterise the sub-surface profile across the site. A summary of the tests conducted is presented in Table 3.

Table 3: Summary of CPTs

Site	EFCPT No.	Maximum Termination Depth (m)	Reason for Termination
TSF South track	CPT6	1.24	Refusal
TSF South track	CPT7	2.37	Refusal
TSF East track	CPT12	2.28	Refusal
TSF East track	CPT12 B	1.68	Refusal
TSF East track	CPT13	2.82	Refusal
TSF East track	CPT14	2.24	Refusal
TSF North track	CPT17	3.04	Refusal

Logs for the CPTs are presented in Appendix D. Test numbers correlate to Test Pit numbers.

3.5.2 CPTU – Dissipation Testing

Based on the results of the EFCPT, a total of 4 Piezocone (CPTU) tests were conducted to target specific material types identified. Stop pause dissipation testing was conducted within each target material to assess the in-situ permeability of the target materials. The piezocone tests conducted are summarised in Table 4.

Table 4: Summary of Piezocone Tests

CPTU No.	Target Depth (m)	Target Material	Test Duration (hrs)
CPTU 12	2.3	SILTSTONE	20.6
CPTU 14	4.3	SILTSTONE	14
CPTU 7/8A	2.4	SILTSTONE	0.1
CPTU 7/8B	2.4	SILTSTONE	14.8

Logs for the CPTU and the dissipation test results are presented in Appendix D. Test numbers correlate to Test Pit numbers.

3.6 Laboratory Testing

Laboratory testing was carried out on borrow material and selected disturbed samples recovered from test pits, in order to characterise the in-situ and borrow materials for design and construction purposes. The testing was carried out by a NATA accredited laboratory in accordance with Australian Standards and comprised the following:

- Particle Size Distribution;
- Specific Gravity;
- Atterberg Limits;
- Compaction Testing (Standard and Modified Compactive Effort);
- Multi Stage Unconsolidated Undrained Triaxial Testing;
- Single Stage Consolidated UndrainedTriaxial Testing
- Crumb Test; and
- Pinhole Dispersion test (95% and 98% MMDD).

A summary of the average laboratory test results for each material type is presented below in Table 5. Details of the samples selected for testing, the laboratory test schedule and results are presented in Appendix E.

Table 5: Summary of Laboratory Test Data for Materials Encountered

Material Location	Typical Depth to Base	PSD			Physical Parameters			
		Fines (<75 µm)	Sand (>75 µm)	Gravel (>2mm)	Maximum Dry Density	Optimum Moisture Content	Emmerson Class	Plasticity Index
	m	%	%	%	%	%	No.	%
Alluvial Cover – Sandy SILT	0.6	49.0	32.0	19.0	1.9	13.0	2.3	16.5
Bedrock - SILTSTONE	>3.0	43.0	37.0	20.0	1.8	15.0	4.0	9.0
Borrow Material - STOCKPILED	NA	-	-	-	1.7	14	6	NP

*NP denotes Not Plastic.

4. Sub-surface Ground Conditions

4.1 Introduction

The sub-surface ground conditions described below are based on the findings of the geotechnical investigations performed along the 4 access tracks which broadly trace the interior of the proposed TSF footprint.

4.2 TSF Footprint

A total of twenty (20) test pits were excavated within the vicinity of the TSF footprint. These were located along the interior of the proposed TSF embankments.

The general sub-surface profile is consistent across the site, with only local variation in the degree of cementation and percentage of sand and gravel contained within the soil layers. The upper most layer is composed entirely of a sandy, silty, organic soil, which typically comprises the top 0.2m. Beneath the surface topsoil, is a layer of alluvium which is spatially inconsistent nature; this is likely related to influence of sub-surface ground waters and the resultant weathering.

Where this horizon is present, it typically extends from 0.2 m – 0.6 m and gradually transitions into the more diagenetically altered siltstone below. The transitional alluvial cover consists of medium dense to dense sandy SILT with gravel underlain by a sandy SILT with local cementation and gravel.

The typical sub-surface profile beneath the TSF Site is summarised in Table 6.

Table 6: Summary of Typical Sub-Surface Profile at TSF Site

Location	Description
GL – 0.2 m	Sandy SILT [ML], soft, non-plastic, brown-grey with gravel, dry, contains roots and organics.
0.2 m – 0.6 m	Sandy SILT [ML], soft, non-plastic, pale-brown with gravel, dry, transition phase between topsoil and red-brown horizon. Loose and unconsolidated material.
0.6 m – 1.2 m	Sandy SILT [ML], stiff, non-plastic, red-brown with gravel, dry, locally very conglomeritic with occasional lateritic texture.
1.2 m – 3. 0m	Sandy SILT [ML], stiff, non-plastic, white-grey, mottled red, dry, contains quartz cobbles (excavated as rock - SILTSTONE).

5. Borrow Material Assessment

5.1 Introduction

Borrow material for the construction of the embankments has been identified as material from within the footprint of the TSF and stockpiled material from adjacent open pits. For the purpose of the assessment and in order to estimate the shear strength parameters of the borrow material, the following assumptions have been made;

- The same borrow material will be available from these stockpiles, in sufficient volumes for construction of the embankments;
- The material selected for borrow retains similar cohesion, permeability and shrink / swell properties across the pits;
- Prior to being used as a construction material, the material will be worked as needed to conform to specifications for embankment fill.

5.2 Borrow Materials

Based on the results of the laboratory test work, the embankment material is likely to comprise low plasticity clay with silt, sand and gravel, and is likely to encompass the following material types in Table 7 under the Unified Soil Classification System (USCS).

Table 7 presents expected values for maximum unit wet density, effective stress cohesion and friction angle for these materials after Hunt (1986). Design density and strength values adopted for the embankment material are also presented.

Table 7: Embankment Material Geotechnical Parameters

USCS	Description	Maximum Wet Density (σ)	Saturated Effective Cohesion (c')	Effective Stress Friction Angle (ϕ')
		kN/m³	kPa	degrees
SM-SC	Sand-silt clay mix with slightly plastic fines	19.9 – 22.7	14	33
SC	Clayey sand, poorly graded sand-clay mix	19.6 – 21.8	11	31
ML	Inorganic silts and clayey silts	18.5 – 21.2	9	32
ML-CL	Mixture of inorganic silt and clay	19.2 – 21.1	22	32
CL	Inorganic clays of low to medium plasticity	18.5 – 21.1	13	28
DESIGN	Embankment Material	21.0	10	30

6. TSF Foundation Assessment

6.1 Introduction

An analysis of the TSF location has been performed using data obtained from the site investigation. The foundation conditions and soil types have been determined from the in-situ testing and laboratory testing.

For each soil type, compressibility characteristics were determined according to a combination of the following:

- Soil description;
- Cone Penetrometer Tests;
- Dynamic Cone Penetrometer Tests (DCP's), and;
- Laboratory data.

Stability analyses were carried out, based on the soil compressibility characteristics within the profile. The results of these analyses are presented in the following sections.

6.2 Soil Characterisation

For the purpose of constructing a model considered representative of the project site, the sub-surface profile was characterised in terms of composition by means of physical inspection, laboratory test results and CPT results. Visual inspections combined with the results of specific laboratory tests aided in refining the sub-surface ground profile according to description, however CPT results were used to further characterise the sub-surface profile based on mechanical characteristics by accurately measuring in-situ parameters.

The CPT can provide estimates as to the mechanical characteristics (strength, stiffness, compressibility) of the soil and the soil behaviour type (SBT). CPT data provides a repeatable index of the aggregate behaviour of the in-situ soil in the immediate area of the probe. Hence, a prediction of soil type based on CPT is referred to as Soil Behaviour Type (SBT).

6.2.1 CPT Soil Behaviour Type

The most commonly used CPT Soil Behaviour Type (SBT) chart was suggested by Robertson et al. (1986). This chart uses the basic CPT parameters of cone resistance (qt) and friction ratio (Rf). The chart is global in nature and can provide reasonable predictions of soil behaviour type for CPT soundings to a depth of 20 m without the need for normalising the parameters. Overlap in some zones should be expected and the zones can be modified somewhat based on local experience.

The accuracy of the soil behaviour type characterisation can be further improved when pore pressure measurements are collected, and the data is normalised for the effective overburden stress. In soft soils the penetration pore pressures can be very large, whereas, in stiff heavily over-consolidated CLAY or dense SILT and silty SAND the penetration pore pressures (u2) can be small and sometimes negative relative to the equilibrium pore pressures (u0). The rate of pore pressure dissipation during a pause in penetration can also guide in the characterisation of soil type and is discussed in detail in Section 6.4. To simplify the characterisation, the normalized cone parameters Qt and Fr can be combined into one Soil Behaviour Type index, Ic. The Soil Behaviour Type index can be defined as follows;

$$Ic = ((3.47 - \log Qt)^2 + (\log Fr + 1.22)^2)^2$$

where: $Qt = (qt - \sigma_{vo})/ \sigma'_{vo}$ (normalized cone penetration resistance).

$Fr = (fs/(qt - \sigma_{vo})) \times 100$ (normalized friction ratio, in%).

Table 8 below can be used to characterise soil based on the Soil Behaviour Type index, Ic:

Table 8: Soil Behaviour Index Summary

Ic	Soil Behaviour Type
>3.6	Organic CLAY
2.95 – 3.6	Silty CLAY and CLAY
2.6 – 2.95	Clayey SILT to Silty CLAY
2.05 – 2.6	Silty SAND – Sandy SILT
1.31 – 2.05	SAND to Silty SAND
<1.31	Gravelly SAND – Dense SAND

For the purpose of defining the subsurface ground conditions across the project site, test results were characterised using normalised SBT charts and the Soil Behaviour Type Index.

6.3 Material Permeabilities

In order to further refine the sub-surface ground profile, the in-situ permeability of the ground profile were estimated from field tests, laboratory tests and CPT tests and CPTU dissipation tests. The details of each of these is discussed in the following sections.

6.3.1 Field Permeability Testing

Field permeability testing conducted as part of the geotechnical investigative works comprised falling head tests conducted on hand auger boreholes across the project site. A summary of the field permeability testing is presented in Table 9.

Table 9: Summary of Field Permeability Tests

Location	Test Depth (m)	Average Permeability k_h (m/s)
TP 3	0.6	$1.0\ E^{-7}$
TP 7	0.4	$3.0\ E^{-7}$
TP 12	0.6	$5.6\ E^{-7}$
TP 13	0.7	$1.5\ E^{-6}$
TP 16/17	0.8	$4.5\ E^{-7}$
TP 19	0.6	$1.2\ E^{-5}$

The results of the field permeability testing varied slightly and were considered only indicative of the average permeabilities for the increase in depth below ground and not for each material type encountered within the sub-surface ground profile.

6.3.2 Laboratory Permeability Testing

In order to further define the permeability of target materials, laboratory permeability testing was conducted as part of the geotechnical investigative works and comprised falling head tests. These tests were conducted on selected samples identified as representative of the sub-surface profile across the site.

The results of the laboratory permeability test results are summarised in Table 10.

Table 10: Summary of Laboratory Permeability Tests

Sample Location	Sample Depth	Constant Head Permeability (m/s)
TP02	0.5 m – 1.1 m	6.5 E^{-9}
TP03	0.0 m – 0.7 m	1.6 E^{-8}
TP06	0.6 m – 2.7 m	5.2 E^{-9}
TP13	0.7 m – 2.8 m	4.1 E^{-9}
TP16	1.0 m – 2.8 m	6.2 E^{-9}

Note: "-" denotes that a sample was not tested.

It is important to note that the results of the falling head laboratory permeability tests are considered "remoulded" permeability tests as a result of being compacted to 95 % of the maximum dry density of the material at an optimum moisture content of between 21 % and 24 %, as determined by the Maximum Dry Density testing. As a result, the remoulded permeabilities are considered two orders of magnitude lower than the expected in-situ permeabilities, depending on the state of the soil.

The results of the laboratory permeability testing identified that a combination of the sandy SILT, mottled silty CLAY and high plasticity CLAY used as borrow material for the construction of the embankments and cut-off keys would provide a low permeability composite suitable for construction. The results also provided guidance as to the materials to be targeted with the use of CPT and Piezocone testing.

6.3.3 Piezocone Permeability Testing

An approximate estimate of soil hydraulic conductivity or coefficient of permeability, k, can be made from an estimate of the Soil Behaviour Type index. The average relationship between soil permeability (k) and SBTn Ic can be represented by:

$$k = 10^{(0.952 - 3.04\ Ic)}\ m/s;\ for\ 1.0 < Ic \leq 3.27$$

$$k = 10^{(-4.52 - 1.37\ Ic)}\ m/s;\ for\ 3.27 < Ic < 4.0$$

The above relationships can be used to provide an approximate estimate of soil permeability (k) and to show the likely variation of soil permeability with depth from a CPT sounding. Since the normalized CPT parameters (Qtn and Fr) respond to the mechanical behaviour of the soil and depend on many soil variables, the suggested relationship between k and Ic is approximate and should only be used as a guide.

For improved estimates, pore pressure dissipation tests were performed in soil layers defined by the CPT. These values were interpreted using two separate methods as detailed in Appendix D. The interpretation methods account for the soil shear strength, soil rigidity, and confining stresses likely to influence the soil behaviour and as a result the parameter to be interpreted. Numerical analyses have previously demonstrated

that the rate of dissipation increases as the soil rigidity or the soil confining pressure increases, which is a consequence of higher excess pore pressure gradient at higher depths or at larger rigidities.

During a pause in penetration, any excess pore pressure generated around the cone will start to dissipate. The rate of dissipation depends upon the coefficient of consolidation, which in turn, depends on the compressibility and permeability of the soil. The rate of dissipation also depends on the diameter of the probe. A dissipation test is performed at any required depth by stopping the penetration and measuring the decay of pore pressure with time. In order to accurately estimate the in-situ permeabilities of the target materials, the equilibrium pore pressure was required. As such, each dissipation test was continued until no further dissipation was observed. This can occur rapidly in SAND, but may take many hours in plastic clays.

A total of four (4) piezocone dissipation tests were conducted within target materials. The results of the dissipation tests are summarised in Table 11.

Table 11: Summary of Piezocone Test Result

CPTU No.	Target Depth (m)	Target Material	Permeability k_h (m/s)
CPTU 12	2.3	SILTSTONE	$5\ E^{-9}$
CPTU 14	4.3	SILTSTONE	$5.2\ E^{-9}$
CPTU 7/8A	2.4	SILTSTONE	$1.7\ E^{-6}$
CPTU 7/8B	2.4	SILTSTONE	$4.89\ E^{-8}$

It should be noted that given that the SILTSTONE is inherently dry, the development of negative pore pressure necessitated that the piezocone be extracted and re-saturated several times at each location. This may affect the results of the dissipation test. The results of the in-situ permeability testing are considered indicative of the average permeabilities for the increase in depth below ground

6.4 Laboratory Triaxial Test Interpretation

6.4.1 Multistage Unconsolidated Undrained Triaxial Testing

A part of the geotechnical investigation, three (3) samples were collected for Multistage Unconsolidated Undrained triaxial testing. These samples were considered representative of the following material types:

- Sample 1: White-grey Sandy SILT from Test Pit 02 at 0.5 m below ground level;
- Sample 2: White-grey Clayey SILT from Test Pit 13 at 0.7 m below ground level; and
- Sample 3: Stockpiled borrow material B1 – SILT/CLAY.

Critical to the estimation of shear strength parameters used in the analysis of the settlement and stability of the embankments is the interpretation of the triaxial data. The results of the multistage consolidated undrained triaxial tests were reviewed and interpreted in order to estimate the in-situ and composite shear strength and compressibility parameters.

The multistage unconsolidated undrained triaxial tests were conducted at nominal cell pressures of 75, 150, 300 kPa for each specimen, except for Sample 1, where the test at 300 kPa could not be carried out because the sample had reached a strain of 20% before the third stage could begin. Each test specimen was compacted to 95% standard compactive effort at optimum moisture content. A summary of the interpreted test is data for each sample presented below.

Table 12: Sampled 1 UU Triaxial Test Results

Parameter	Result
Initial Moisture Content (%)	9.4
Wet Density (t/m^3)	2.13
Dry Density (t/m^3)	1.94
Estimated Voids Ratio	0.37
Estimated Saturation Ratio	71
Cohesion	120
Internal Angle of Friction	20
Strain at Failure (%)	11.5 (Stg 1); 19.28 (Stg 2); -
Deviator Stress at Failure	444 (Stg 1); 522 (Stg 2); -
Modulus of Elasticity E_s (Mpa)	22.1 (Stg 1); 63.8 (Stg 2); -

Table 13: Sampled 2 UU Triaxial Test Results

Parameter	Result
Initial Moisture Content (%)	16.2
Wet Density (t/m^3)	1.88
Dry Density (t/m^3)	1.62
Estimated Voids Ratio	0.64
Estimated Saturation Ratio	67
Cohesion	24.1
Internal Angle of Friction	16.5
Strain at Failure (%)	5.4 (Stg 1); 9.78 (Stg 2); 15.09 (Stg 3)
Deviator Stress at Failure	120 (Stg 1); 191 (Stg 2); 301 (Stg 3)
Modulus of Elasticity E_s (Mpa)	12.8 (Stg 1); 24.5 (Stg 2); 44.7 (Stg 2)

Table 14: Sampled 3 UU Triaxial Test Results

Parameter	Result
Initial Moisture Content (%)	15.6
Wet Density (t/m^3)	1.86
Dry Density (t/m^3)	1.61
Estimated Voids Ratio	.65
Estimated Saturation Ratio	64
Cohesion	46.1
Internal Angle of Friction	21.0
Strain at Failure (%)	5.84 (Stg 1); 10.17 (Stg 2); 15.22 (Stg 3)
Deviator Stress at Failure	208 (Stg 1); 293 (Stg 2); 446 (Stg 3)
Modulus of Elasticity E_s (Mpa)	17.1 (Stg 1); 41.9 (Stg 2); 46.2 (Stg 2)

All three shear strength envelopes were observed as being close to linear. All the samples were partially saturated, between 63 and 71%, and this will have had the effect of increasing both the angle of friction and the apparent cohesion. If the soil becomes saturated (this is unlikely if it is to be used in fill and the results are to be used for design during the construction period) then the shear strength in this condition is likely to be less than indicated by the shear strength envelopes.

Sample 1 was extremely compact having a low void ratio of 0.37 and a dry density of 1.94 t/m3. As a result, the apparent cohesion was high at 120 kPa. Presumably this is the effect of the gravel component of the soil. Only two all-round stress increments were carried out on this specimen because a strain of 20% had been reached after the second increment. The specimen failed by barrel failure at high strains, indicating that any shear failure of a structure built with this soil will have experienced excessive settlements well before any shear failure. Based on a 1% strain as the failure criterion, the equivalent shear strength parameters would equate to a cohesion of 0 kPa and an internal angle of friction of 35°. The stress strain curves start to become significantly non-linear beyond 1% strain. The failure criterion used was maximum deviator stress, but it appears from the stress strain curves that this might not have been completely attained.

Sample 2 and Sample 3 had relatively high void ratios of 0.64 and 0.65 respectively, and showed correspondingly lower cohesions of 24.1 and 46.1 kPa. Both are low strength materials, presumably owing to their silt and clay content, and the low dry densities of 1.61 and 1.62 t/m^3.

The modulus of elasticity was calculated from the stress strain curves, using the steepest portion of the curves, and are tabulated above. All the test results appear to be internally consistent and reliable although consideration will need to be given to the level of saturation expected during operation of the facility.

6.4.2 Multistage Consolidated Undrained Triaxial Testing

A part of the geotechnical investigation, three (3) samples were collected for Single Stage Consolidated Undrained triaxial testing. These samples were considered representative of the following material types:

- Sample 4: White-grey Sandy SILT from Test Pit 02 at 0.5 m – 1.1 m below ground level;
- Sample 5: White-grey Clayey SILT from Test Pit 13 at 0.5 m – 1.1 m below ground level; and
- Sample 6: Stockpiled borrow material B1 – SILT/CLAY.

Critical to the estimation of shear strength parameters used in the analysis of the settlement and stability of the embankments is the interpretation of the triaxial data. The results of the multistage consolidated undrained triaxial tests were reviewed and interpreted in order to estimate the in-situ and composite shear strength and compressibility parameters.

The multistage unconsolidated undrained triaxial tests were conducted at nominal cell pressures of 75, 150, 300 kPa for each specimen, except for Sample 1, where the test at 300 kPa could not be carried out because the sample had reached a strain of 20% before the third stage could begin. Each test specimen was compacted to 95% standard compactive effort at optimum moisture content. A summary of the interpreted test is data for each sample presented below.

Table 15: Sampled 4 CU Triaxial Test Results

Parameter	Result
Initial Moisture Content (%)	9.3
Wet Density (t/m^3)	2.14
Dry Density (t/m^3)	1.96
Estimated Voids Ratio	0.36
Estimated Saturation Ratio	70
Strain at Failure (%)	7.36
Deviator Stress at Failure	477
Modulus of Elasticity E_s (Mpa)	56.7

Table 16: Sampled 5 CU Triaxial Test Results

Parameter	Result
Initial Moisture Content (%)	16.2
Wet Density (t/m^3)	1.88
Dry Density (t/m^3)	1.62
Estimated Voids Ratio	0.64
Estimated Saturation Ratio	67
Cohesion	24.1
Internal Angle of Friction	16.5
Strain at Failure (%)	7.68
Deviator Stress at Failure	484
Modulus of Elasticity E_s (Mpa)	23.2

Table 17: Sampled 6 CU Triaxial Test Results

Parameter	Result
Initial Moisture Content (%)	15.6
Wet Density (t/m^3)	1.86
Dry Density (t/m^3)	1.61
Estimated Voids Ratio	0.65
Estimated Saturation Ratio	64
Strain at Failure (%)	10.46
Deviator Stress at Failure	578
Modulus of Elasticity E_s (Mpa)	30

The results are consistent with what one might expect from recompacted soils. The Volume Change Curves indicate that the specimens dilate initially, and the moisture content, density and void ratios are consistent with the UU results.

Moduli of elasticity were calculated from the test data and the results appear to be internally consistent and reliable.

6.5 Soil Compressibility

In elastic analysis, settlement is most sensitive to the selection of input parameters for soil compressibility, that is modulus of elasticity (E) and Poisson's ratio (μ). The analysis uses values of E and μ which are regarded as representative of the foundation under consideration. Undrained moduli are used to calculate immediate settlement and drained moduli are used to calculate long-term settlement, including creep.

Compressibility parameters for the in-situ soils were evaluated from in-situ and laboratory testing as well as visual and tactile assessments of the materials encountered in test pits and boreholes.

The range of moduli values assigned to each horizon is based on experience with similar soils, and correlations with field assessments. The recommended drained moduli of elasticity (E) for each interpreted horizon are summarised in Table 18.

Table 18: Summary of Inferred Soil Foundation Elastic Moduli

Structure	Layer	Consistency	Depth to base (m)	E (MPa)		
				Lowest	Expected	Highest
TSF Embankment	Alluvial Cover – Sandy SILT	Soft - Firm	0.2	10	20	30
	Conglomerate – Sandy SILT	Stiff	1.2	35	50	70
	Bedrock - SILTSTONE	Stiff – V. Stiff	>3	75	85	100

Note: ">" indicates the base of layer was not encountered.

6.6 Settlement Analysis

Standard elastic settlement analysis has been used to examine the potential settlements of the embankments. The method takes into consideration the layered soil profile by using the variation in moduli of elasticity with depth and allows for pre-consolidation. Standard elastic settlement analysis is based on the equation:

$$S = \frac{q \times B \times (1 - \mu^2) \times i}{E}$$

where: S = settlement.

q = increase in effective pressure.

B = width or diameter of footing.

μ = Poisson's ratio.

i = influence factor.

E = modulus of elasticity.

The influence factor (i) takes into account the shape of the footing or embankment and the thickness of the various soil horizons. Factors for footings of various dimensions and layer thickness ratios are published by Harr (Ref. 7) and Lee, White and Ingles (Ref. 8).

6.6.1 Loadings for Analysis

Estimated settlements have been calculated for the TSF embankment using interpreted design parameters, foundation geometries and loadings typically expected during construction and operation. Additional settlement analyses will need to be carried out as part of the detailed design, if the embankment geometries and layout change and/or foundation loads, sizes and founding depths vary from those described herein.

The maximum load applied to the embankment is assumed to be 400 kPa as a result of effective overburden (embankment to 19.74 m high). For the purpose of the analysis the average load is assumed to be 250 kPa.

6.6.2 Settlement Analysis Results

Total and differential settlements were estimated for the embankments assuming a range of moduli of elasticity as presented in Table 11. Total settlement is the expected maximum settlement of each embankment, and differential settlement is the potential difference in settlement across the embankment caused by differential loads and foundation conditions. These settlements are based on the expected bearing pressures and foundation geometries. The estimated settlements are summarised in Table 19.

Table 19: Estimated Settlement of TSF Embankment

Embankment	Bearing Pressure	Most Compressible		Expected Compressibility		Least Compressible	
	Total (kPa)	Total (mm)	Differential (mm)	Total (mm)	Differential (mm)	Total (mm)	Differential (mm)
TSF Embankment	250	40	5	30	5	20	5

6.7 Slope Stability Assessment Methodology

Slope stability assessment was undertaken assuming a uniform slope of 1 (V) : 3 (H) upstream and downstream batters. The target static stability factor of safety (FoS) is 1.50, and the maximum allowable degree of saturation in the slope to achieve this was assessed.

The following analysis techniques were used:

- Hoek & Bray (1981) – chart solution for circular failure slip with upstream tension crack
- Michalowski (2002) – chart solution for log-spiral failure slip
- Cousins (1978)– chart solution for circular failure slip, presented in Hunt (1986).

The embankment material is unlikely to be susceptible to seismic liquefaction, given its high fines content and well-compacted state. Seismic stability was assessed by considering

- What percent reduction in soil strength was required in order to achieve a post seismic FoS of unity;
- What coefficients of horizontal (kh) and vertical (kv=+/-0.5kh) acceleration were required to achieve a FoS of unity.

6.7.1 Static Stability

Results of static stability analyses are presented in Table 20 for target factor of safety (FoS) value of 1.50. These results indicate adequate stability even for the case of a part-saturated embankment.

Table 20: Static Stability Results

Analysis Method	Static FoS	Embankment Percentage Saturation
Hoek & Bray (1981)	1.50	50%
Michalowski (2002)	1.50	90%
Cousins (1978)	1.50	60%

6.7.2 Seismic Stability

Results of seismic stability analyses are presented in Table 21 for a target factor of safety (FoS) value of unity.

The strength reduction results point to a robust embankment even if marked strength reduction occurs post seismic shaking.

Simplistic pseudo-static assessment using kh and kv indicate adequate seismic stability. The peak ground acceleration (PGA) for the site is <0.06g for the Operating Basis Earthquake (OBE) and Maximum Design Earthquake (MDE) events. The kh and kv for FoS of unity are 0.10g and +/- 0.055g respectively.

Table 21: Seismic Stability Results

Assessment Method	Seismic FoS	Result
Strength Reduction	1.0	30% reduction in c' and ϕ'
	1.0	100% reduction in c' No reduction in ϕ'
Lateral Acceleration	1.0	k_h=0.10g k_v=+/- 0.5k_h

7. General Geotechnical Issues

7.1 Retaining Structures

Soil loads on retaining structures should be based on Rankine theory and may be calculated in accordance with the procedure outlined by Duncan and Seed (Ref. 10). Where backfill comprises select sand gravel with less than 15 % fines, the following parameters are considered applicable:

- Effective angle of friction (ø') = 36°.
- Cohesion (c') = 0 kPa.
- Angle of repose (β max.) = 35°.
- Bulk Unit Weight (γ) = 20 kN/m^3.

Rankine earth pressure coefficients of Ka (active) = 0.26 and Kp (passive) = 3.85 are recommended assuming that the retaining wall is vertical and sufficiently flexible, the ground behind the wall is horizontal, and zero wall friction develops. Ko (at rest) is dependent on the degree of compaction near the retaining structure. Assuming controlled backfill conditions in which heavy compaction equipment does not traffic adjacent to the retaining wall and hand compaction is undertaken in these areas, a value of 0.5 may be assumed. A higher degree of compaction could result in values of Ko of between 2.0 and a maximum value of Kp.

These parameters will vary depending upon the type of backfill material and should be reviewed on a case by case basis.

In order to provide adequate drainage and minimise lateral earth pressures it is recommended that a granular backfill material with the following properties be placed within 3m of retaining structures:

- Maximum fines content (% passing 0.075 mm) 15 %.
- Maximum particle size 50 mm.
- Minimum compaction of 92 % of modified maximum dry density (AS1289.5.2) at
- a moisture content of -3 % to +1 % of optimum moisture content.

Adequate drainage must be provided to ensure that water does not collect behind the walls. As an alternative, a geotextile drainage blanket may be installed down the back face of retaining structures, draining to a toe drain at the base of the wall. In either case, and regardless of the backfill material, reduced and careful compaction adjacent to the retaining structures, together with adequate drainage, is required to control excessive earth and hydrostatic pressures.

7.2 Earthworks

In general, subgrade preparation, road base and structural fill should be compacted to 95 % of Maximum Modified Dry Density (MMDD) at +/- 3 % of Optimum Moisture Content (OMC) in 300 mm layers with a 13-15 Tonne vibrating pad foot roller.

Additionally, depending on the moisture content of the materials, moisture conditioning (i.e. dry or wetting of the materials) may be required.

7.3 Excavatability

The test pits across the site were excavated with a Backhoe and as such most test pits were refused in the surficial soil and alluvium at depths of between 1.3 m and 2.8 m below ground level.

It is assumed that the alluvium can be excavated without the need for blasting. We expect that a dozer or excavator (D9N tracked dozer with single tine, 30 tonne excavator with single tooth ripping tine or similar) may be used in the excavation of the surficial material.

7.4 Heave Potential

There are no indications that the alluvial soils (the particle size distributions of which are clay/silt, sand and gravel-dominated) have significant heave potential.

7.5 Collapsing Soils

The alluvial soils are generally medium dense as a minimum, and often medium dense to dense. In general, the alluvial soils and duricrust are not expected to be prone to collapse.

9. Conclusions and Recommendations

9.1 General

Based on the investigations and analyses, it has been established that it is feasible to design and construct the TSF at the proposed location.

9.2 Ground Conditions

Typical ground conditions (from surface down) encountered during the investigation of the site are summarised in Table 22, below.

Table 22: Summary of Typical Sub-Surface Profile at TSF Site

Location	Description
GL – 0.2 m	Sandy SILT [ML], soft, non-plastic, brown-grey with gravel, dry, contains roots and organics.
0.2 m – 0.6 m	Sandy SILT [ML], soft, non-plastic, pale-brown with gravel, dry, transition phase between topsoil and red-brown horizon. Loose and unconsolidated material.
0.6 m – 1.2 m	Sandy SILT [ML], stiff, non-plastic, red-brown with gravel, dry, locally very conglomeritic with occasional lateritic texture.
1.2 m – 3. 0m	Sandy SILT [ML], stiff, non-plastic, white-grey, mottled red, dry, contains quartz cobbles (excavated as rock - SILTSTONE).

- It is unlikely that significant groundwater will be encountered during construction. Where encountered, seepage rates are expected to be low due to the fine grain size of in situ soils.
- Prior to commencing earthworks, the upper 150 mm to 300 mm thick topsoil layer should be removed and stockpiled. The near surface sandy GRAVEL is suitable for re-use as general and select fill.

9.3 TSF Foundation Design

It is feasible to design and construct the TSF at the proposed location. Stability analyses indicated that the minimum global factor of safely was above 1.5 and the likelihood of large scale failure under normal operating condition is considered low.

As a result of the investigation the following recommendations can be made:

- Approximately 150 mm – 300 mm of topsoil will need to be stripped from the TSF footprint, and stockpiled at designated locations along the alignment;
- A drainage layer is essential behind all retaining structures to reduce water pressures. This could comprise a geotextile blanket or a clean sand/gravel, free of deleterious material, with a fines content below 15 %.

11. Limitations

MHA Geotechnical (MHA) has prepared this report for the development of the Tailings Storage Facility (TSF) at ACH Minerals' Ravensthorpe Gold Project in accordance with MHA's proposal dated the 5th of November 2017. This report is provided for the exclusive use of ACH Minerals Pty Ltd and their consultants for this project only and for the purposes as described in the report. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of MHA, does so entirely at its own risk and without recourse to MHA for any loss or damage. In preparing this report MHA has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after MHA's field testing has been completed.

MHA's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by MHA in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. MHA cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by MHA. This is because this report has been written as advice and opinion rather than instructions for construction.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of MHA.

MHA may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to MHA.

Any such risk assessment would, however, be necessarily restricted to the geotechnical components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Should you have any questions regarding the content of this report, please do not hesitate to contact us directly.

Sincerely,

For and on behalf of MHA Geotechnical,

Mitch Hanger

Director

Principal Geotechnical Engineer

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11. Australian Standards. AS1170.4-1993, Minimum Design Loads on Structures. Part 4: Earthquake Loads.

Appendix B

Geotechnical Field Investigation Test Pit Logs and Photographs
(MHA Geotechnical Pty Ltd)

Sampling Methods

Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in- situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as: 4,6,7 N=13
- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as: 15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Soil Descriptions

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	20 - 63
Medium gravel	6 - 20
Fine gravel	2.36 - 6
Coarse sand	0.6 - 2.36
Medium sand	0.2 - 0.6
Fine sand	0.075 - 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	20 - 35%	Sandy Clay
Slightly	12 - 20%	Slightly Sandy Clay
With some	5 - 12%	Clay with some sand
With a trace of	0 - 5%	Clay with a trace of sand

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes;
- Poorly graded - an excess or deficiency of particular sizes within the specified range;
- Uniformly graded - an excess of a particular particle size;
- Gap graded - a deficiency of a particular particle size with the range.

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	vs	<12
Soft	s	12 - 25
Firm	f	25 - 50
Stiff	st	50 - 100
Very stiff	vst	100 - 200
Hard	h	>200

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	SPT N value	CPT qc value (MPa)
Very loose	vl	<4	<2
Loose	l	4 - 10	2 -5
Medium dense	md	10 - 30	5 - 15
Dense	d	30 - 50	15 - 25
Very dense	vd	>50	>25

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.

TEST PIT LOG

Job No:	P02-17	Date Started:	20/11/2017
Test Pit ID:	TP 01	Date Finished:	20/11/2017
Contractor:	Gary	Bucket Width:	0.55m
Machine:	JCB	Easting:	-33.685685
Logged By:	Harvey Morcom	Northing:	120.206652

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Depths (From)	Depths (To)	Main material	Material Description	Comments	DCP Depth (mm)	DCP Blows/100m	Laboratory Samples
0	0.2	TOPSOIL	SANDY SILT, [ML], soft, non-plastic, brown grey with gravel, dry.	Roots and organics	100		Bulk
					200		
					300		
					400		
					500		
0.2	0.75	ALLUVIUM	SANDY SILT, [ML], stiff, non-plastic, red brown, with gravel, dry.	Indurated, excavated as rock.	600		Bulk
					700		
					800		
					900		
					1000		
0.75	1.6	ALLUVIUM	SANDY SILT, [ML], stiff, non-plastic, white grey motled red orange	Siltstone, excavated as rock.	1100		Bulk
					1200		
					1300		
					1400		
					1500		
1.6	EOH	REFUSAL			1600		
					1700		
					1800		
					1900		
					2000		
					2100		
					2200		
					2300		
					2400		
					2500		
					2600		
					2700		
					2800		
					2900		
					3000		

NOTES AND COMMENTS

Many small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m and few small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m.

Groundwater recorded at _____ m on the ____/____/____.

Co-ordinate System:_____, Zone: _____.

Origin	Soil Name	Group	Consistency	Plasticity/Grain size	Colour	With/Trace	Moisture
TOPSOIL	Primary	Pt	Fine Grain:	Fine grain:	red	clay	dry
CONCRETE	PEAT	OH	very soft	non-plastic	orange	silt	dry to moist
BITUMEN	CLAY	OL	soft	low plasticity	yellow	sand	moist
FILL	SILT	CH	firm	low - medium	brown	gravel	wet
BASSENDEAN SAND	SAND	CL	stiff	medium plasticity	purple	cobbles	moist to wet
SAND FROM TAMALA LST	GRAVEL	MH	very stiff	medium to high	green	OM	saturated
TAMALA LST	COBBLES	ML	hard	high plasticity	white	BR	
GUILDFORD FORMATION	BOULDERS	SW	Coarse Grain:	Coarse Grain:	cream	Fines:	
ALLUVIUM	Scondary:	SP	very loose	Fine	grey	<=15% "Trace"	
COLLUVIUM	clayey	SC	loose	Medium	black	15-30% "With"	
AEOLIAN	silty	SM	medium dense	Coarse Grain:	blue	>30% "Secondary"	
SWAMP DEPOSIT	sandy	GW	dense	Additional:	Additional:	Coarse:	
LATERITE	gravelly	GP	very dense	Unifor, gap graded, poorly graded. Rounded, sub rounded, sub angular, angular, flaky, platy	Can be modified using pale, dark and motled	<=5% "Trace"	
	cobbly	GC				5-12% "With"	
	bouldery	GM				>12% "Secondary"	

Test pit TP 01 – 1.6m to refusal, 3 soil horizons in a clockwise rotation starting top right; TOPSOIL, ALLUVIUM (red brown sandy silt) and ALLUVIUM (white mottled sandy silt).

TEST PIT LOG

Job No:	P02-17	Date Started:	20/11/2017
Test Pit ID:	TP 02	Date Finished:	20/11/2017
Contractor:	Gary	Bucket Width:	0.55m
Machine:	JCB	Easting:	-33.6864494
Logged By:	Harvey Morcom	Northing:	120.2067161

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Depths (From)	Depths (To)	Main material	Material Description	Comments	DCP Depth (mm)	DCP Blows/100m	Laboratory Samples
0	0.1	TOPSOIL	SANDY SILT, [ML], soft, non-plastic, brown grey with gravel, dry.	Roots and organics	100		N/S
					200		
					300		
					400		
					500		
0.1	0.5	ALLUVIUM	GRAVELLY SILT, [ML], firm, non-plastic, red brown, with gravel, dry.	Indurated, excavated as rock.	600		Bulk
					700		
					800		
					900		
					1000		
0.5	1.1	ALLUVIUM	GRAVELLY SILT, [ML], firm, non-plastic, red brown, with gravel, dry.	Siltstone, excavated as rock.	1100		Bulk
					1200		
					1300		
					1400		
					1500		
1.1	2.7	ALLUVIUM	CLAY, [CL], soft, low-medium plasticity, grey white, dry.		1600		Bulk x2
					1700		
					1800		
					1900		
					2000		
2.7	EOH	TERMINATION			2100		
					2200		
					2300		
					2400		
					2500		
					2600		
					2700		
					2800		
					2900		
					3000		

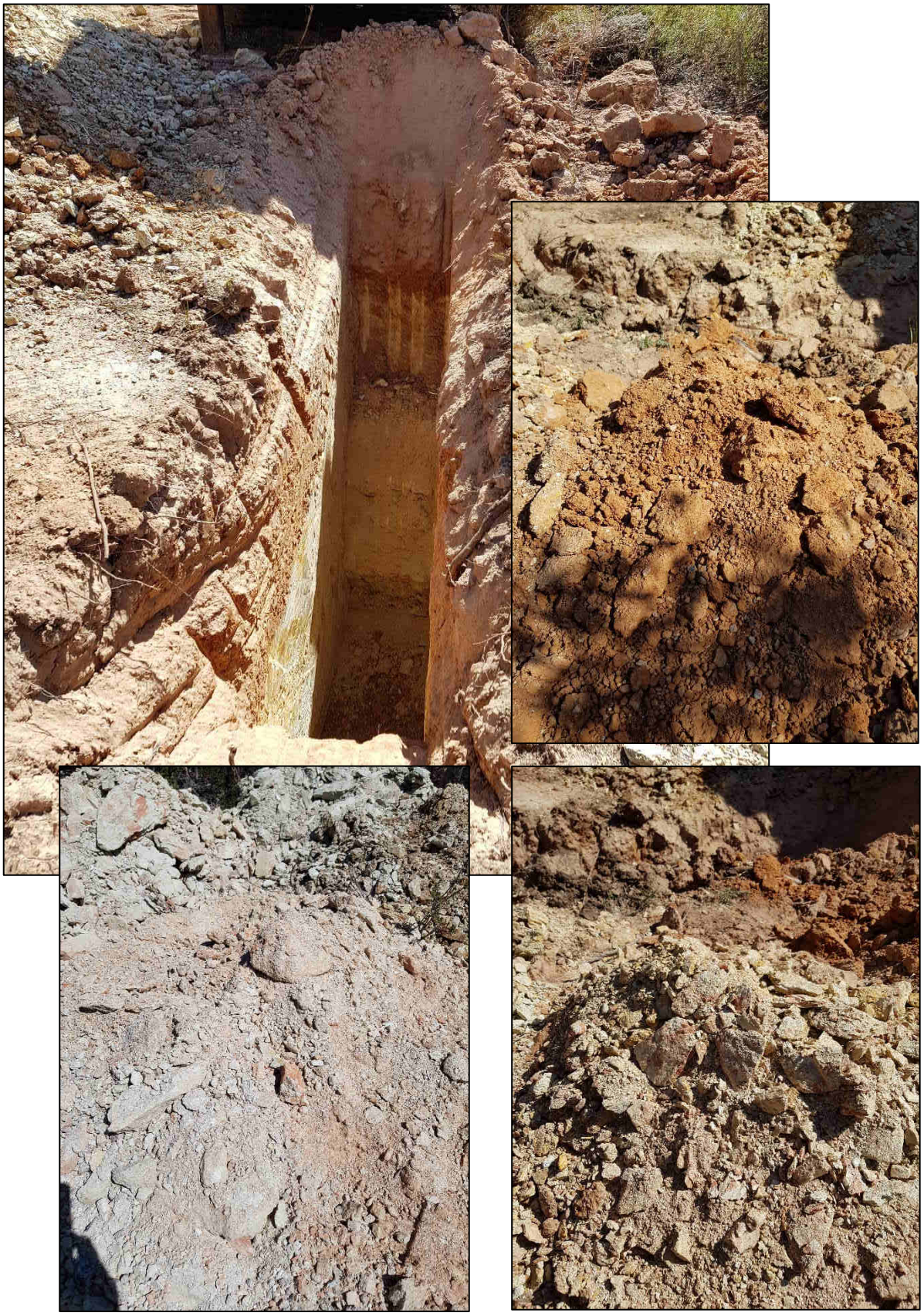
NOTES AND COMMENTS

Many small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m and few small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m.

Groundwater recorded at _____ m on the ____/____/____.

Co-ordinate System:_____, Zone: _____.

Origin	Soil Name	Group	Consistency	Plasticity/Grain size	Colour	With/Trace	Moisture
TOPSOIL	Primary	Pt	Fine Grain:	Fine grain:	red	clay	dry
CONCRETE	PEAT	OH	very soft	non-plastic	orange	silt	dry to moist
BITUMEN	CLAY	OL	soft	low plasticity	yellow	sand	moist
FILL	SILT	CH	firm	low - medium	brown	gravel	wet
BASSENDEAN SAND	SAND	CL	stiff	medium plasticity	purple	cobbles	moist to wet
SAND FROM TAMALA LST	GRAVEL	MH	very stiff	medium to high	green	OM	saturated
TAMALA LST	COBBLES	ML	hard	high plasticity	white	BR	
GUILDFORD FORMATION	BOULDERS	SW	Coarse Grain:	Coarse Grain:	cream	Fines:	
ALLUVIUM	Scondary:	SP	very loose	Fine	grey	<=15% "Trace"	
COLLUVIUM	clayey	SC	loose	Medium	black	15-30% "With"	
AEOLIAN	silty	SM	medium dense	Coarse Grain:	blue	>30% "Secondary"	
SWAMP DEPOSIT	sandy	GW	dense	Additional:	Additional:	Coarse:	
LATERITE	gravelly	GP	very dense	Unifor, gap graded, poorly graded. Rounded, sub rounded, sub angular, angular, flaky, platy	Can be modified using pale, dark and motled	<=5% "Trace"	
	cobbly	GC				5-12% "With"	
	bouldery	GM				>12% "Secondary"	



Test Pit TP 02 – 2.7m to termination, 3 soil horizons in a clockwise rotation starting top right; TOPSOIL, ALLUVIUM (red brown sandy silt) and ALLUVIUM (white mottled sandy silt).

TEST PIT LOG

Job No:	P02-17	Date Started:	20/11/2017
Test Pit ID:	TP 03	Date Finished:	20/11/2017
Contractor:	Gary	Bucket Width:	0.55m
Machine:	JCB	Easting:	-33.6873212
Logged By:	Harvey Morcom	Northing:	120.2068039

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Depths (From)	Depths (To)	Main material	Material Description	Comments	DCP Depth (mm)	DCP Blows/100m	Laboratory Samples
0	0.1	TOPSOIL	SANDY SILT, [ML], soft, non-plastic, brown grey with gravel, dry.	Roots and organics	100		N/S
					200		
					300		
					400		
					500		
0.1	0.7	ALLUVIUM	SILT, [ML], soft, non-plastic, grey white, with gravel and sand, dry to moist.	Indurated, excavated as rock.	600		Bulk
					700		
					800		
					900		
					1000		
0.7	3	ALLUVIUM	clayey SILT, [ML], very stiff, non-plastic, grey white motled red, dry.	Indurated, excavated as rock.	1100		Bulk x2
					1200		
					1300		
					1400		
					1500		
3	EOH	TERMINATION			1600		
					1700		
					1800		
					1900		
					2000		
					2100		
					2200		
					2300		
					2400		
					2500		
					2600		
					2700		
					2800		
					2900		
					3000		

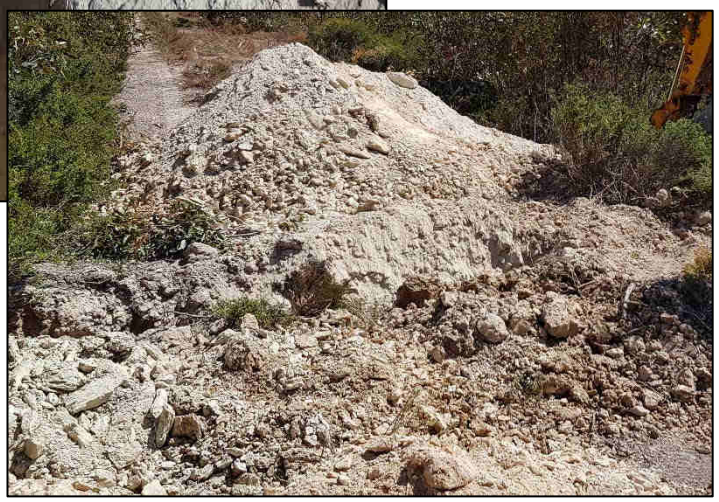
NOTES AND COMMENTS

Many small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m and few small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m.

Groundwater recorded at _____ m on the ____/____/____.

Co-ordinate System:_____, Zone: _____.

Origin	Soil Name	Group	Consistency	Plasticity/Grain size	Colour	With/Trace	Moisture
TOPSOIL	Primary	Pt	Fine Grain:	Fine grain:	red	clay	dry
CONCRETE	PEAT	OH	very soft	non-plastic	orange	silt	dry to moist
BITUMEN	CLAY	OL	soft	low plasticity	yellow	sand	moist
FILL	SILT	CH	firm	low - medium	brown	gravel	wet
BASSENDEAN SAND	SAND	CL	stiff	medium plasticity	purple	cobbles	moist to wet
SAND FROM TAMALA LST	GRAVEL	MH	very stiff	medium to high	green	OM	saturated
TAMALA LST	COBBLES	ML	hard	high plasticity	white	BR	
GUILDFORD FORMATION	BOULDERS	SW	Coarse Grain:	Coarse Grain:	cream	Fines:	
ALLUVIUM	Scondary:	SP	very loose	Fine	grey	<=15% "Trace"	
COLLUVIUM	clayey	SC	loose	Medium	black	15-30% "With"	
AEOLIAN	silty	SM	medium dense	Coarse Grain:	blue	>30% "Secondary"	
SWAMP DEPOSIT	sandy	GW	dense	Additional:	Additional:	Coarse:	
LATERITE	gravelly	GP	very dense	Unifor, gap graded, poorly graded. Rounded, sub rounded, sub angular, angular, flaky, platy	Can be modified using pale, dark and motled	<=5% "Trace"	
	cobbly	GC				5-12% "With"	
	bouldery	GM				>12% "Secondary"	



Test pit TP 03 – 3.0m to refusal, 2 soil horizons; TOPSOIL and ALLUVIUM (red brown sandy silt) and ALLUVIUM (white mottled sandy silt).

TEST PIT LOG

Job No:	P02-17	Date Started:	20/11/2017
Test Pit ID:	TP 04	Date Finished:	20/11/2017
Contractor:	Gary	Bucket Width:	0.55m
Machine:	JCB	Easting:	-33.6883154
Logged By:	Harvey Morcom	Northing:	120.2069192

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Depths (From)	Depths (To)	Main material	Material Description	Comments	DCP Depth (mm)	DCP Blows/100m	Laboratory Samples
0	0.25	TOPSOIL	sandy gravelly SILT, [ML], firm, non-plastic, brown grey with gravel, dry.	Roots and organics	100		N/S
					200		
					300		
					400		
					500		
0.25	1	ALLUVIUM	SILT, [ML], firm, non-plastic, grey white red motling, with gravel and sand, dry.	Indurated, locally cemented.	600		Bulk
					700		
					800		
					900		
					1000		
1	3.1	ALLUVIUM	SILT, [ML], stiff, non-plastic, grey white, dry.	Indurated, excavated as siltstone.	1100		Bulk
					1200		
					1300		
					1400		
					1500		
3.1	EOH	TERMINATION			1600		
					1700		
					1800		
					1900		
					2000		
					2100		
					2200		
					2300		
					2400		
					2500		
					2600		
					2700		
					2800		
					2900		
					3000		

NOTES AND COMMENTS

Many small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m and few small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m.

Groundwater recorded at _____ m on the ____/____/____.

Co-ordinate System:_____, Zone: _____.

Origin	Soil Name	Group	Consistency	Plasticity/Grain size	Colour	With/Trace	Moisture
TOPSOIL	Primary	Pt	Fine Grain:	Fine grain:	red	clay	dry
CONCRETE	PEAT	OH	very soft	non-plastic	orange	silt	dry to moist
BITUMEN	CLAY	OL	soft	low plasticity	yellow	sand	moist
FILL	SILT	CH	firm	low - medium	brown	gravel	wet
BASSENDEAN SAND	SAND	CL	stiff	medium plasticity	purple	cobbles	moist to wet
SAND FROM TAMALA LST	GRAVEL	MH	very stiff	medium to high	green	OM	saturated
TAMALA LST	COBBLES	ML	hard	high plasticity	white	BR	
GUILDFORD FORMATION	BOULDERS	SW	Coarse Grain:	Coarse Grain:	cream	Fines:	
ALLUVIUM	Scondary:	SP	very loose	Fine	grey	<=15% "Trace"	
COLLUVIUM	clayey	SC	loose	Medium	black	15-30% "With"	
AEOLIAN	silty	SM	medium dense	Coarse Grain:	blue	>30% "Secondary"	
SWAMP DEPOSIT	sandy	GW	dense	Additional:	Additional:	Coarse:	
LATERITE	gravelly	GP	very dense	Unifor, gap graded, poorly graded. Rounded, sub rounded, sub angular, angular, flaky, platy	Can be modified using pale, dark and motled	<=5% "Trace"	
	cobbly	GC				5-12% "With"	
	bouldery	GM				>12% "Secondary"	

Test pit TP 04 – 3.1m terminated, 2 soil horizons; TOPSOIL and ALLUVIUM (red brown sandy silt) and ALLUVIUM (white mottled sandy silt).

TEST PIT LOG

Job No:	P02-17	Date Started:	20/11/2017
Test Pit ID:	TP 05	Date Finished:	20/11/2017
Contractor:	Gary	Bucket Width:	0.55m
Machine:	JCB	Easting:	-33.688971
Logged By:	Harvey Morcom	Northing:	120.2069675

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Depths (From)	Depths (To)	Main material	Material Description	Comments	DCP Depth (mm)	DCP Blows/100m	Laboratory Samples
0	0.1	TOPSOIL	sandy gravelly SILT, [ML], firm, non-plastic, brown grey with gravel, dry.	Roots and organics	100		N/S
					200		
					300		
					400		
					500		
0.1	0.8	ALLUVIUM	SILT, [ML], firm, non-plastic, light brown, trace gravel with sand, dry.	Gravelly / sandy	600		Bulk
					700		
					800		
					900		
					1000		
0.8	1.8	ALLUVIUM	gravelly SILT, [ML], firm, low plasticity, red brown, trace gravel, dry.	Indurated, excavated as rock.	1100		Bulk
					1200		
					1300		
					1400		
					1500		
1.8	2.9	ALLUVIUM	SILT, [ML], stiff, non-plastic, grey white, dry.		1600		Bulk
					1700		
					1800		
					1900		
					2000		
2.9	EOH	TERMINATION			2100		
					2200		
					2300		
					2400		
					2500		
					2600		
					2700		
					2800		
					2900		
					3000		

NOTES AND COMMENTS

Many small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m and few small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m.

Groundwater recorded at _____ m on the ____/____/____.

Co-ordinate System:_____, Zone: _____.

Origin	Soil Name	Group	Consistency	Plasticity/Grain size	Colour	With/Trace	Moisture
TOPSOIL	Primary	Pt	Fine Grain:	Fine grain:	red	clay	dry
CONCRETE	PEAT	OH	very soft	non-plastic	orange	silt	dry to moist
BITUMEN	CLAY	OL	soft	low plasticity	yellow	sand	moist
FILL	SILT	CH	firm	low - medium	brown	gravel	wet
BASSENDEAN SAND	SAND	CL	stiff	medium plasticity	purple	cobbles	moist to wet
SAND FROM TAMALA LST	GRAVEL	MH	very stiff	medium to high	green	OM	saturated
TAMALA LST	COBBLES	ML	hard	high plasticity	white	BR	
GUILDFORD FORMATION	BOULDERS	SW	Coarse Grain:	Coarse Grain:	cream	Fines:	
ALLUVIUM	Scondary:	SP	very loose	Fine	grey	<=15% "Trace"	
COLLUVIUM	clayey	SC	loose	Medium	black	15-30% "With"	
AEOLIAN	silty	SM	medium dense	Coarse Grain:	blue	>30% "Secondary"	
SWAMP DEPOSIT	sandy	GW	dense	Additional:	Additional:	Coarse:	
LATERITE	gravelly	GP	very dense	Unifor, gap graded, poorly graded. Rounded, sub rounded, sub angular, angular, flaky, platy	Can be modified using pale, dark and motled	<=5% "Trace"	
	cobbly	GC				5-12% "With"	
	bouldery	GM				>12% "Secondary"	

Test pit TP 05 – 2.9m terminated, 4 soil horizons; TOPSOIL and 3 grades of ALLUVIUM; light brown silt, red brown gravelly silt and grey white sandy silt.

TEST PIT LOG

Job No:	P02-17	Date Started:	20/11/2017
Test Pit ID:	TP 07	Date Finished:	20/11/2017
Contractor:	Gary	Bucket Width:	0.55m
Machine:	JCB	Easting:	-33.6889939
Logged By:	Harvey Morcom	Northing:	120.2084628

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Depths (From)	Depths (To)	Main material	Material Description	Comments	DCP Depth (mm)	DCP Blows/100m	Laboratory Samples
0	0.1	TOPSOIL	sandy gravelly SILT, [ML], firm, non-plastic, brown grey with gravel, dry.	Roots and organics	100		N/S
					200		
					300		
					400		
					500		
0.1	0.6	ALLUVIUM	SILT, [ML], soft, non-plastic, grey, with gravel and sand, dry.	roots and organics, gravelly / sandy, loose unconsolidated soil	600		Bulk
					700		
					800		
					900		
					1000		
0.6	2.7	ALLUVIUM	SILT, [ML], stiff, non-plastic, grey white, dry.	Indurated, excavated as siltstone.	1100		Bulk
					1200		
					1300		
					1400		
					1500		
2.7	EOH	TERMINATION			1600		
					1700		
					1800		
					1900		
					2000		
					2100		
					2200		
					2300		
					2400		
					2500		
					2600		
					2700		
					2800		
					2900		
					3000		

NOTES AND COMMENTS

Many small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m and few small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m.

Groundwater recorded at _____ m on the ____/____/____.

Co-ordinate System:_____, Zone: _____.

Origin	Soil Name	Group	Consistency	Plasticity/Grain size	Colour	With/Trace	Moisture
TOPSOIL	Primary	Pt	Fine Grain:	Fine grain:	red	clay	dry
CONCRETE	PEAT	OH	very soft	non-plastic	orange	silt	dry to moist
BITUMEN	CLAY	OL	soft	low plasticity	yellow	sand	moist
FILL	SILT	CH	firm	low - medium	brown	gravel	wet
BASSENDEAN SAND	SAND	CL	stiff	medium plasticity	purple	cobbles	moist to wet
SAND FROM TAMALA LST	GRAVEL	MH	very stiff	medium to high	green	OM	saturated
TAMALA LST	COBBLES	ML	hard	high plasticity	white	BR	
GUILDFORD FORMATION	BOULDERS	SW	Coarse Grain:	Coarse Grain:	cream	Fines:	
ALLUVIUM	Scondary:	SP	very loose	Fine	grey	<=15% "Trace"	
COLLUVIUM	clayey	SC	loose	Medium	black	15-30% "With"	
AEOLIAN	silty	SM	medium dense	Coarse Grain:	blue	>30% "Secondary"	
SWAMP DEPOSIT	sandy	GW	dense	Additional:	Additional:	Coarse:	
LATERITE	gravelly	GP	very dense	Unifor, gap graded, poorly graded. Rounded, sub rounded, sub angular, angular, flaky, platy	Can be modified using pale, dark and motled	<=5% "Trace"	
	cobbly	GC				5-12% "With"	
	bouldery	GM				>12% "Secondary"	

Test pit TP 06 – 2.7m terminated, 3 soil horizons; TOPSOIL and 2 grades of ALLUVIUM; predominantly composed of the grey white siltstone, however with darker grey gravelly material.

TEST PIT LOG

Job No:	P02-17	Date Started:	20/11/2017
Test Pit ID:	TP 07	Date Finished:	20/11/2017
Contractor:	Gary	Bucket Width:	0.55m
Machine:	JCB	Easting:	-33.6889501
Logged By:	Harvey Morcom	Northing:	120.2091173

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Depths (From)	Depths (To)	Main material	Material Description	Comments	DCP Depth (mm)	DCP Blows/100m	Laboratory Samples
0	0.1	TOPSOIL	sandy gravelly SILT, [ML], firm, non-plastic, brown grey with gravel, dry.	Roots and organics.	100		N/S
					200		
					300		
					400		
					500		
0.1	0.2	ALLUVIUM	SILT, [ML], soft, non-plastic, dark grey, with sand, dry.	Gravel clasts, loose, unconsolidated.	600		Bulk
					700		
					800		
					900		
					1000		
0.2	2.5	ALLUVIUM	SILT, [ML], stiff, non-plastic, white, dry to moist.	Indurated, excavated as siltstone.	1100		Bulk x2
					1200		
					1300		
					1400		
					1500		
2.5	EOH	TERMINATION			1600		
					1700		
					1800		
					1900		
					2000		
					2100		
					2200		
					2300		
					2400		
					2500		
					2600		
					2700		
					2800		
					2900		
					3000		

NOTES AND COMMENTS

Many small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m and few small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m.

Groundwater recorded at _____ m on the ____/____/____.

Co-ordinate System:_____, Zone: _____.

Origin	Soil Name	Group	Consistency	Plasticity/Grain size	Colour	With/Trace	Moisture
TOPSOIL	Primary	Pt	Fine Grain:	Fine grain:	red	clay	dry
CONCRETE	PEAT	OH	very soft	non-plastic	orange	silt	dry to moist
BITUMEN	CLAY	OL	soft	low plasticity	yellow	sand	moist
FILL	SILT	CH	firm	low - medium	brown	gravel	wet
BASSENDEAN SAND	SAND	CL	stiff	medium plasticity	purple	cobbles	moist to wet
SAND FROM TAMALA LST	GRAVEL	MH	very stiff	medium to high	green	OM	saturated
TAMALA LST	COBBLES	ML	hard	high plasticity	white	BR	
GUILDFORD FORMATION	BOULDERS	SW	Coarse Grain:	Coarse Grain:	cream	Fines:	
ALLUVIUM	Scondary:	SP	very loose	Fine	grey	<=15% "Trace"	
COLLUVIUM	clayey	SC	loose	Medium	black	15-30% "With"	
AEOLIAN	silty	SM	medium dense	Coarse Grain:	blue	>30% "Secondary"	
SWAMP DEPOSIT	sandy	GW	dense	Additional:	Additional:	Coarse:	
LATERITE	gravelly	GP	very dense	Unifor, gap graded, poorly graded. Rounded, sub rounded, sub angular, angular, flaky, platy	Can be modified using pale, dark and motled	<=5% "Trace"	
	cobbly	GC				5-12% "With"	
	bouldery	GM				>12% "Secondary"	

Test pit TP 07 – 2.5m terminated, 3 soil horizons; TOPSOIL and 2 grades of ALLUVIUM; 0.2m of dark grey surficial top soil blending into the typical white siltstone.

TEST PIT LOG

Job No:	P02-17	Date Started:	20/11/2017
Test Pit ID:	TP 08	Date Finished:	20/11/2017
Contractor:	Gary	Bucket Width:	0.55m
Machine:	JCB	Easting:	-33.6889116
Logged By:	Harvey Morcom	Northing:	120.2096444

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Depths (From)	Depths (To)	Main material	Material Description	Comments	DCP Depth (mm)	DCP Blows/100m	Laboratory Samples
0	0.1	TOPSOIL	sandy gravelly SILT, [ML], firm, non-plastic, brown grey with gravel, dry.	Roots and organics.	100		N/S
					200		
					300		
					400		
					500		
0.1	0.4	ALLUVIUM	sandy SILT, [ML], soft, non-plastic, grey, with sand, dry.	Unconsolidated.	600		Bulk
					700		
					800		
					900		
					1000		
0.4	2.2	ALLUVIUM	SILT, [ML], stiff, non-plastic, white, dry to moist.	Indurated, excavated as siltstone.	1100		Bulk
					1200		
					1300		
					1400		
					1500		
2.2	EOH	TERMINATION			1600		
					1700		
					1800		
					1900		
					2000		
					2100		
					2200		
					2300		
					2400		
					2500		
					2600		
					2700		
					2800		
					2900		
					3000		

NOTES AND COMMENTS

Many small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m and few small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m.

Groundwater recorded at _____ m on the ____/____/____.

Co-ordinate System:_____, Zone: _____.

Origin	Soil Name	Group	Consistency	Plasticity/Grain size	Colour	With/Trace	Moisture
TOPSOIL	Primary	Pt	Fine Grain:	Fine grain:	red	clay	dry
CONCRETE	PEAT	OH	very soft	non-plastic	orange	silt	dry to moist
BITUMEN	CLAY	OL	soft	low plasticity	yellow	sand	moist
FILL	SILT	CH	firm	low - medium	brown	gravel	wet
BASSENDEAN SAND	SAND	CL	stiff	medium plasticity	purple	cobbles	moist to wet
SAND FROM TAMALA LST	GRAVEL	MH	very stiff	medium to high	green	OM	saturated
TAMALA LST	COBBLES	ML	hard	high plasticity	white	BR	
GUILDFORD FORMATION	BOULDERS	SW	Coarse Grain:	Coarse Grain:	cream	Fines:	
ALLUVIUM	Scondary:	SP	very loose	Fine	grey	<=15% "Trace"	
COLLUVIUM	clayey	SC	loose	Medium	black	15-30% "With"	
AEOLIAN	silty	SM	medium dense	Coarse Grain:	blue	>30% "Secondary"	
SWAMP DEPOSIT	sandy	GW	dense	Additional:	Additional:	Coarse:	
LATERITE	gravelly	GP	very dense	Unifor, gap graded, poorly graded. Rounded, sub rounded, sub angular, angular, flaky, platy	Can be modified using pale, dark and motled	<=5% "Trace"	
	cobbly	GC				5-12% "With"	
	bouldery	GM				>12% "Secondary"	

Test pit TP 08 – 2.2m terminated, 3 soil horizons; TOPSOIL and 2 grades of ALLUVIUM; 0.4m of dark grey surficial top soil blending into the white siltstone.

TEST PIT LOG

Job No:	P02-17	Date Started:	20/11/2017
Test Pit ID:	TP 09	Date Finished:	20/11/2017
Contractor:	Gary	Bucket Width:	0.55m
Machine:	JCB	Easting:	-33.6888324
Logged By:	Harvey Morcom	Northing:	120.2104839

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Depths (From)	Depths (To)	Main material	Material Description	Comments	DCP Depth (mm)	DCP Blows/100m	Laboratory Samples
0	0.1	TOPSOIL	sandy gravelly SILT, [ML], firm, non-plastic, brown grey with gravel, dry.	Roots and organics.	100		N/S
					200		
					300		
					400		
					500		
0.1	0.2	ALLUVIUM	sandy SILT, [ML], firm-stiff, non-plastic, grey, with sand, dry.	Quartz clasts, gravelly.	600		Bulk
					700		
					800		
					900		
					1000		
0.2	2.2	ALLUVIUM	SILT, [ML], stiff, non-plastic, white, dry to moist.	Indurated, excavated as siltstone.	1100		Bulk x2
					1200		
					1300		
					1400		
					1500		
2.2	EOH	TERMINATION			1600		
					1700		
					1800		
					1900		
					2000		
					2100		
					2200		
					2300		
					2400		
					2500		
					2600		
					2700		
					2800		
					2900		
					3000		

NOTES AND COMMENTS

Many small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m and few small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m.

Groundwater recorded at _____ m on the ____/____/____.

Co-ordinate System:_____, Zone: _____.

Origin	Soil Name	Group	Consistency	Plasticity/Grain size	Colour	With/Trace	Moisture
TOPSOIL	Primary	Pt	Fine Grain:	Fine grain:	red	clay	dry
CONCRETE	PEAT	OH	very soft	non-plastic	orange	silt	dry to moist
BITUMEN	CLAY	OL	soft	low plasticity	yellow	sand	moist
FILL	SILT	CH	firm	low - medium	brown	gravel	wet
BASSENDEAN SAND	SAND	CL	stiff	medium plasticity	purple	cobbles	moist to wet
SAND FROM TAMALA LST	GRAVEL	MH	very stiff	medium to high	green	OM	saturated
TAMALA LST	COBBLES	ML	hard	high plasticity	white	BR	
GUILDFORD FORMATION	BOULDERS	SW	Coarse Grain:	Coarse Grain:	cream	Fines:	
ALLUVIUM	Scondary:	SP	very loose	Fine	grey	<=15% "Trace"	
COLLUVIUM	clayey	SC	loose	Medium	black	15-30% "With"	
AEOLIAN	silty	SM	medium dense	Coarse Grain:	blue	>30% "Secondary"	
SWAMP DEPOSIT	sandy	GW	dense	Additional:	Additional:	Coarse:	
LATERITE	gravelly	GP	very dense	Unifor, gap graded, poorly graded. Rounded, sub rounded, sub angular, angular, flaky, platy	Can be modified using pale, dark and motled	<=5% "Trace"	
	cobbly	GC				5-12% "With"	
	bouldery	GM				>12% "Secondary"	

Test pit TP 09 – 2.2m terminated, 3 soil horizons. TOPSOIL and 2 grades of ALLUVIUM; grey surficial top soil blending into the white siltstone.

TEST PIT LOG

Job No:	P02-17	Date Started:	20/11/2017
Test Pit ID:	TP 10	Date Finished:	20/11/2017
Contractor:	Gary	Bucket Width:	0.55m
Machine:	JCB	Easting:	-33.6888137
Logged By:	Harvey Morcom	Northing:	120.2109811

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Depths (From)	Depths (To)	Main material	Material Description	Comments	DCP Depth (mm)	DCP Blows/100m	Laboratory Samples
0	0.1	TOPSOIL	sandy gravelly SILT, [ML], firm, non-plastic, brown grey with gravel, dry.	Roots and organics.	100		N/S
					200		
					300		
					400		
					500		
0.1	2.5	ALLUVIUM	SILT, [ML], stiff to very stiff, non-plastic, white orange mottling, dry to moist.	Clayey silt, less granular, excavated as rock.	600		Bulk X2
					700		
					800		
					900		
					1000		
2.5	EOH	TERMINATION			1100		
					1200		
					1300		
					1400		
					1500		
					1600		
					1700		
					1800		
					1900		
					2000		
					2100		
					2200		
					2300		
					2400		
					2500		
					2600		
					2700		
					2800		
					2900		
					3000		

NOTES AND COMMENTS

Many small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m and few small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m.

Groundwater recorded at _____ m on the ____/____/____.

Co-ordinate System:_____, Zone: _____.

Origin	Soil Name	Group	Consistency	Plasticity/Grain size	Colour	With/Trace	Moisture
TOPSOIL	Primary	Pt	Fine Grain:	Fine grain:	red	clay	dry
CONCRETE	PEAT	OH	very soft	non-plastic	orange	silt	dry to moist
BITUMEN	CLAY	OL	soft	low plasticity	yellow	sand	moist
FILL	SILT	CH	firm	low - medium	brown	gravel	wet
BASSENDEAN SAND	SAND	CL	stiff	medium plasticity	purple	cobbles	moist to wet
SAND FROM TAMALA LST	GRAVEL	MH	very stiff	medium to high	green	OM	saturated
TAMALA LST	COBBLES	ML	hard	high plasticity	white	BR	
GUILDFORD FORMATION	BOULDERS	SW	Coarse Grain:	Coarse Grain:	cream	Fines:	
ALLUVIUM	Scondary:	SP	very loose	Fine	grey	<=15% "Trace"	
COLLUVIUM	clayey	SC	loose	Medium	black	15-30% "With"	
AEOLIAN	silty	SM	medium dense	Coarse Grain:	blue	>30% "Secondary"	
SWAMP DEPOSIT	sandy	GW	dense	Additional:	Additional:	Coarse:	
LATERITE	gravelly	GP	very dense	Unifor, gap graded, poorly graded. Rounded, sub rounded, sub angular, angular, flaky, platy	Can be modified using pale, dark and motled	<=5% "Trace"	
	cobbly	GC				5-12% "With"	
	bouldery	GM				>12% "Secondary"	

Test pit TP 10 – 2.5m terminated, 2 soil horizons. TOPSOIL and ALLUVIUM; brown grey surficial top soil and white siltstone with minor red mottling.

TEST PIT LOG

Job No:	P02-17	Date Started:	20/11/2017
Test Pit ID:	TP 11	Date Finished:	20/11/2017
Contractor:	Gary	Bucket Width:	0.55m
Machine:	JCB	Easting:	-33.6885004
Logged By:	Harvey Morcom	Northing:	120.2113023

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Depths (From)	Depths (To)	Main material	Material Description	Comments	DCP Depth (mm)	DCP Blows/100m	Laboratory Samples
0	0.2	TOPSOIL	sandy gravelly SILT, [ML], firm, non-plastic, brown grey with gravel, dry.	Roots and organics.	100		N/S
					200		
					300		
					400		
					500		
0.2	2.8	ALLUVIUM	SILT, [ML], stiff to very stiff, non-plastic, white, dry to moist.	Clayey silt, less granular, excavated as rock.	600		Bulk X2
					700		
					800		
					900		
					1000		
2.8	EOH	TERMINATION			1100		
					1200		
					1300		
					1400		
					1500		
					1600		
					1700		
					1800		
					1900		
					2000		
					2100		
					2200		
					2300		
					2400		
					2500		
					2600		
					2700		
					2800		
					2900		
					3000		

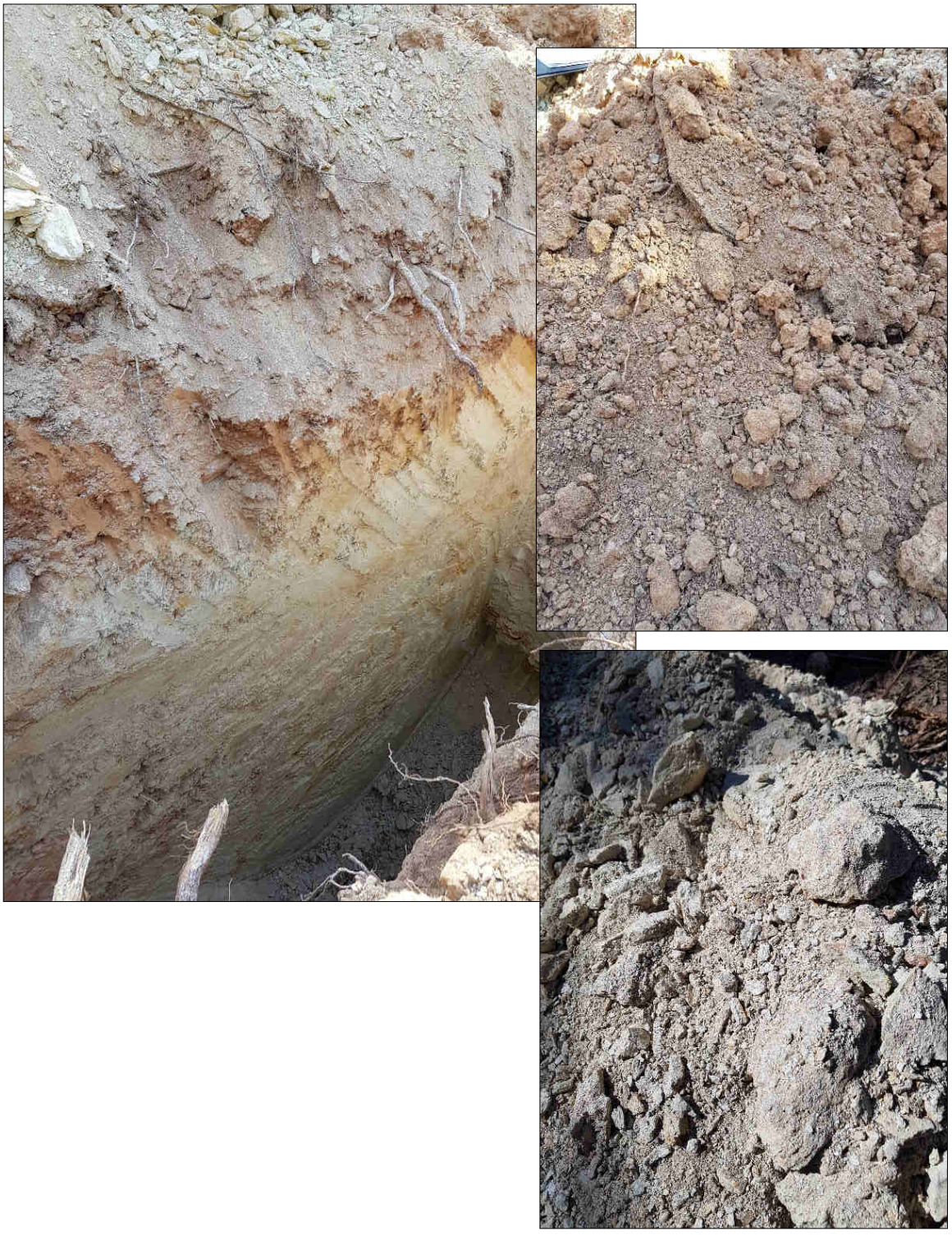
NOTES AND COMMENTS

Many small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m and few small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m.

Groundwater recorded at _____ m on the ____/____/____.

Co-ordinate System:_____, Zone: _____.

Origin	Soil Name	Group	Consistency	Plasticity/Grain size	Colour	With/Trace	Moisture
TOPSOIL	Primary	Pt	Fine Grain:	Fine grain:	red	clay	dry
CONCRETE	PEAT	OH	very soft	non-plastic	orange	silt	dry to moist
BITUMEN	CLAY	OL	soft	low plasticity	yellow	sand	moist
FILL	SILT	CH	firm	low - medium	brown	gravel	wet
BASSENDEAN SAND	SAND	CL	stiff	medium plasticity	purple	cobbles	moist to wet
SAND FROM TAMALA LST	GRAVEL	MH	very stiff	medium to high	green	OM	saturated
TAMALA LST	COBBLES	ML	hard	high plasticity	white	BR	
GUILDFORD FORMATION	BOULDERS	SW	Coarse Grain:	Coarse Grain:	cream	Fines:	
ALLUVIUM	Scondary:	SP	very loose	Fine	grey	<=15% "Trace"	
COLLUVIUM	clayey	SC	loose	Medium	black	15-30% "With"	
AEOLIAN	silty	SM	medium dense	Coarse Grain:	blue	>30% "Secondary"	
SWAMP DEPOSIT	sandy	GW	dense	Additional:	Additional:	Coarse:	
LATERITE	gravelly	GP	very dense	Unifor, gap graded, poorly graded. Rounded, sub rounded, sub angular, angular, flaky, platy	Can be modified using pale, dark and motled	<=5% "Trace"	
	cobbly	GC				5-12% "With"	
	bouldery	GM				>12% "Secondary"	



Test pit TP 11 – 2.8m terminated, 2 soil horizons. TOPSOIL and ALLUVIUM; brown grey surficial top soil and white siltstone.

TEST PIT LOG

Job No:	P02-17	Date Started:	20/11/2017
Test Pit ID:	TP 12	Date Finished:	20/11/2017
Contractor:	Gary	Bucket Width:	0.55m
Machine:	JCB	Easting:	-33.6877109
Logged By:	Harvey Morcom	Northing:	120.2112202

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Depths (From)	Depths (To)	Main material	Material Description	Comments	DCP Depth (mm)	DCP Blows/100m	Laboratory Samples
0	0.1	TOPSOIL	sandy gravelly SILT, [ML], firm, non-plastic, brown grey with gravel, dry.	Roots and organics.	100		N/S
					200		
					300		
					400		
					500		
0.1	2.8	ALLUVIUM	SILT, [ML], firm, non-plastic, white, with clay, dry to moist.	Clayey silt, less granular, excavated as rock.	600		Bulk
					700		
					800		
					900		
					1000		
2.8	EOH	TERMINATION			1100		
					1200		
					1300		
					1400		
					1500		
					1600		
					1700		
					1800		
					1900		
					2000		
					2100		
					2200		
					2300		
					2400		
					2500		
					2600		
					2700		
					2800		
					2900		
					3000		

NOTES AND COMMENTS

Many small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m and few small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m.

Groundwater recorded at _____ m on the ____/____/____.

Co-ordinate System:_____, Zone: _____.

Origin	Soil Name	Group	Consistency	Plasticity/Grain size	Colour	With/Trace	Moisture
TOPSOIL	Primary	Pt	Fine Grain:	Fine grain:	red	clay	dry
CONCRETE	PEAT	OH	very soft	non-plastic	orange	silt	dry to moist
BITUMEN	CLAY	OL	soft	low plasticity	yellow	sand	moist
FILL	SILT	CH	firm	low - medium	brown	gravel	wet
BASSENDEAN SAND	SAND	CL	stiff	medium plasticity	purple	cobbles	moist to wet
SAND FROM TAMALA LST	GRAVEL	MH	very stiff	medium to high	green	OM	saturated
TAMALA LST	COBBLES	ML	hard	high plasticity	white	BR	
GUILDFORD FORMATION	BOULDERS	SW	Coarse Grain:	Coarse Grain:	cream	Fines:	
ALLUVIUM	Scondary:	SP	very loose	Fine	grey	<=15% "Trace"	
COLLUVIUM	clayey	SC	loose	Medium	black	15-30% "With"	
AEOLIAN	silty	SM	medium dense	Coarse Grain:	blue	>30% "Secondary"	
SWAMP DEPOSIT	sandy	GW	dense	Additional:	Additional:	Coarse:	
LATERITE	gravelly	GP	very dense	Unifor, gap graded, poorly graded. Rounded, sub rounded, sub angular, angular, flaky, platy	Can be modified using pale, dark and motled	<=5% "Trace"	
	cobbly	GC				5-12% "With"	
	bouldery	GM				>12% "Secondary"	

Test pit TP 12 – 2.8m terminated, 2 soil horizons. TOPSOIL and ALLUVIUM; brown grey surficial top soil and white siltstone.

TEST PIT LOG

Job No:	P02-17	Date Started:	20/11/2017
Test Pit ID:	TP 13	Date Finished:	20/11/2017
Contractor:	Gary	Bucket Width:	0.55m
Machine:	JCB	Easting:	-33.6867749
Logged By:	Harvey Morcom	Northing:	120.2111142

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Depths (From)	Depths (To)	Main material	Material Description	Comments	DCP Depth (mm)	DCP Blows/100m	Laboratory Samples
0	0.1	TOPSOIL	sandy gravelly SILT, [ML], firm, non-plastic, brown grey with gravel, dry.	Roots and organics.	100		N/S
					200		
					300		
					400		
					500		
0.1	0.7	ALLUVIUM	SILT, [ML], firm, non-plastic, grey white red motling, with gravel and sand, dry.	Clayey silt, less granular, excavated as rock.	600		Bulk
					700		
					800		
					900		
					1000		
0.7	2.8	ALLUVIUM	SILT, [ML], firm, non-plastic, white, with clay, dry to moist.	Clayey silt, less granular, excavated as rock.	1100		Bulk
					1200		
					1300		
					1400		
					1500		
2.8	EOH	TERMINATION			1600		
					1700		
					1800		
					1900		
					2000		
					2100		
					2200		
					2300		
					2400		
					2500		
					2600		
					2700		
					2800		
					2900		
					3000		

NOTES AND COMMENTS

Many small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m and few small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m.

Groundwater recorded at _____ m on the ____/____/____.

Co-ordinate System:_____, Zone: _____.

Origin	Soil Name	Group	Consistency	Plasticity/Grain size	Colour	With/Trace	Moisture
TOPSOIL	Primary	Pt	Fine Grain:	Fine grain:	red	clay	dry
CONCRETE	PEAT	OH	very soft	non-plastic	orange	silt	dry to moist
BITUMEN	CLAY	OL	soft	low plasticity	yellow	sand	moist
FILL	SILT	CH	firm	low - medium	brown	gravel	wet
BASSENDEAN SAND	SAND	CL	stiff	medium plasticity	purple	cobbles	moist to wet
SAND FROM TAMALA LST	GRAVEL	MH	very stiff	medium to high	green	OM	saturated
TAMALA LST	COBBLES	ML	hard	high plasticity	white	BR	
GUILDFORD FORMATION	BOULDERS	SW	Coarse Grain:	Coarse Grain:	cream	Fines:	
ALLUVIUM	Scondary:	SP	very loose	Fine	grey	<=15% "Trace"	
COLLUVIUM	clayey	SC	loose	Medium	black	15-30% "With"	
AEOLIAN	silty	SM	medium dense	Coarse Grain:	blue	>30% "Secondary"	
SWAMP DEPOSIT	sandy	GW	dense	Additional:	Additional:	Coarse:	
LATERITE	gravelly	GP	very dense	Unifor, gap graded, poorly graded. Rounded, sub rounded, sub angular, angular, flaky, platy	Can be modified using pale, dark and motled	<=5% "Trace"	
	cobbly	GC				5-12% "With"	
	bouldery	GM				>12% "Secondary"	

Test pit TP 13 – 2.9m terminated, 3 soil horizons. TOPSOIL and ALLUVIUM; brown grey surficial top soil and white siltstone with some red mottling.

TEST PIT LOG

Job No:	P02-17	Date Started:	21/11/2017
Test Pit ID:	TP 14	Date Finished:	21/11/2017
Contractor:	Gary	Bucket Width:	0.55m
Machine:	JCB	Easting:	-33.6861255
Logged By:	Harvey Morcom	Northing:	120.2110391

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Depths (From)	Depths (To)	Main material	Material Description	Comments	DCP Depth (mm)	DCP Blows/100m	Laboratory Samples
0	0.2	TOPSOIL	sandy gravelly SILT, [ML], firm, non-plastic, brown grey with gravel, dry.	Roots and organics.	100		N/S
					200		
					300		
					400		
					500		
0.2	1	ALLUVIUM	SILT, [ML], very stiff, non-plastic, white red motling, with gravel and sand, dry.	Cobbly, excavated as rock.	600		Bulk
					700		
					800		
					900		
					1000		
1	EOH	REFUSAL			1100		
					1200		
					1300		
					1400		
					1500		
					1600		
					1700		
					1800		
					1900		
					2000		
					2100		
					2200		
					2300		
					2400		
					2500		
					2600		
					2700		
					2800		
					2900		
					3000		

NOTES AND COMMENTS

Many small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m and few small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m.

Groundwater recorded at _____ m on the ____/____/____.

Co-ordinate System:_____, Zone: _____.

Origin	Soil Name	Group	Consistency	Plasticity/Grain size	Colour	With/Trace	Moisture
TOPSOIL	Primary	Pt	Fine Grain:	Fine grain:	red	clay	dry
CONCRETE	PEAT	OH	very soft	non-plastic	orange	silt	dry to moist
BITUMEN	CLAY	OL	soft	low plasticity	yellow	sand	moist
FILL	SILT	CH	firm	low - medium	brown	gravel	wet
BASSENDEAN SAND	SAND	CL	stiff	medium plasticity	purple	cobbles	moist to wet
SAND FROM TAMALA LST	GRAVEL	MH	very stiff	medium to high	green	OM	saturated
TAMALA LST	COBBLES	ML	hard	high plasticity	white	BR	
GUILDFORD FORMATION	BOULDERS	SW	Coarse Grain:	Coarse Grain:	cream	Fines:	
ALLUVIUM	Scondary:	SP	very loose	Fine	grey	<=15% "Trace"	
COLLUVIUM	clayey	SC	loose	Medium	black	15-30% "With"	
AEOLIAN	silty	SM	medium dense	Coarse Grain:	blue	>30% "Secondary"	
SWAMP DEPOSIT	sandy	GW	dense	Additional:	Additional:	Coarse:	
LATERITE	gravelly	GP	very dense	Unifor, gap graded, poorly graded. Rounded, sub rounded, sub angular, angular, flaky, platy	Can be modified using pale, dark and motled	<=5% "Trace"	
	cobbly	GC				5-12% "With"	
	bouldery	GM				>12% "Secondary"	

Test pit TP 14 – 1.0m refusal. TOPSOIL and gravelly ALLUVIUM; brown grey surficial top soil and white siltstone with some cobbles.

TEST PIT LOG

Job No:	P02-17	Date Started:	21/11/2017
Test Pit ID:	TP 15	Date Finished:	21/11/2017
Contractor:	Gary	Bucket Width:	0.55m
Machine:	JCB	Easting:	-33.6856138
Logged By:	Harvey Morcom	Northing:	120.2109576

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Depths (From)	Depths (To)	Main material	Material Description	Comments	DCP Depth (mm)	DCP Blows/100m	Laboratory Samples
0	0.2	TOPSOIL	sandy gravelly SILT, [ML], firm, non-plastic, brown grey with gravel, dry.	Roots and organics.	100		N/S
					200		
					300		
					400		
					500		
0.2	2.7	ALLUVIUM	SILT, [ML], very stiff, non-plastic, white, with gravel and sand, dry.	Excavated as rock.	600		Bulk x2
					700		
					800		
					900		
					1000		
2.7	EOH	REFUSAL			1100		
					1200		
					1300		
					1400		
					1500		
					1600		
					1700		
					1800		
					1900		
					2000		
					2100		
					2200		
					2300		
					2400		
					2500		
					2600		
					2700		
					2800		
					2900		
					3000		

NOTES AND COMMENTS

Many small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m and few small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m.

Groundwater recorded at _____ m on the ____/____/____.

Co-ordinate System:_____, Zone: _____.

Origin	Soil Name	Group	Consistency	Plasticity/Grain size	Colour	With/Trace	Moisture
TOPSOIL	Primary	Pt	Fine Grain:	Fine grain:	red	clay	dry
CONCRETE	PEAT	OH	very soft	non-plastic	orange	silt	dry to moist
BITUMEN	CLAY	OL	soft	low plasticity	yellow	sand	moist
FILL	SILT	CH	firm	low - medium	brown	gravel	wet
BASSENDEAN SAND	SAND	CL	stiff	medium plasticity	purple	cobbles	moist to wet
SAND FROM TAMALA LST	GRAVEL	MH	very stiff	medium to high	green	OM	saturated
TAMALA LST	COBBLES	ML	hard	high plasticity	white	BR	
GUILDFORD FORMATION	BOULDERS	SW	Coarse Grain:	Coarse Grain:	cream	Fines:	
ALLUVIUM	Scondary:	SP	very loose	Fine	grey	<=15% "Trace"	
COLLUVIUM	clayey	SC	loose	Medium	black	15-30% "With"	
AEOLIAN	silty	SM	medium dense	Coarse Grain:	blue	>30% "Secondary"	
SWAMP DEPOSIT	sandy	GW	dense	Additional:	Additional:	Coarse:	
LATERITE	gravelly	GP	very dense	Unifor, gap graded, poorly graded. Rounded, sub rounded, sub angular, angular, flaky, platy	Can be modified using pale, dark and motled	<=5% "Trace"	
	cobbly	GC				5-12% "With"	
	bouldery	GM				>12% "Secondary"	

Test pit TP 15 – 2.7m refusal. TOPSOIL and gravelly ALLUVIUM; brown grey surficial top soil and white siltstone with some cobbles.

TEST PIT LOG

Job No:	P02-17	Date Started:	21/11/2017
Test Pit ID:	TP 16	Date Finished:	21/11/2017
Contractor:	Gary	Bucket Width:	0.55m
Machine:	JCB	Easting:	-33.6852333
Logged By:	Harvey Morcom	Northing:	120.210323

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Depths (From)	Depths (To)	Main material	Material Description	Comments	DCP Depth (mm)	DCP Blows/100m	Laboratory Samples
0	0.2	TOPSOIL	sandy gravelly SILT, [ML], firm, non-plastic, brown grey with gravel, dry.	Roots and organics.	100		N/S
					200		
					300		
					400		
					500		
0.2	0.6	ALLUVIUM	gravelly SILT, [ML], very stiff, low plasticity, red brown, with gravel, dry.	Excavated as rock. Lateritic formation.	600		Bulk
					700		
					800		
					900		
					1000		
0.6	1	ALLUVIUM	SILT, [ML], very stiff, low plasticity, red brown white blend, with gravel, dry.	transition phase between soil units above and below.	1100		Bulk
					1200		
					1300		
					1400		
					1500		
1	2.8	ALLUVIUM	SILT, [ML], very stiff, non-plastic, white, with gravel and sand, dry.	Excavated as rock.	1600		Bulk
					1700		
					1800		
					1900		
					2000		
2.8	EOH	TERMINATED			2100		
					2200		
					2300		
					2400		
					2500		
					2600		
					2700		
					2800		
					2900		
					3000		

NOTES AND COMMENTS

Many small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m and few small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m.

Groundwater recorded at _____ m on the ____/____/____.

Co-ordinate System:_____, Zone: _____.

Origin	Soil Name	Group	Consistency	Plasticity/Grain size	Colour	With/Trace	Moisture
TOPSOIL	Primary	Pt	Fine Grain:	Fine grain:	red	clay	dry
CONCRETE	PEAT	OH	very soft	non-plastic	orange	silt	dry to moist
BITUMEN	CLAY	OL	soft	low plasticity	yellow	sand	moist
FILL	SILT	CH	firm	low - medium	brown	gravel	wet
BASSENDEAN SAND	SAND	CL	stiff	medium plasticity	purple	cobbles	moist to wet
SAND FROM TAMALA LST	GRAVEL	MH	very stiff	medium to high	green	OM	saturated
TAMALA LST	COBBLES	ML	hard	high plasticity	white	BR	
GUILDFORD FORMATION	BOULDERS	SW	Coarse Grain:	Coarse Grain:	cream	Fines:	
ALLUVIUM	Scondary:	SP	very loose	Fine	grey	<=15% "Trace"	
COLLUVIUM	clayey	SC	loose	Medium	black	15-30% "With"	
AEOLIAN	silty	SM	medium dense	Coarse Grain:	blue	>30% "Secondary"	
SWAMP DEPOSIT	sandy	GW	dense	Additional:	Additional:	Coarse:	
LATERITE	gravelly	GP	very dense	Unifor, gap graded, poorly graded. Rounded, sub rounded, sub angular, angular, flaky, platy	Can be modified using pale, dark and motled	<=5% "Trace"	
	cobbly	GC				5-12% "With"	
	bouldery	GM				>12% "Secondary"	

Test pit TP 16 – 2.8m termination. TOPSOIL and gravelly ALLUVIUM; red brown surficial top soil and white siltstone with some gravel.

TEST PIT LOG

Job No:	P02-17	Date Started:	21/11/2017
Test Pit ID:	TP 17	Date Finished:	21/11/2017
Contractor:	Gary	Bucket Width:	0.55m
Machine:	JCB	Easting:	-33.6852913
Logged By:	Harvey Morcom	Northing:	120.2093694

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Depths (From)	Depths (To)	Main material	Material Description	Comments	DCP Depth (mm)	DCP Blows/100m	Laboratory Samples
0	0.2	TOPSOIL	sandy gravelly SILT, [ML], firm, non-plastic, brown grey with gravel, dry.	Roots and organics.	100		N/S
					200		
					300		
					400		
					500		
0.2	0.6	ALLUVIUM	sandy SILT, [ML], very stiff, low plasticity, yellow brown, with gravel, dry.	Yellow brown transition between topsoil and red brown silt beneath.	600		N/S
					700		
					800		
					900		
					1000		
0.6	1.2	ALLUVIUM	SILT, [ML], very stiff, low plasticity, red brown, with gravel, dry.	Cobbled, conglomertitc, contains large quartz clasts.	1100		Bulk
					1200		
					1300		
					1400		
					1500		
1.2	2.7	ALLUVIUM	SILT, [ML], very stiff, non-plastic, white, with gravel and sand, dry.	Excavated as rock.	1600		Bulk
					1700		
					1800		
					1900		
					2000		
2.7	EOH	TERMINATED			2100		
					2200		
					2300		
					2400		
					2500		
					2600		
					2700		
					2800		
					2900		
					3000		

NOTES AND COMMENTS

Many small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m and few small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m.

Groundwater recorded at _____ m on the ____/____/____.

Co-ordinate System:_____, Zone: _____.

Origin	Soil Name	Group	Consistency	Plasticity/Grain size	Colour	With/Trace	Moisture
TOPSOIL	Primary	Pt	Fine Grain:	Fine grain:	red	clay	dry
CONCRETE	PEAT	OH	very soft	non-plastic	orange	silt	dry to moist
BITUMEN	CLAY	OL	soft	low plasticity	yellow	sand	moist
FILL	SILT	CH	firm	low - medium	brown	gravel	wet
BASSENDEAN SAND	SAND	CL	stiff	medium plasticity	purple	cobbles	moist to wet
SAND FROM TAMALA LST	GRAVEL	MH	very stiff	medium to high	green	OM	saturated
TAMALA LST	COBBLES	ML	hard	high plasticity	white	BR	
GUILDFORD FORMATION	BOULDERS	SW	Coarse Grain:	Coarse Grain:	cream	Fines:	
ALLUVIUM	Scondary:	SP	very loose	Fine	grey	<=15% "Trace"	
COLLUVIUM	clayey	SC	loose	Medium	black	15-30% "With"	
AEOLIAN	silty	SM	medium dense	Coarse Grain:	blue	>30% "Secondary"	
SWAMP DEPOSIT	sandy	GW	dense	Additional:	Additional:	Coarse:	
LATERITE	gravelly	GP	very dense	Unifor, gap graded, poorly graded. Rounded, sub rounded, sub angular, angular, flaky, platy	Can be modified using pale, dark and motled	<=5% "Trace"	
	cobbly	GC				5-12% "With"	
	bouldery	GM				>12% "Secondary"	

Test pit TP 17 – 2.7m termination. TOPSOIL (right) grading into ALLUVIUM, white siltstone (left).

TEST PIT LOG

Job No:	P02-17	Date Started:	21/11/2017
Test Pit ID:	TP 18	Date Finished:	21/11/2017
Contractor:	Gary	Bucket Width:	0.55m
Machine:	JCB	Easting:	-33.6853516
Logged By:	Harvey Morcom	Northing:	120.2085011

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Depths (From)	Depths (To)	Main material	Material Description	Comments	DCP Depth (mm)	DCP Blows/100m	Laboratory Samples
0	0.2	TOPSOIL	sandy SILT, [ML], firm, non-plastic, brown grey with gravel and sand, dry.	Roots and organics.	100		N/S
					200		
					300		
					400		
					500		
0.2	0.6	ALLUVIUM	sandy SILT, [ML], very stiff, low plasticity, yellow brown, with gravel, dry.	Yellow brown transition between topsoil and red brown silt beneath.	600		Bulk
					700		
					800		
					900		
					1000		
0.6	1.2	ALLUVIUM	SILT, [ML], very stiff, low plasticity, red brown, with gravel, dry.	Cobbled, conglomertitc, contains large quartz clasts.	1100		Bulk
					1200		
					1300		
					1400		
					1500		
1.2	2.8	ALLUVIUM	SILT, [ML], very stiff, non-plastic, yellow white, with gravel and sand, dry.	Excavated as rock.	1600		Bulk x2
					1700		
					1800		
					1900		
					2000		
2.8	EOH	TERMINATED			2100		
					2200		
					2300		
					2400		
					2500		
					2600		
					2700		
					2800		
					2900		
					3000		

NOTES AND COMMENTS

Many small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m and few small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m.

Groundwater recorded at _____ m on the ____/____/____.

Co-ordinate System:_____, Zone: _____.

Origin	Soil Name	Group	Consistency	Plasticity/Grain size	Colour	With/Trace	Moisture
TOPSOIL	Primary	Pt	Fine Grain:	Fine grain:	red	clay	dry
CONCRETE	PEAT	OH	very soft	non-plastic	orange	silt	dry to moist
BITUMEN	CLAY	OL	soft	low plasticity	yellow	sand	moist
FILL	SILT	CH	firm	low - medium	brown	gravel	wet
BASSENDEAN SAND	SAND	CL	stiff	medium plasticity	purple	cobbles	moist to wet
SAND FROM TAMALA LST	GRAVEL	MH	very stiff	medium to high	green	OM	saturated
TAMALA LST	COBBLES	ML	hard	high plasticity	white	BR	
GUILDFORD FORMATION	BOULDERS	SW	Coarse Grain:	Coarse Grain:	cream	Fines:	
ALLUVIUM	Scondary:	SP	very loose	Fine	grey	<=15% "Trace"	
COLLUVIUM	clayey	SC	loose	Medium	black	15-30% "With"	
AEOLIAN	silty	SM	medium dense	Coarse Grain:	blue	>30% "Secondary"	
SWAMP DEPOSIT	sandy	GW	dense	Additional:	Additional:	Coarse:	
LATERITE	gravelly	GP	very dense	Unifor, gap graded, poorly graded. Rounded, sub rounded, sub angular, angular, flaky, platy	Can be modified using pale, dark and motled	<=5% "Trace"	
	cobbly	GC				5-12% "With"	
	bouldery	GM				>12% "Secondary"	

Test pit TP 18 – 2.7m termination. TOPSOIL (right) grading into ALLUVIUM, white siltstone (left).

TEST PIT LOG

Job No:	P02-17	Date Started:	21/11/2017
Test Pit ID:	TP 19	Date Finished:	21/11/2017
Contractor:	Gary	Bucket Width:	0.55m
Machine:	JCB	Easting:	-33.6854116
Logged By:	Harvey Morcom	Northing:	120.2077879

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Depths (From)	Depths (To)	Main material	Material Description	Comments	DCP Depth (mm)	DCP Blows/100m	Laboratory Samples
0	0.2	TOPSOIL	sandy SILT, [ML], firm, non-plastic, brown grey with gravel and sand, dry.	Roots and organics.	100		N/S
					200		
					300		
					400		
					500		
0.2	0.6	ALLUVIUM	sandy SILT, [ML], very stiff, low plasticity, white and red brown, with gravel, dry.	White and red brown transition.	600		Bulk
					700		
					800		
					900		
					1000		
0.6	2.8	ALLUVIUM	SILT, [ML], very stiff, non-plastic, white, with gravel and sand, dry.	Excavated as rock.	1100		Bulk
					1200		
					1300		
					1400		
					1500		
2.8	EOH	TERMINATED			1600		
					1700		
					1800		
					1900		
					2000		
					2100		
					2200		
					2300		
					2400		
					2500		
					2600		
					2700		
					2800		
					2900		
					3000		

NOTES AND COMMENTS

Many small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m and few small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m.

Groundwater recorded at _____ m on the ____/____/____.

Co-ordinate System:_____, Zone: _____.

Origin	Soil Name	Group	Consistency	Plasticity/Grain size	Colour	With/Trace	Moisture
TOPSOIL	Primary	Pt	Fine Grain:	Fine grain:	red	clay	dry
CONCRETE	PEAT	OH	very soft	non-plastic	orange	silt	dry to moist
BITUMEN	CLAY	OL	soft	low plasticity	yellow	sand	moist
FILL	SILT	CH	firm	low - medium	brown	gravel	wet
BASSENDEAN SAND	SAND	CL	stiff	medium plasticity	purple	cobbles	moist to wet
SAND FROM TAMALA LST	GRAVEL	MH	very stiff	medium to high	green	OM	saturated
TAMALA LST	COBBLES	ML	hard	high plasticity	white	BR	
GUILDFORD FORMATION	BOULDERS	SW	Coarse Grain:	Coarse Grain:	cream	Fines:	
ALLUVIUM	Scondary:	SP	very loose	Fine	grey	<=15% "Trace"	
COLLUVIUM	clayey	SC	loose	Medium	black	15-30% "With"	
AEOLIAN	silty	SM	medium dense	Coarse Grain:	blue	>30% "Secondary"	
SWAMP DEPOSIT	sandy	GW	dense	Additional:	Additional:	Coarse:	
LATERITE	gravelly	GP	very dense	Unifor, gap graded, poorly graded. Rounded, sub rounded, sub angular, angular, flaky, platy	Can be modified using pale, dark and motled	<=5% "Trace"	
	cobbly	GC				5-12% "With"	
	bouldery	GM				>12% "Secondary"	

Test pit TP 19 – 2.8m termination. TOPSOIL grading into ALLUVIUM, white siltstone.

TEST PIT LOG

Job No:	P02-17	Date Started:	21/11/2017
Test Pit ID:	TP 20	Date Finished:	21/11/2017
Contractor:	Gary	Bucket Width:	0.55m
Machine:	JCB	Easting:	-33.6854699
Logged By:	Harvey Morcom	Northing:	120.206819

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ABN: 53 4043 898 19
MHAGeotechnical.com.au
E: info@mhageotechnical.com.au

Depths (From)	Depths (To)	Main material	Material Description	Comments	DCP Depth (mm)	DCP Blows/100m	Laboratory Samples
0	0.2	TOPSOIL	sandy SILT, [ML], firm, non-plastic, brown grey with gravel and sand, dry.	Roots and organics.	100		N/S
					200		
					300		
					400		
					500		
0.2	0.4	ALLUVIUM	sandy SILT, [ML], very stiff, low plasticity, white brown, with gravel, dry.	Indurated, excavated as rock.	600		Bulk
					700		
					800		
					900		
					1000		
0.4	1.3	ALLUVIUM	SILT, [ML], very stiff, non-plastic, white yellow, with gravel and sand, dry.	Lateritic conglomerate.	1100		Bulk
					1200		
					1300		
					1400		
					1500		
1.3	EOH	REFUSAL			1600		
					1700		
					1800		
					1900		
					2000		
					2100		
					2200		
					2300		
					2400		
					2500		
					2600		
					2700		
					2800		
					2900		
					3000		

NOTES AND COMMENTS

Many small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m and few small (1 - 2 mm) / medium (2 - 10 mm) / large (>10 mm) roots to _____ m.

Groundwater recorded at _____ m on the ____/____/____.

Co-ordinate System:_____, Zone: _____.

Origin	Soil Name	Group	Consistency	Plasticity/Grain size	Colour	With/Trace	Moisture
TOPSOIL	Primary	Pt	Fine Grain:	Fine grain:	red	clay	dry
CONCRETE	PEAT	OH	very soft	non-plastic	orange	silt	dry to moist
BITUMEN	CLAY	OL	soft	low plasticity	yellow	sand	moist
FILL	SILT	CH	firm	low - medium	brown	gravel	wet
BASSENDEAN SAND	SAND	CL	stiff	medium plasticity	purple	cobbles	moist to wet
SAND FROM TAMALA LST	GRAVEL	MH	very stiff	medium to high	green	OM	saturated
TAMALA LST	COBBLES	ML	hard	high plasticity	white	BR	
GUILDFORD FORMATION	BOULDERS	SW	Coarse Grain:	Coarse Grain:	cream	Fines:	
ALLUVIUM	Scondary:	SP	very loose	Fine	grey	<=15% "Trace"	
COLLUVIUM	clayey	SC	loose	Medium	black	15-30% "With"	
AEOLIAN	silty	SM	medium dense	Coarse Grain:	blue	>30% "Secondary"	
SWAMP DEPOSIT	sandy	GW	dense	Additional:	Additional:	Coarse:	
LATERITE	gravelly	GP	very dense	Unifor, gap graded, poorly graded. Rounded, sub rounded, sub angular, angular, flaky, platy	Can be modified using pale, dark and motled	<=5% "Trace"	
	cobbly	GC				5-12% "With"	
	bouldery	GM				>12% "Secondary"	

Test pit TP 20 – 1.3m refusal. TOPSOIL into lateritic ALLUVIUM, gravelly and conglomeritic.

Appendix C

Geotechnical Field Investigation Field Permeability Test Results
(MHA Geotechnical Pty Ltd)

Summary of Field Falling Head Tests									
Site/Location: ACH Minerals - Ravensthorpe Gold Project - Tailings Storage Facility									
Number	Saturation	Location (Decimal Degrees)		Date	Time	Time Interval	Water Level	h	k
		Latitude	Longitude						
		(mE)	(mS)			(min)	(mbToC)	(m)	(m/s)
TP 03	Unsaturated	241073	6269009	Tuesday, 21 November 2017	12:42:00	0	-0.060	-0.060	-
				Temperature: 36°C	16:28:00	15240	-0.095	-0.0350	7.9E-06
		Test Column	Depth	0.600					
			Diameter	0.110					
			Surface Area of base	0.0095					
								Ave	7.94E-06
	Partially Saturated	241073	6269009	Tuesday, 21 November 2017	16:48:00	0	-0.036	-0.036	-
				Temperature: 36°C	18:22:00	5640	-0.065	-0.0290	2.6E-05
		Test Column	Depth	0.600	6:52:00	383400	-0.175	-0.1100	1.0E-07
			Diameter	0.110					
			Surface Area of base	0.0095					
								Ave	1.30E-05
	Saturated	241073	6269009	Tuesday, 21 November 2017	6:59:00	0	-0.038	-0.038	-
				Temperature: 36°C	9:10:00	7860	-0.070	-0.0320	1.7E-05
		Test Column	Depth	0.600	10:27:00	476220	-0.075	-0.0050	1.8E-06
			Diameter	0.110					
			Surface Area of base	0.0095					
								Ave	9.32E-06
TP 07	Unsaturated	241292	268835	Tuesday, 21 November 2017	12:45:00	0	-0.100	-0.100	-
				Temperature: 36°C	16:31:00	12960	-0.425	-0.3250	1.0E-06
		Test Column	Depth	0.400					
			Diameter	0.110					
			Surface Area of base	0.0095					
								Ave	1.01E-06
	Partially Saturated	241292	268835	Tuesday, 21 November 2017	16:31:00	0	-0.073	-0.073	-
				Temperature: 36°C	6:05:00	41640	-0.420	-0.3470	2.9E-07
		Test Column	Depth	0.400	7:03:00	45120	-0.425	-0.0050	2.4E-04
			Diameter	0.110					
			Surface Area of base	0.0095					
								Ave	1.22E-04
	Saturated	241292	268835	Tuesday, 21 November 2017	7:03:00	0	-0.114	-0.114	-
				Temperature: 36°C	8:55:00	6780	-0.410	-0.2960	2.1E-06
		Test Column	Depth	0.400	10:11:00	11340	-0.042	0.3685	4.5E-06
			Diameter	0.110					
			Surface Area of base	0.0095					
								Ave	3.33E-06
TP 12	Unsaturated			Tuesday, 21 November 2017	13:11:00	0	0.000	0.000	-
				Temperature: 36°C	13:19:00	480	-0.050	-0.0500	1.8E-04
		Test Column	Depth	0.600	13:34:00	1380	-0.080		1.6E-04
			Diameter	0.110	16:36:00	12300	-0.150		5.5E-06
			Surface Area of base	0.0095					
								Ave	1.13E-04
	Partially Saturated			Tuesday, 21 November 2017	16:36:00	0	-0.037	-0.037	-
				Temperature: 36°C	6:15:00	49140	-0.190	-0.1530	5.6E-07
		Test Column	Depth	0.600	7:22:00	53160	-0.210	-0.0200	5.3E-05
			Diameter	0.110					
			Surface Area of base	0.0095					
								Ave	2.66E-05
	Saturated			Tuesday, 21 November 2017	7:22:00	0	-0.075	-0.075	-
				Temperature: 36°C	8:58:00	5760	-0.175	-0.1000	7.4E-06
		Test Column	Depth	0.600	10:15:00	10380	-0.195	-0.0200	4.6E-05
			Diameter	0.110					
			Surface Area of base	0.0095					
								Ave	2.66E-05
TP 13	Unsaturated			Tuesday, 21 November 2017	13:46:00	0	-0.090	-0.090	-
				Temperature: 36°C	13:57:00	660	-0.110	-0.0200	3.2E-04
		Test Column	Depth	0.600	18:18:00	16320	-0.330		1.2E-06
			Diameter	0.110	7:19:00	55980	-0.045		
			Surface Area of base	0.0095					
								Ave	1.61E-04
	Partially Saturated			Tuesday, 21 November 2017				0.000	-
				Temperature: 36°C				#REF!	#REF!
		Test Column	Depth	0.600				#REF!	#REF!
			Diameter	0.110					
			Surface Area of base	0.0095					
								Ave	#REF!
	Saturated			Tuesday, 21 November 2017	7:19:00	0	-0.172	#REF!	-
				Temperature: 36°C	9:00:00	6060	-0.220	#REF!	1.5E-05
		Test Column	Depth	0.600	10:17:00	10680	-0.240	#REF!	4.6E-05
			Diameter	0.110					

			Surface Area of base	0.0095					
								Ave	3.02E-05
TP 16-17	Unsaturated			Tuesday, 21 November 2017	12:51:00	0	-0.040	-0.040	-
				Temperature: 36°C	14:02:00	4260	-0.110	-0.0700	1.4E-05
		Test Column	Depth	0.600	14:15:00	5040	-0.125		3.6E-04
			Diameter	0.110	16:40:00	14340	-0.201		6.0E-06
			Surface Area of base	0.0095					
								Ave	1.27E-04
	Partially Saturated			Tuesday, 21 November 2017	16:40:00	0	-0.037	-0.037	-
				Temperature: 36°C	18:18:00	5880	-0.080	-0.0430	1.7E-05
		Test Column	Depth	0.600	7:15:00	52860	-0.290	-0.2100	4.3E-07
			Diameter	0.110					
			Surface Area of base	0.0095					
								Ave	8.59E-06
	Saturated			Tuesday, 21 November 2017	7:15:00	0	-0.070	-0.070	-
				Temperature: 36°C	9:00:00	6300	-0.100	-0.0300	2.2E-05
		Test Column	Depth	0.600	10:20:00	11100	-0.130	-0.0300	2.9E-05
			Diameter	0.110					
			Surface Area of base	0.0095					
								Ave	2.59E-05
TP 19	Unsaturated			Tuesday, 21 November 2017	14:58:00	0	0.000	0.000	-
				Temperature: 36°C	15:22:00	1440	-0.065	-0.0650	4.5E-05
		Test Column	Depth	0.600	16:48:00	6600	-0.100		2.3E-05
			Diameter	0.110	18:20:00	12120	-0.110		7.7E-05
			Surface Area of base	0.0095	7:11:00	58380	-0.182		1.3E-06
								Ave	3.67E-05
	Partially Saturated			Tuesday, 21 November 2017	7:11:00	0	-0.052	-0.052	-
				Temperature: 36°C	9:06:00	6900	-0.080	-0.0280	2.2E-05
		Test Column	Depth	0.600	10:22:00	11460	-0.090	-0.0100	9.3E-05
			Diameter	0.110					
			Surface Area of base	0.0095					
								Ave	5.74E-05
	Saturated			Tuesday, 21 November 2017				0.000	-
				Temperature: 36°C				0.0000	2.2E-05
		Test Column	Depth	0.600				0.0000	9.3E-05
			Diameter	0.110					
			Surface Area of base	0.0095					
								Ave	5.74E-05

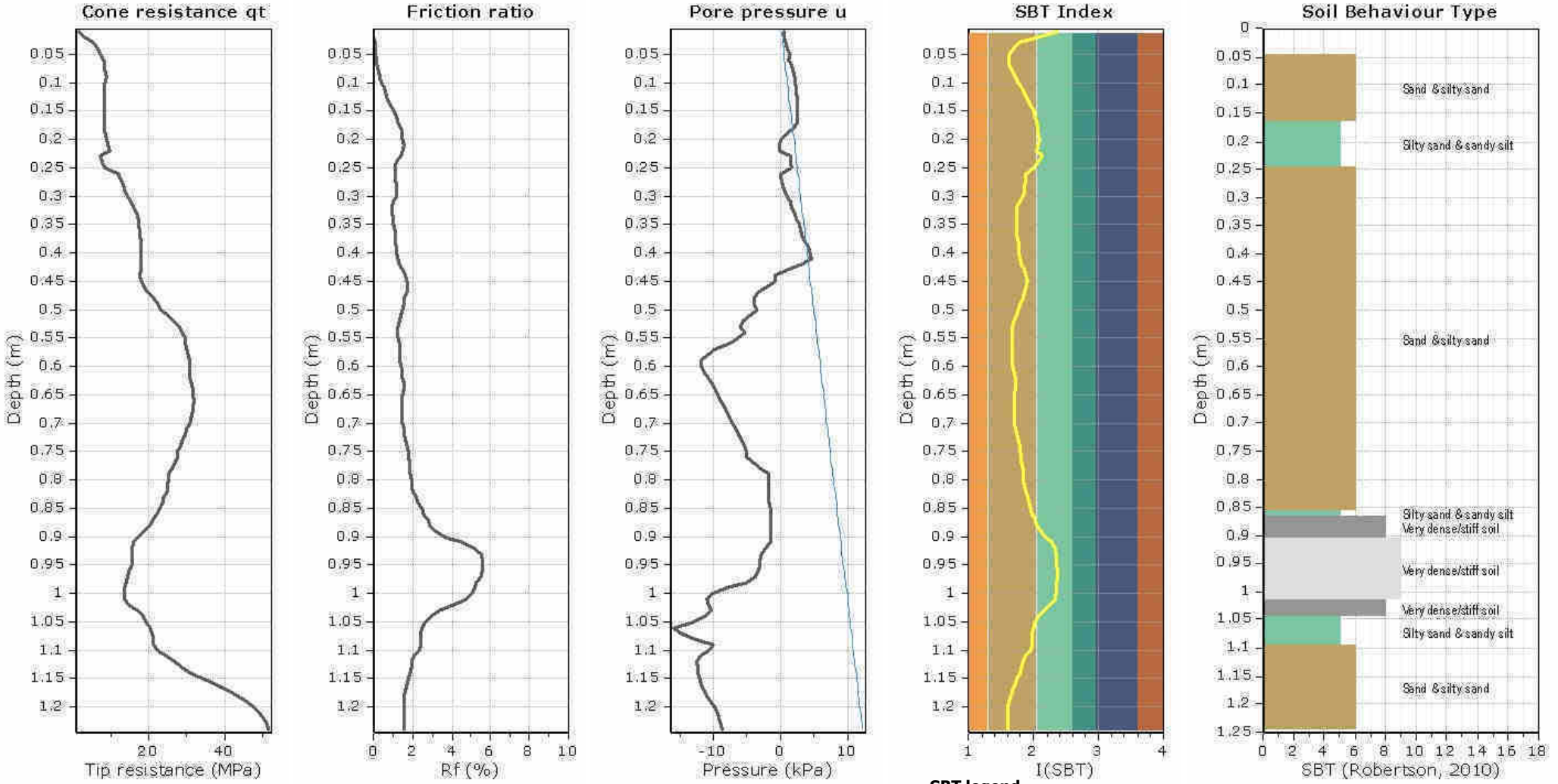
Appendix D

Geotechnical Field Investigation CPT Results
(MHA Geotechnical Pty Ltd)

MHA Geotechnical
Suite 2, 464 Murray St PERTH
T: +61 8 6110 4768
www.mhageotechnical.com.au

Project:
Location:

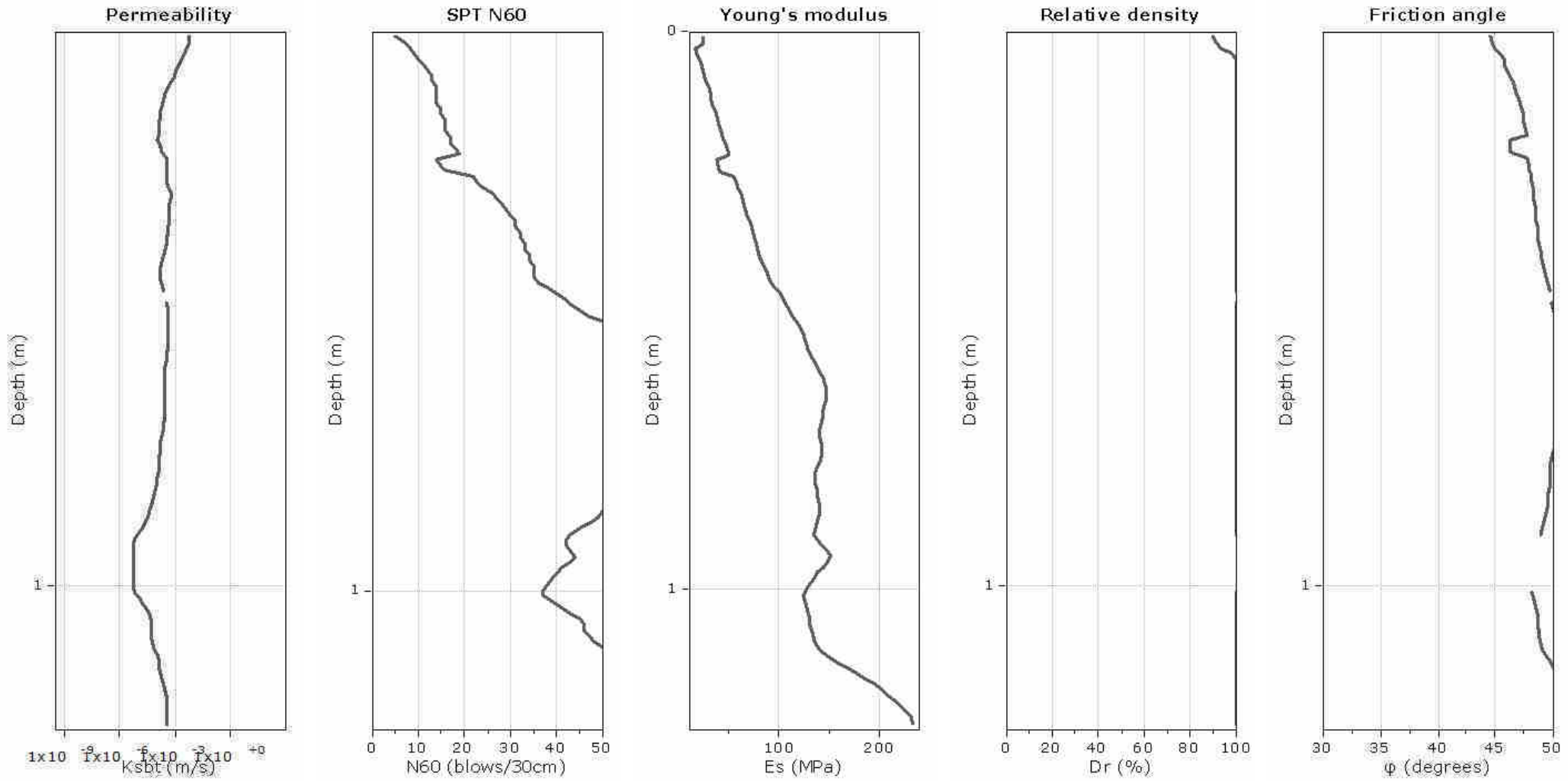
CPT: CPT 6
Total depth: 1.24 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



MHA Geotechnical
Suite 2, 464 Murray St PERTH
T: +61 8 6110 4768
www.mhageotechnical.com.au

Project:
Location:

CPT: CPT 6
Total depth: 1.24 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



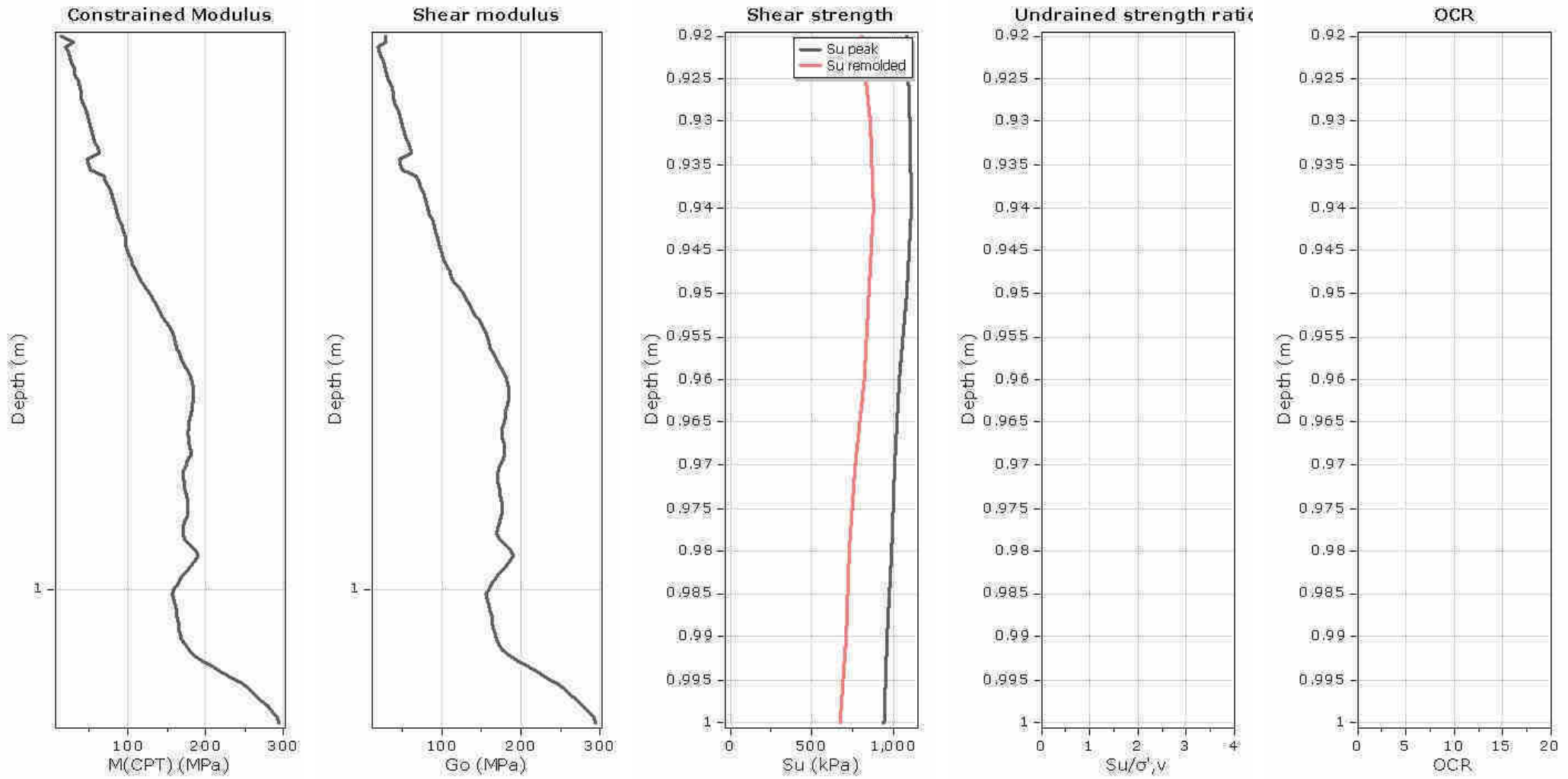
Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

MHA Geotechnical
Suite 2, 464 Murray St PERTH
T: +61 8 6110 4768
www.mhageotechnical.com.au

Project:
Location:

CPT: CPT 6
Total depth: 1.24 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14
OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

MHA Geotechnical
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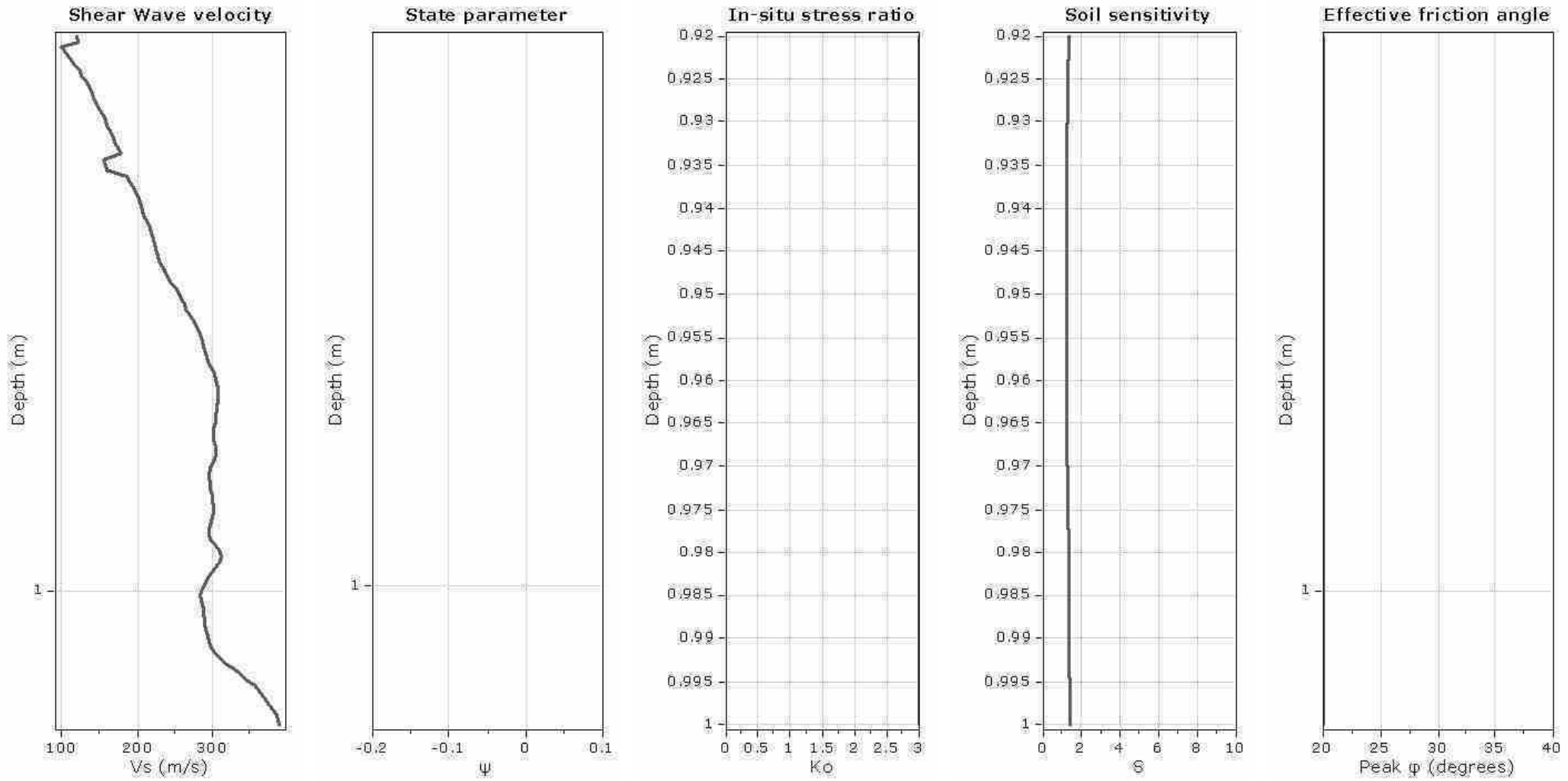
T: +61 8 6110 4768
www.mhageotechnical.com.au

Project:
Location:

CPT: CPT 6
Total depth: 1.24 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



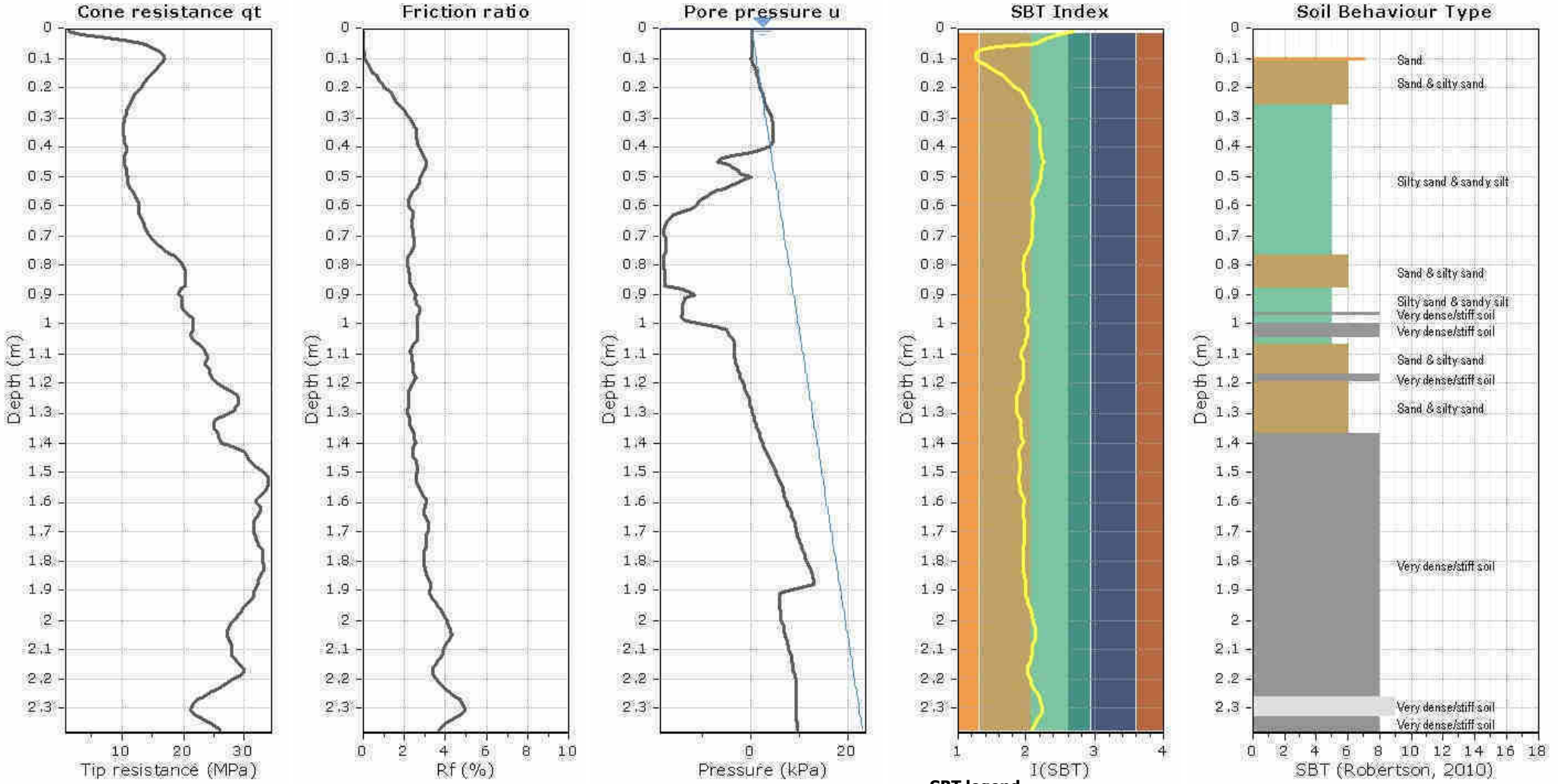
Calculation parameters

Soil Sensitivity factor, N_S: 7.00
User defined estimation data

MHA Geotechnical
Suite 2, 464 Murray St PERTH
T: +61 8 6110 4768
www.mhageotechnical.com.au

Project:
Location:

CPT: CPT 7
Total depth: 2.37 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



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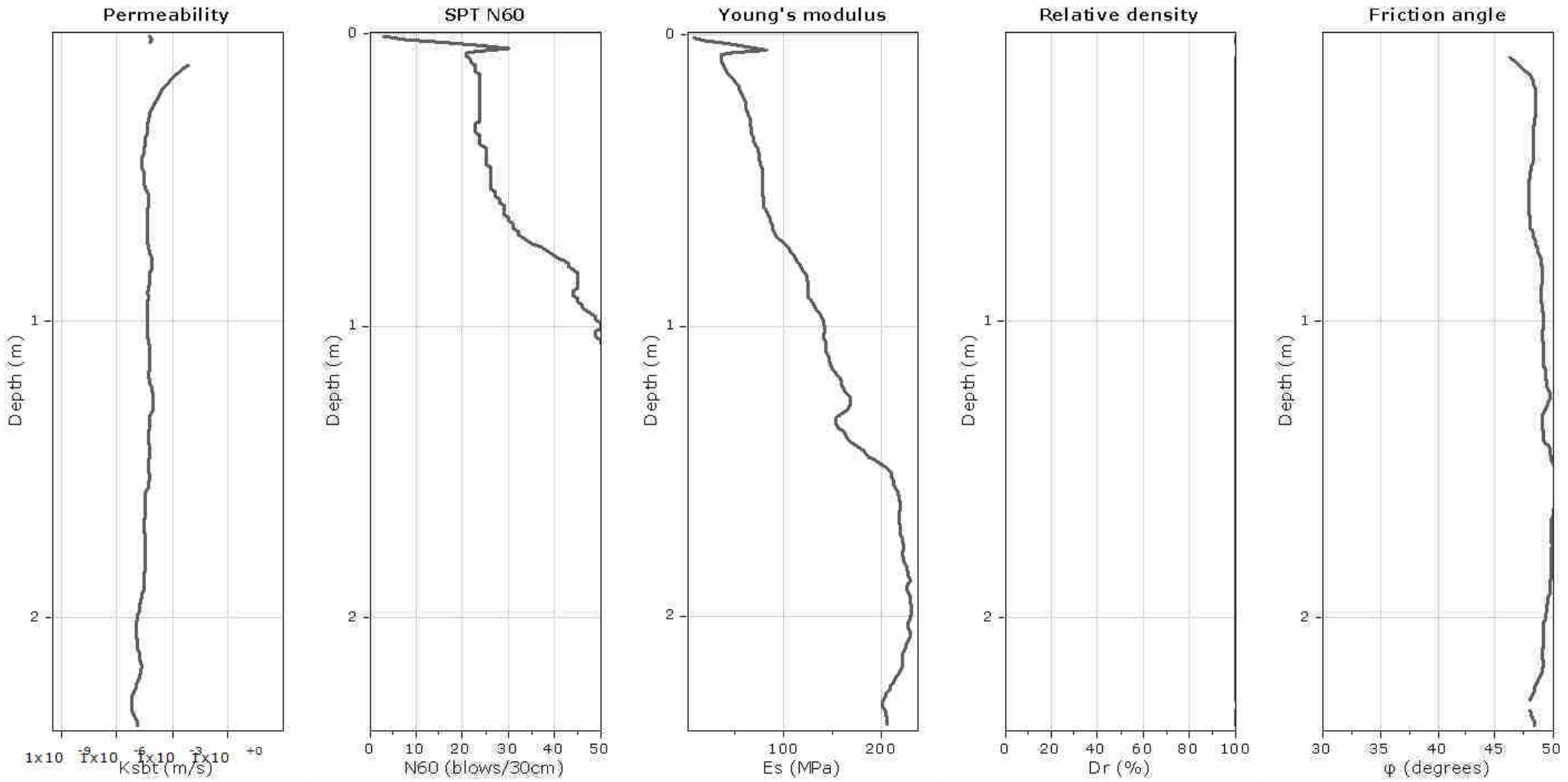
www.mhageotechnical.com.au

Project:
Location:

CPT: CPT 7
Total depth: 2.37 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

MHA Geotechnical
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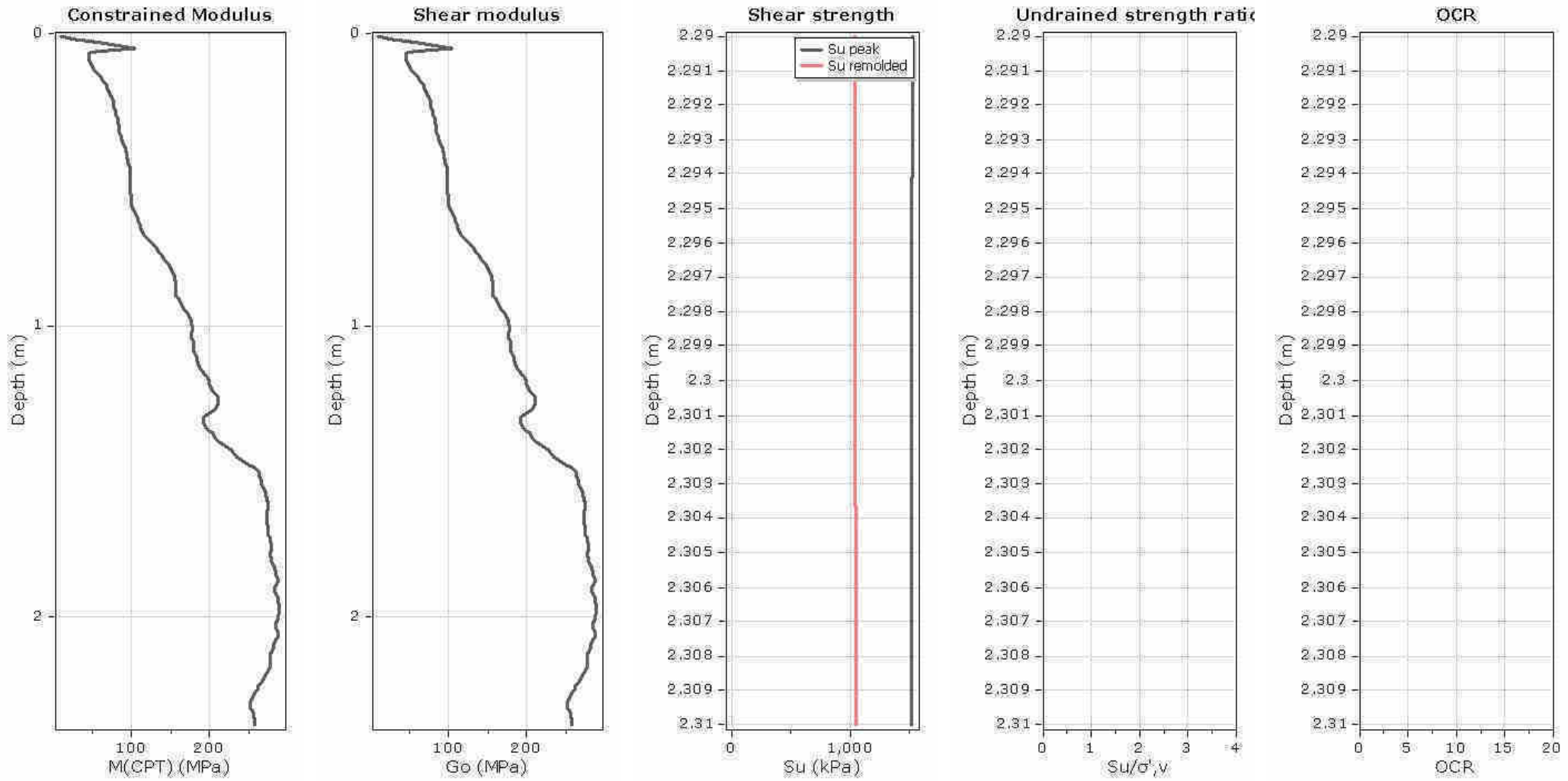
Project:
Location:

CPT: CPT 7
Total depth: 2.37 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14

OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

MHA Geotechnical
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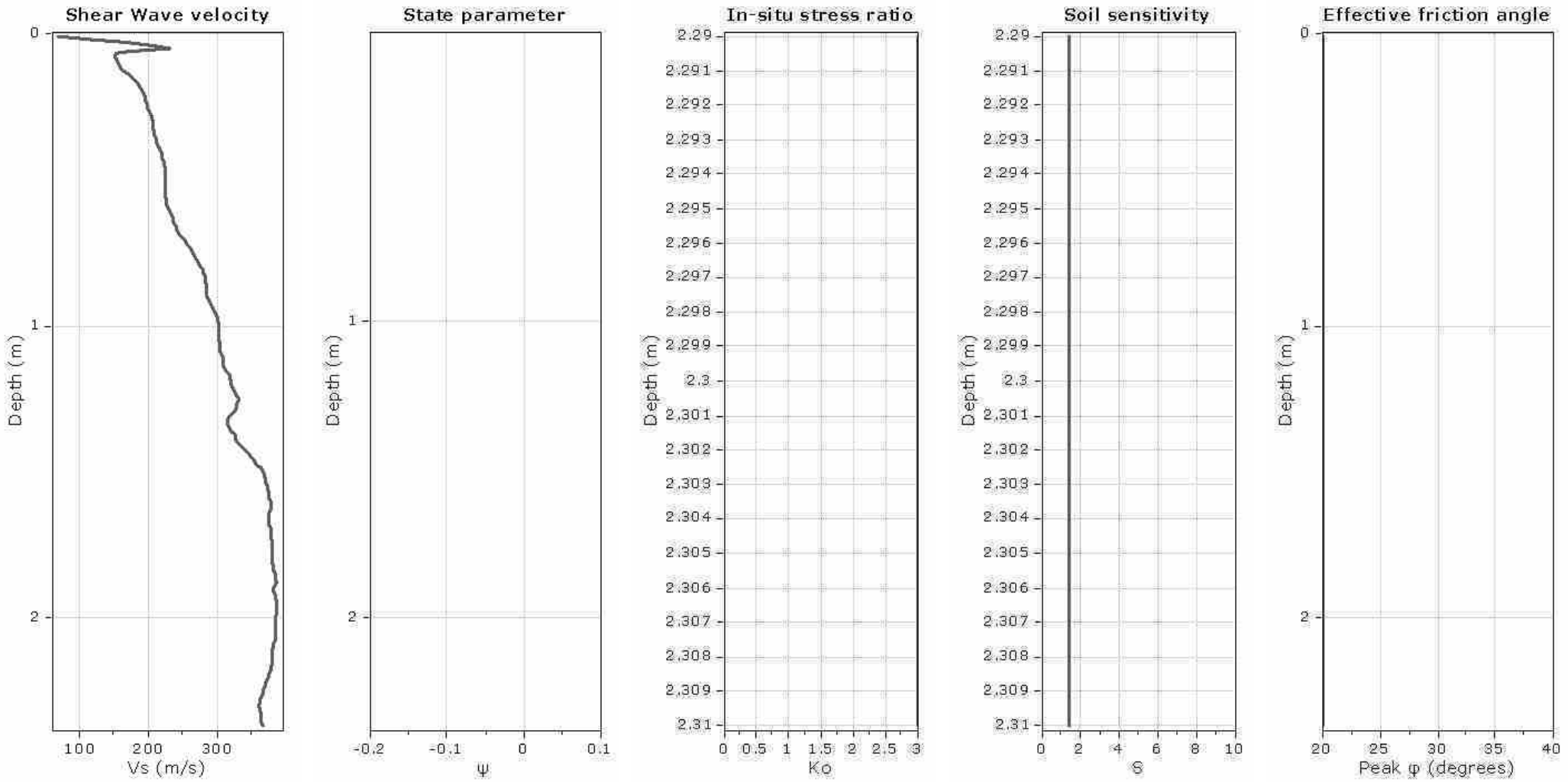
Project:
Location:

CPT: CPT 7
Total depth: 2.37 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



Calculation parameters

Soil Sensitivity factor, N_S: 7.00
User defined estimation data

MHA Geotechnical
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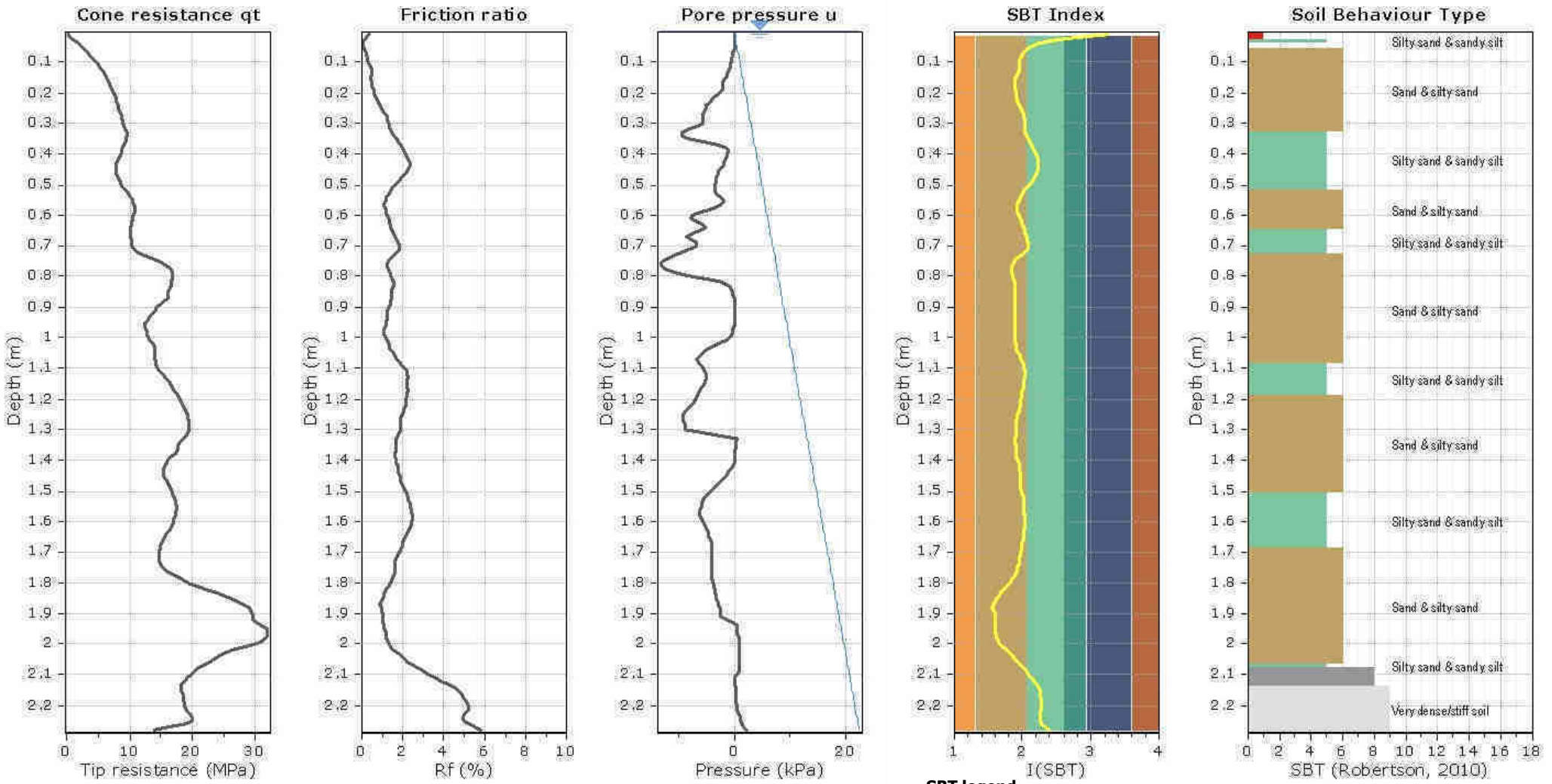
www.mhageotechnical.com.au

Project:
Location:

CPT: CPT 12
Total depth: 2.28 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

MHA Geotechnical
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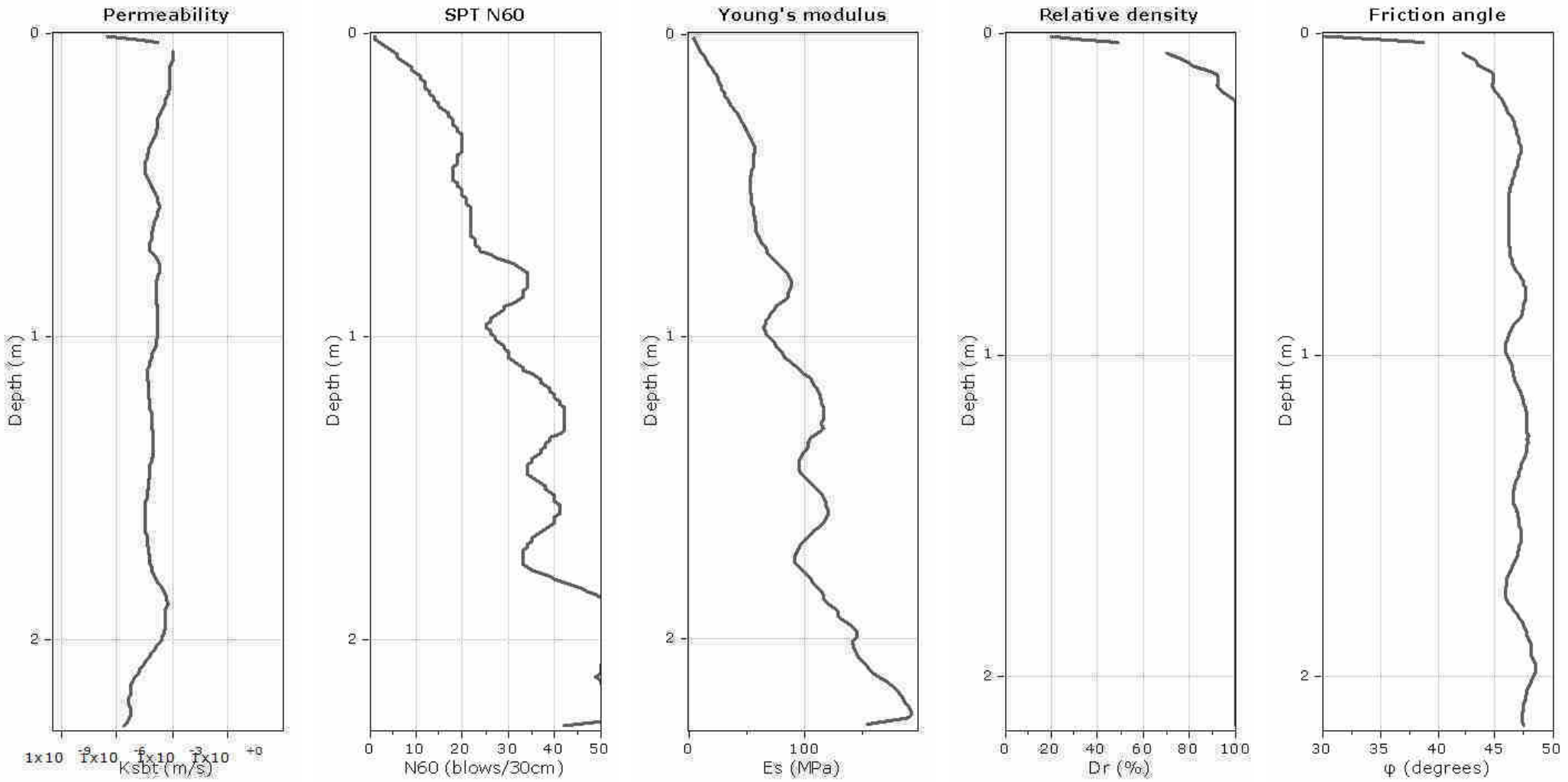
www.mhageotechnical.com.au

Project:
Location:

CPT: CPT 12
Total depth: 2.28 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

MHA Geotechnical
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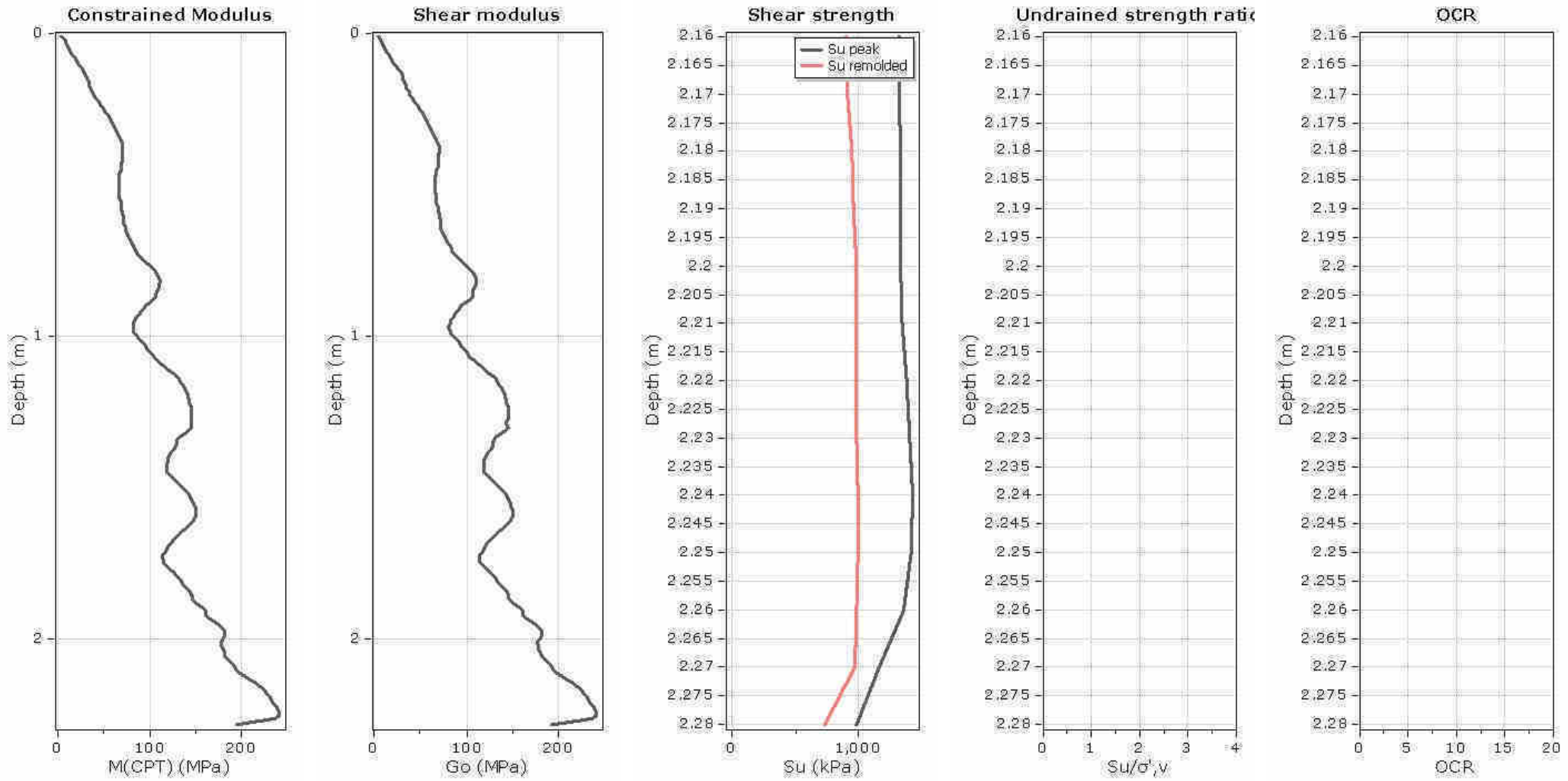
Project:
Location:

CPT: CPT 12
Total depth: 2.28 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14

OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

MHA Geotechnical
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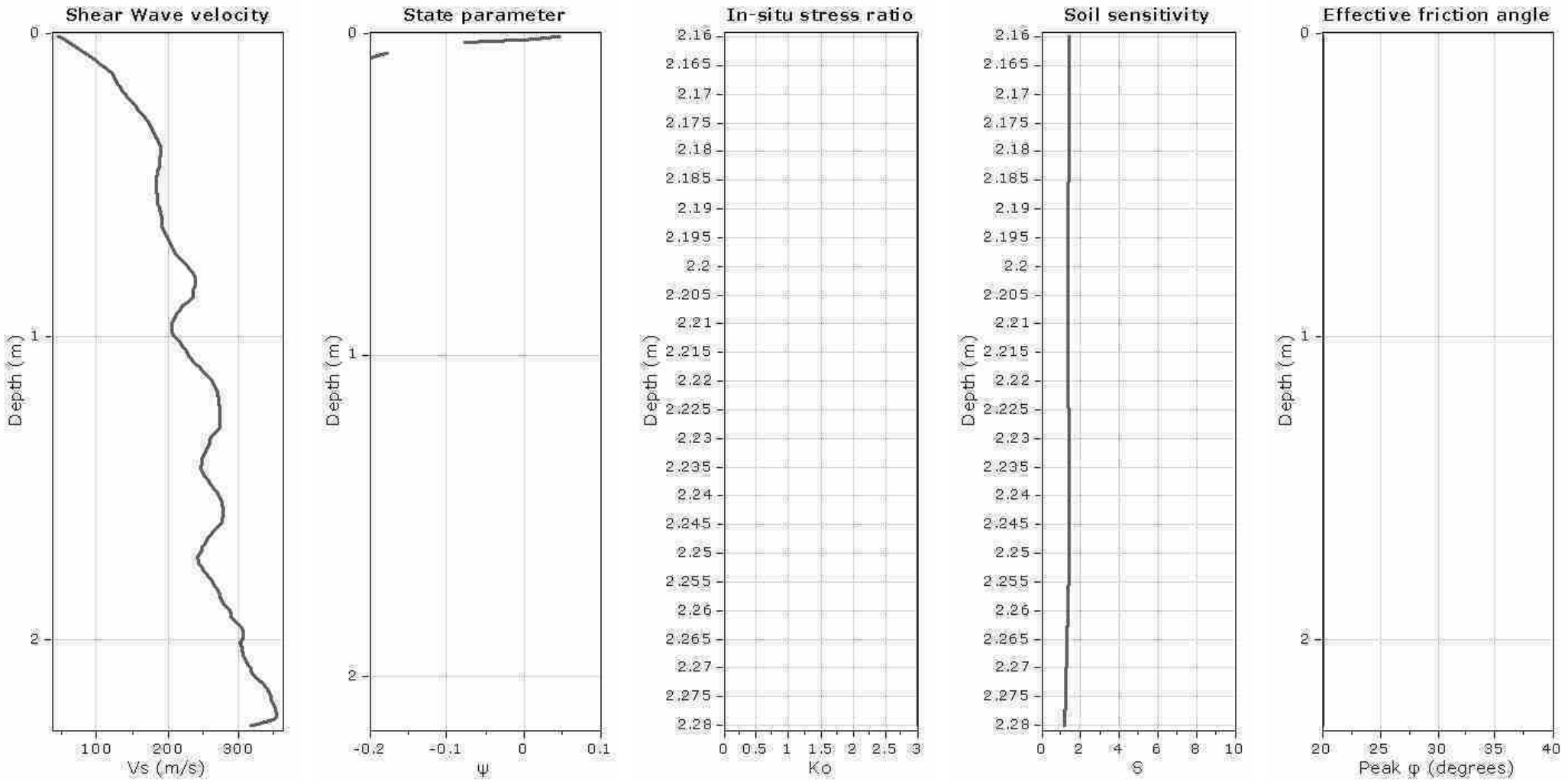
Project:
Location:

CPT: CPT 12
Total depth: 2.28 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



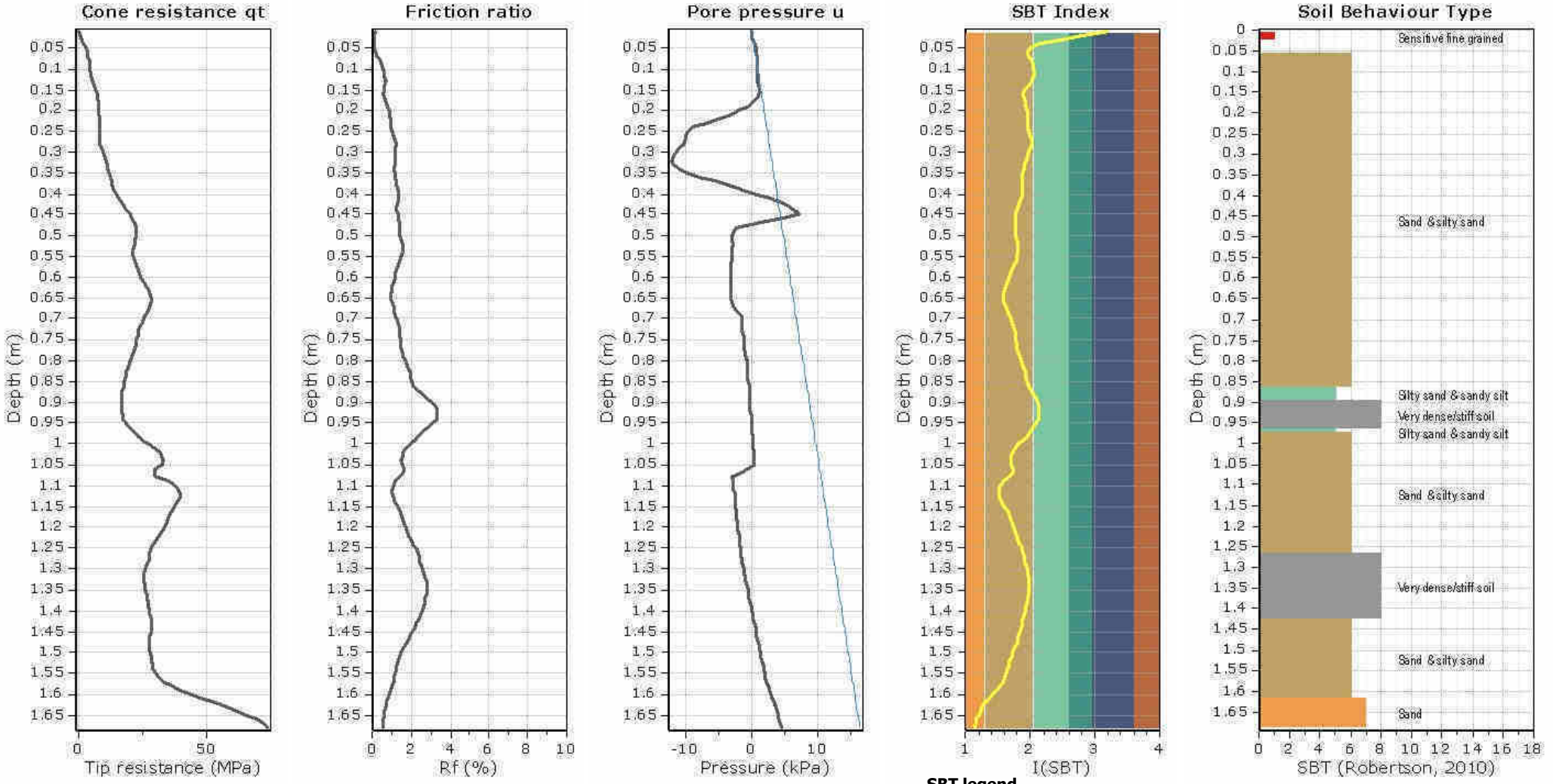
Calculation parameters

Soil Sensitivity factor, N_S: 7.00
User defined estimation data

MHA Geotechnical
Suite 2, 464 Murray St PERTH
T: +61 8 6110 4768
www.mhageotechnical.com.au

Project:
Location:

CPT: CPT 12B
Total depth: 1.68 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



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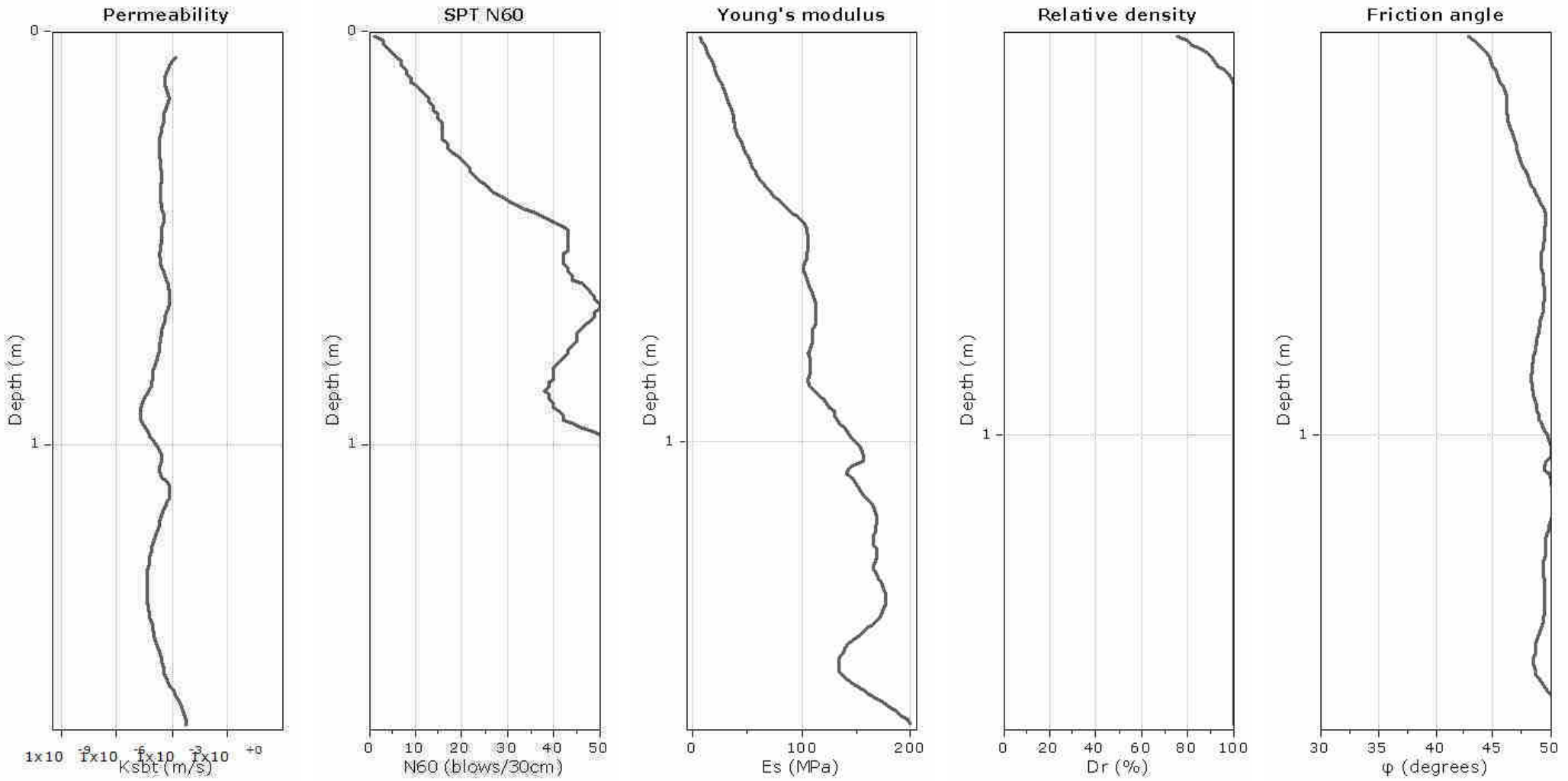
T: +61 8 6110 4768
www.mhageotechnical.com.au

Project:
Location:

CPT: CPT 12B
Total depth: 1.68 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

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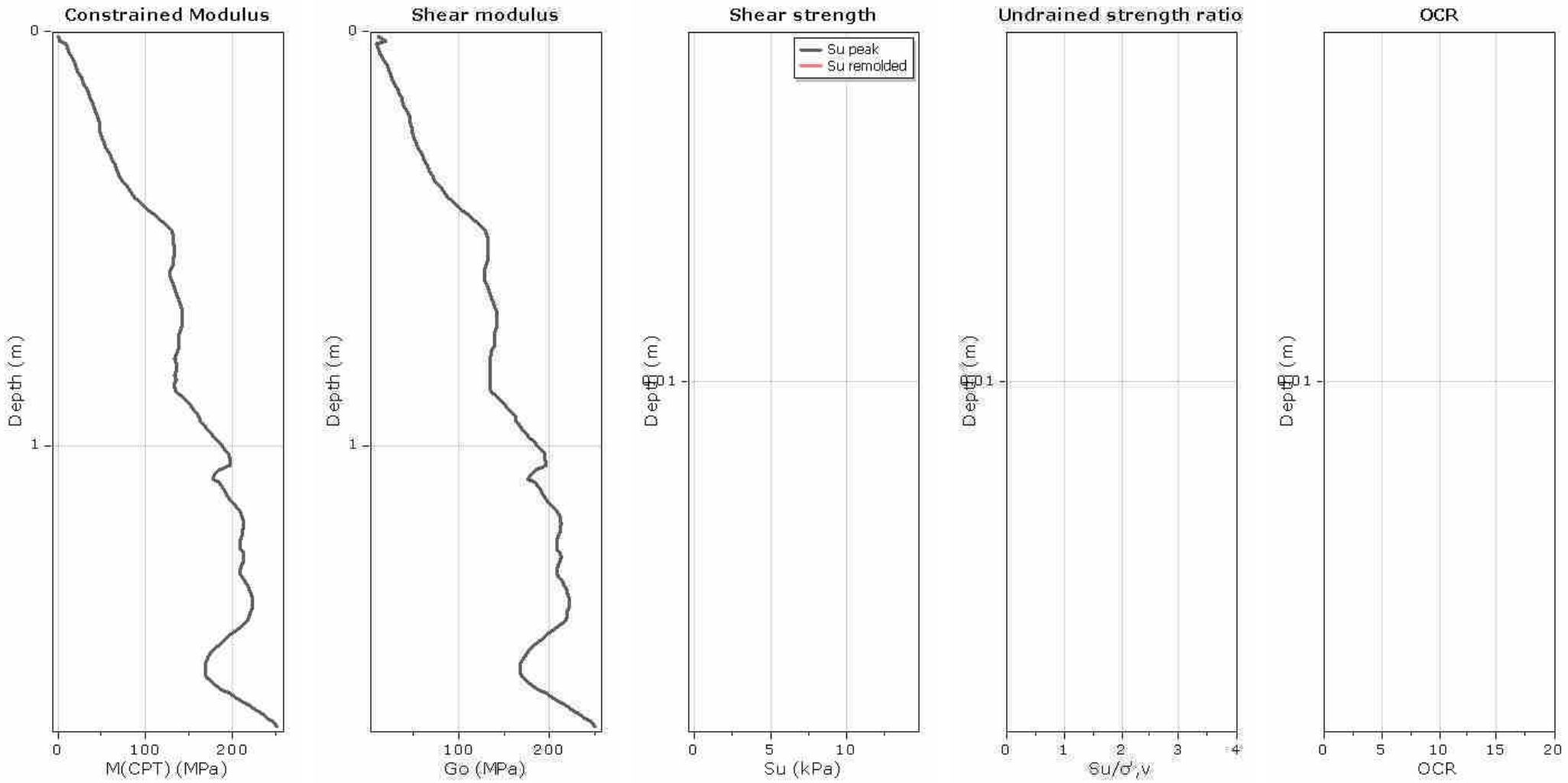
Project:
Location:

CPT: CPT 12B
Total depth: 1.68 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14
OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

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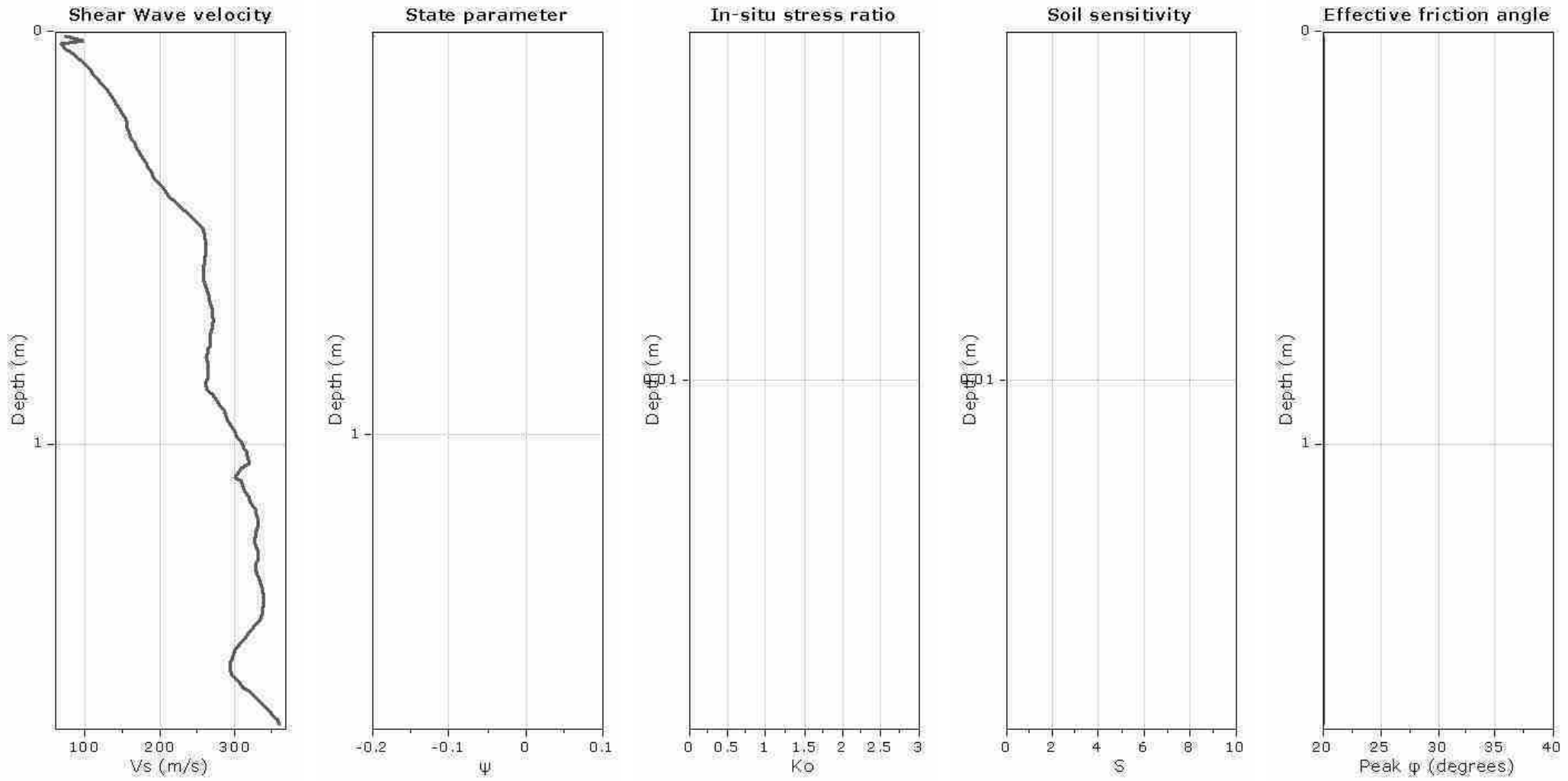
Project:
Location:

CPT: CPT 12B
Total depth: 1.68 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



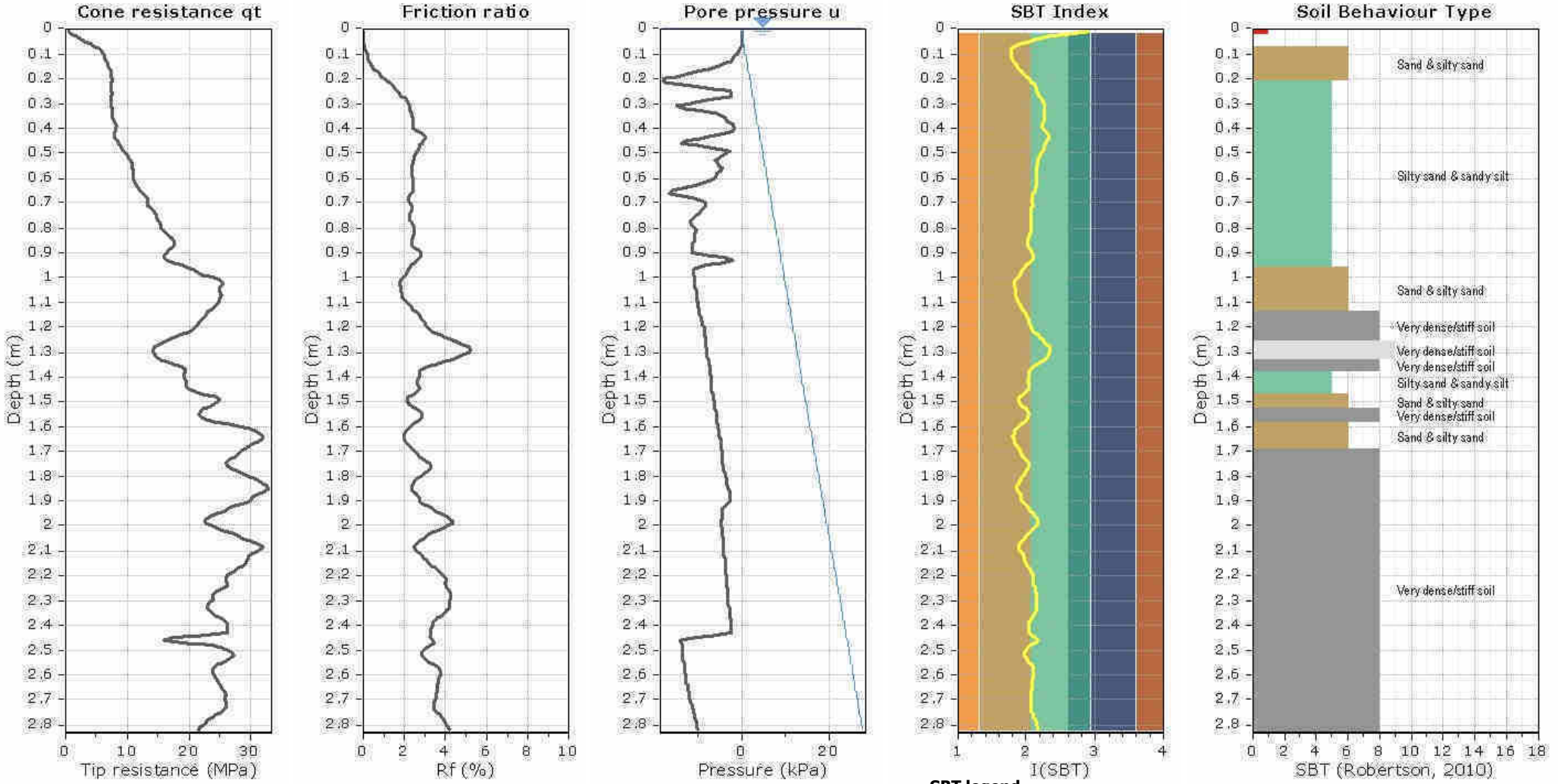
Calculation parameters

Soil Sensitivity factor, N_S: 7.00
User defined estimation data

MHA Geotechnical
Suite 2, 464 Murray St PERTH
T: +61 8 6110 4768
www.mhageotechnical.com.au

Project:
Location:

CPT: CPT 13
Total depth: 2.82 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



MHA Geotechnical
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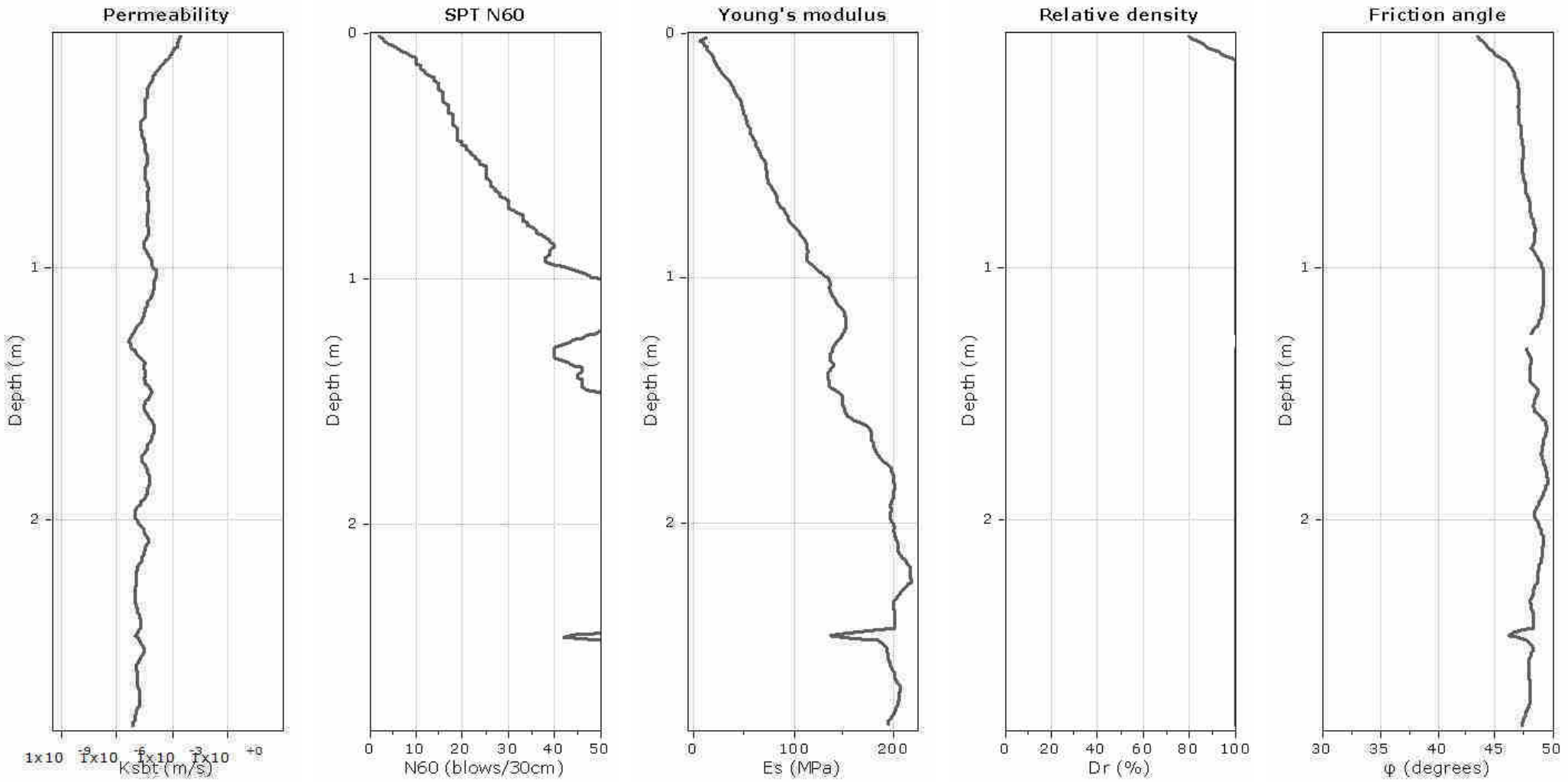
www.mhageotechnical.com.au

Project:
Location:

CPT: CPT 13
Total depth: 2.82 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

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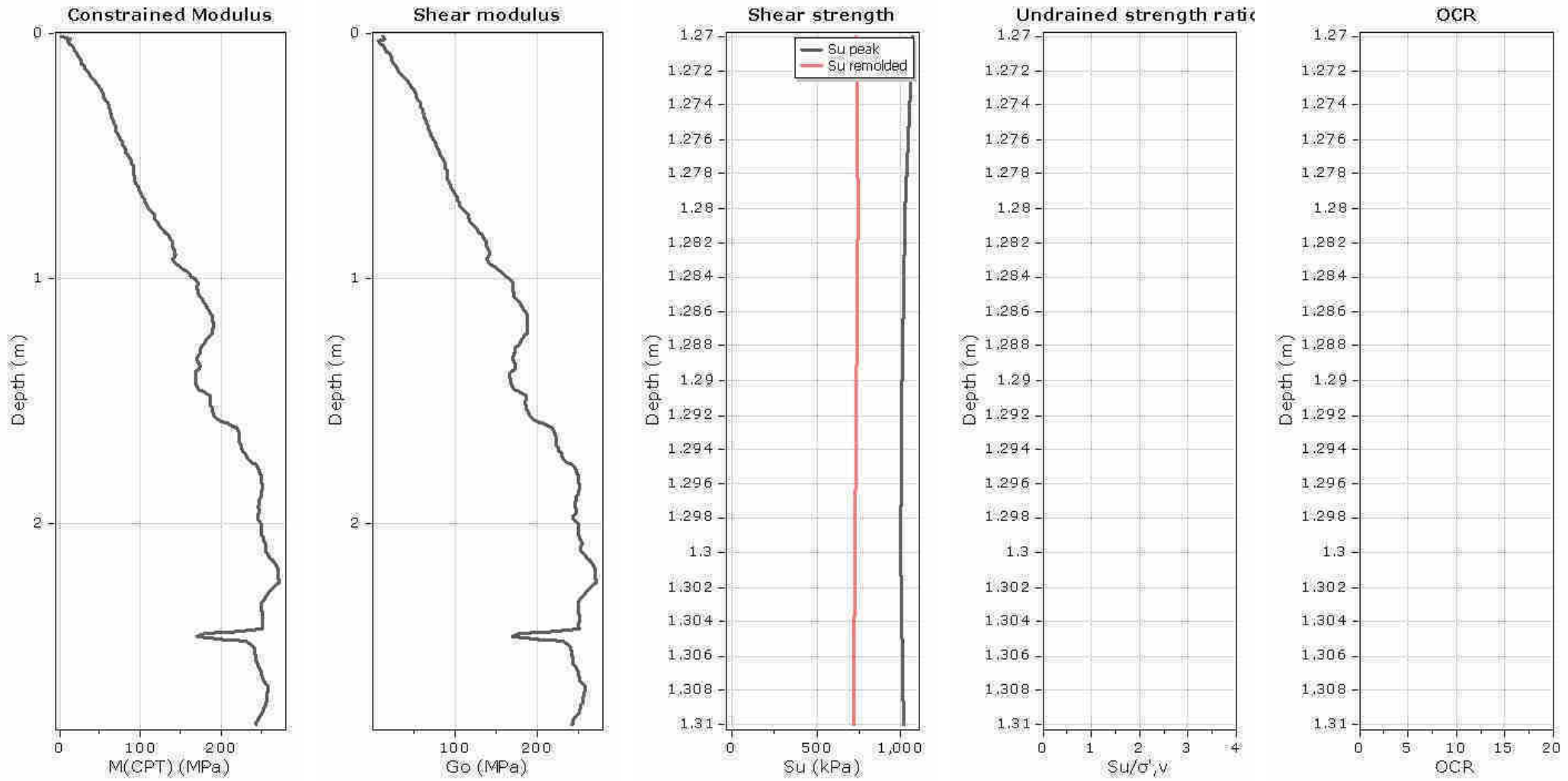
Project:
Location:

CPT: CPT 13
Total depth: 2.82 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14

OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

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Suite 2, 464 Murray St PERTH
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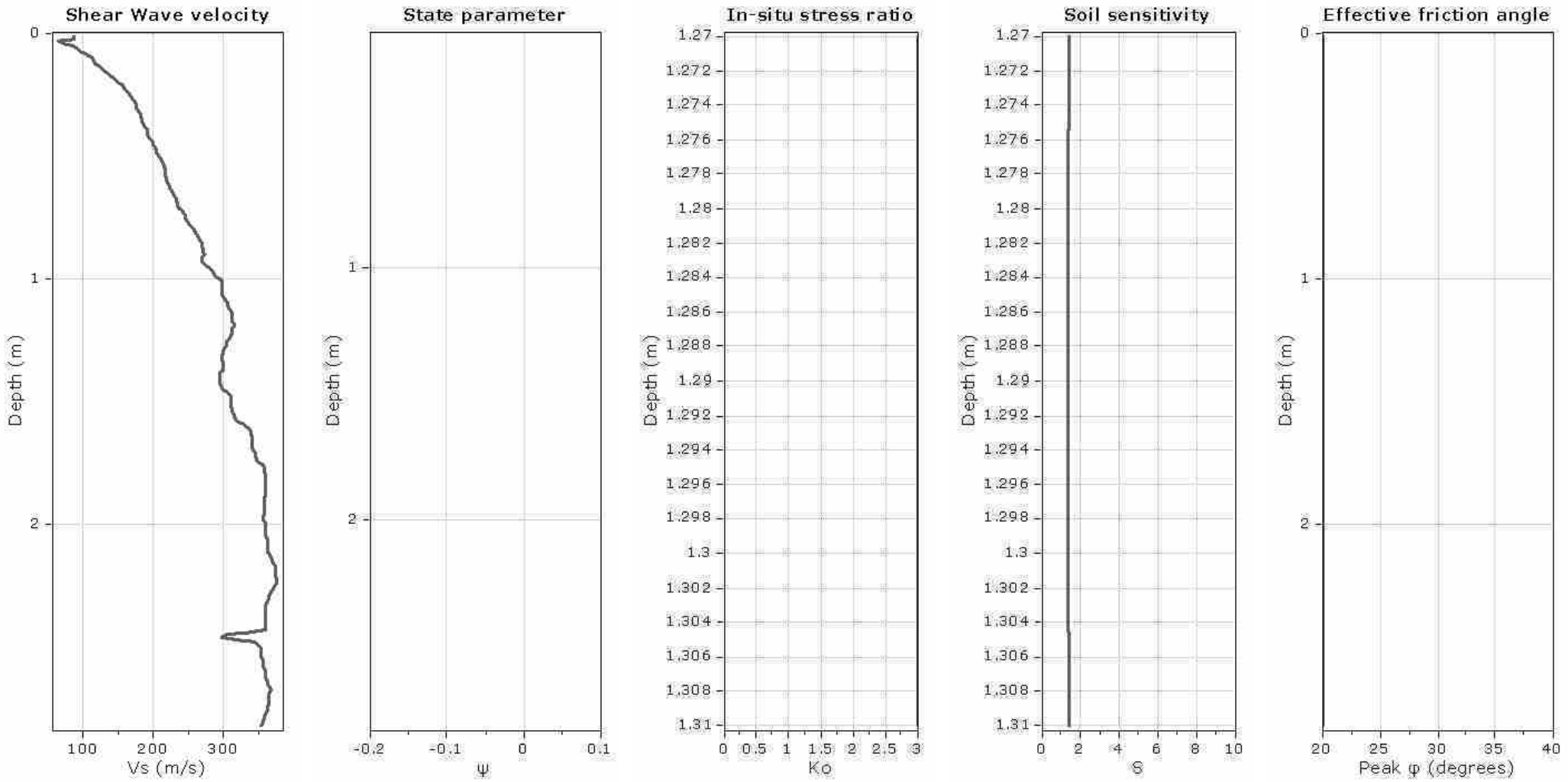
www.mhageotechnical.com.au

Project:
Location:

CPT: CPT 13
Total depth: 2.82 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



Calculation parameters

Soil Sensitivity factor, N_S: 7.00
User defined estimation data

MHA Geotechnical
Suite 2, 464 Murray St PERTH
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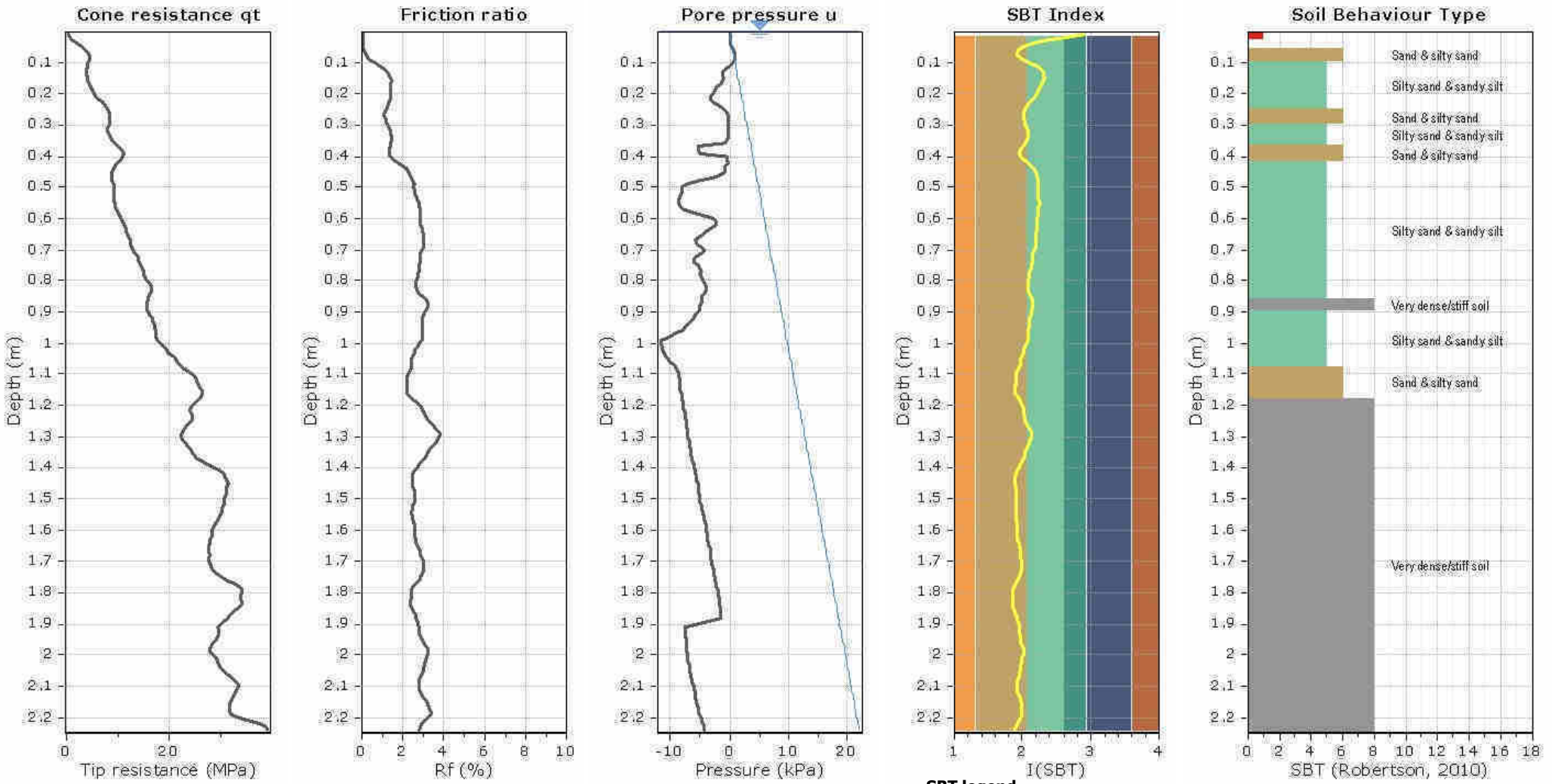
Project:
Location:

CPT: CPT 14
Total depth: 2.24 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



MHA Geotechnical
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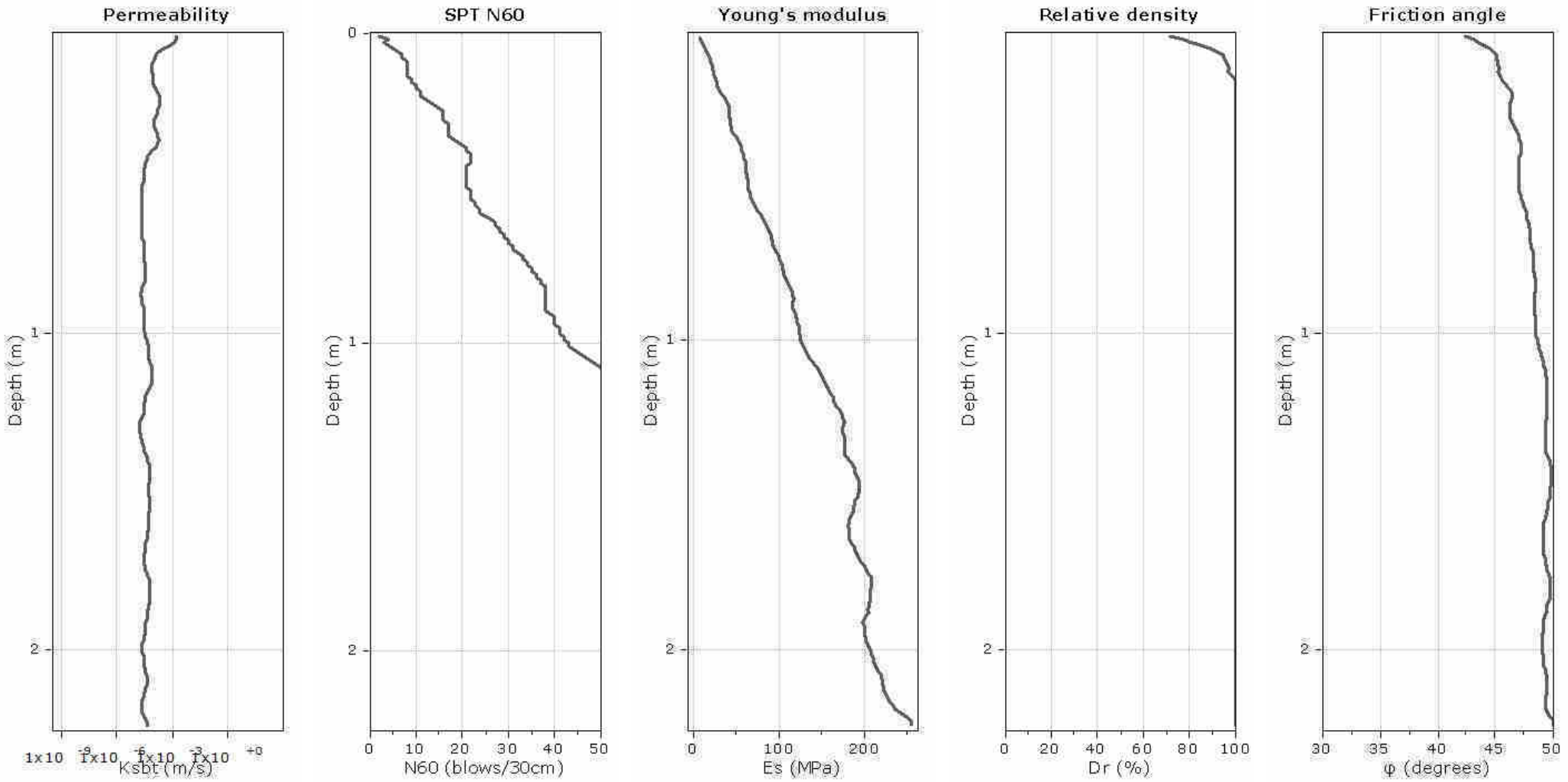
Project:
Location:

CPT: CPT 14
Total depth: 2.24 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
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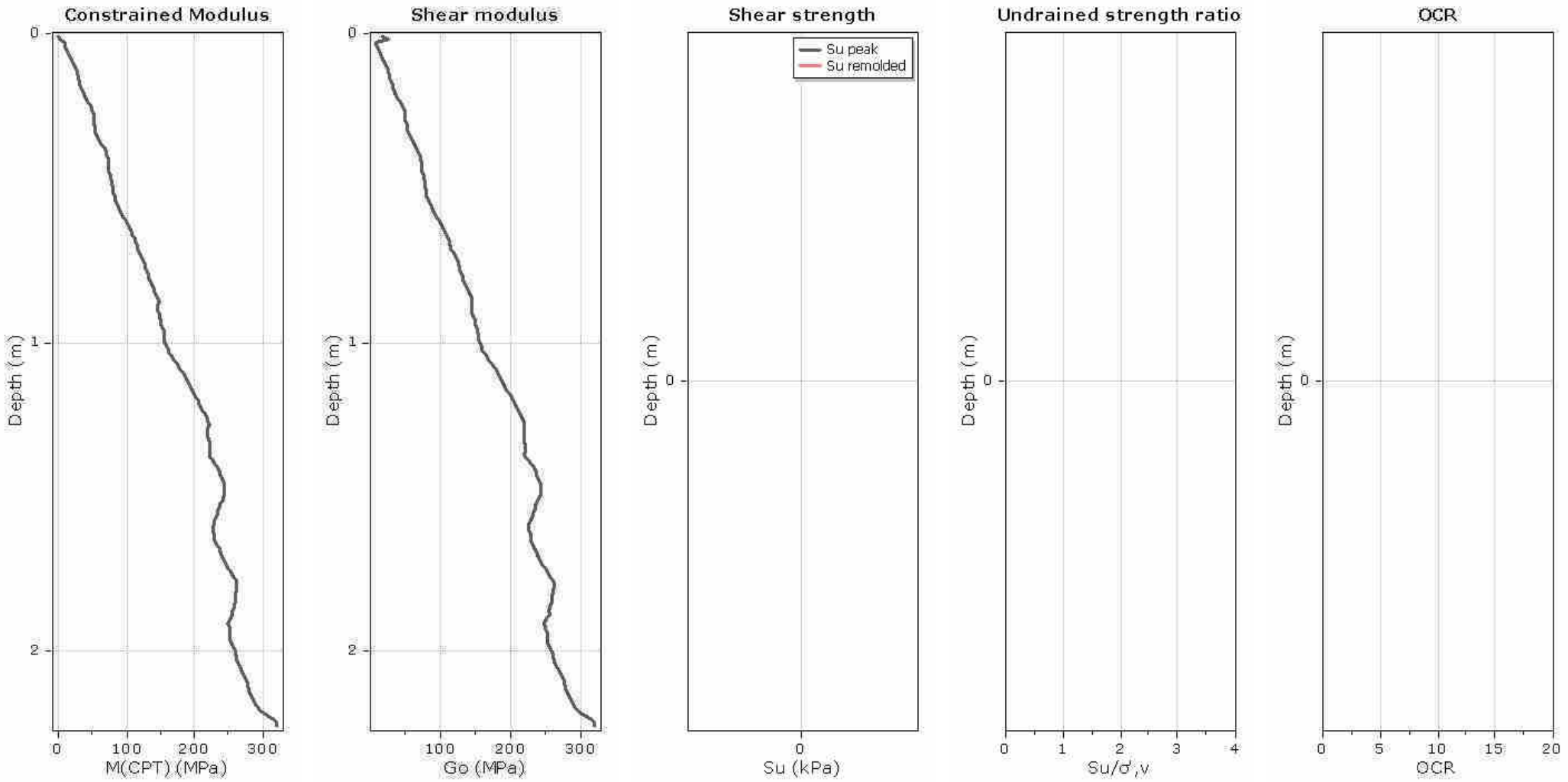
Project:
Location:

CPT: CPT 14
Total depth: 2.24 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14

OCR factor for clays, N_{kt}: 0.33
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Flat Dilatometer Test data

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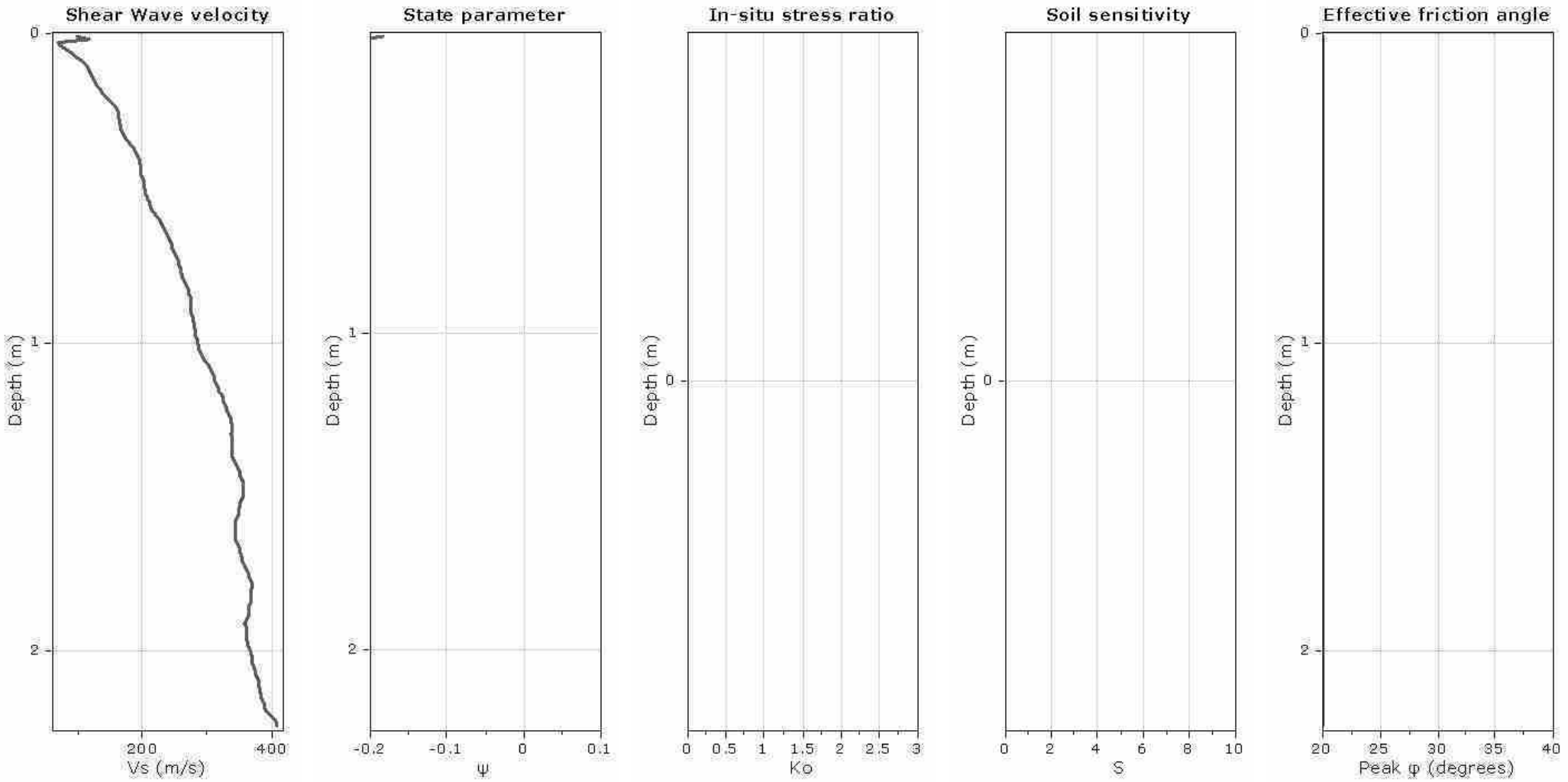
Project:
Location:

CPT: CPT 14
Total depth: 2.24 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



Calculation parameters

Soil Sensitivity factor, N_S: 7.00

User defined estimation data

MHA Geotechnical
Suite 2, 464 Murray St PERTH
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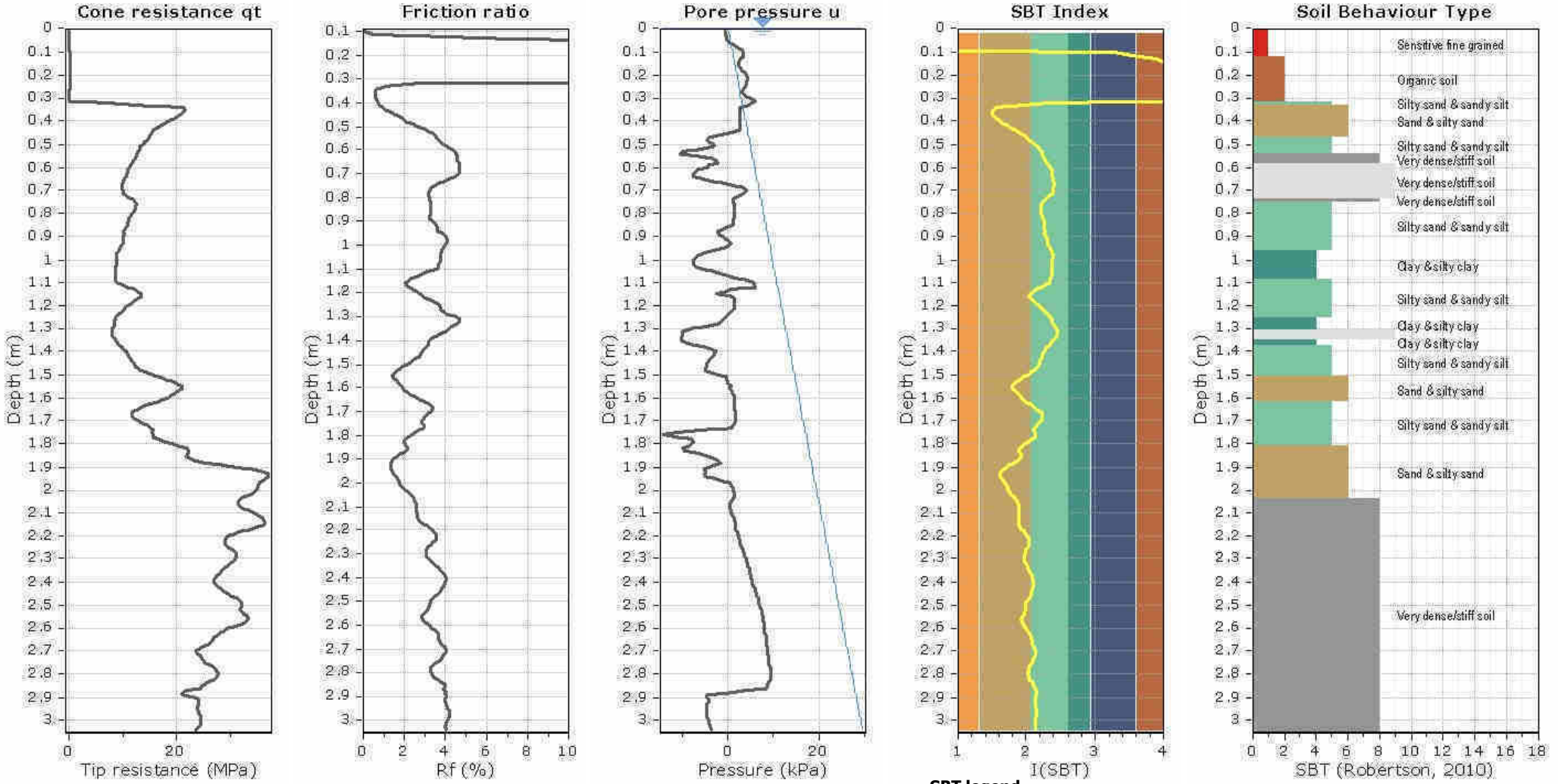
www.mhageotechnical.com.au

Project:
Location:

CPT: CPT 17
Total depth: 3.04 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

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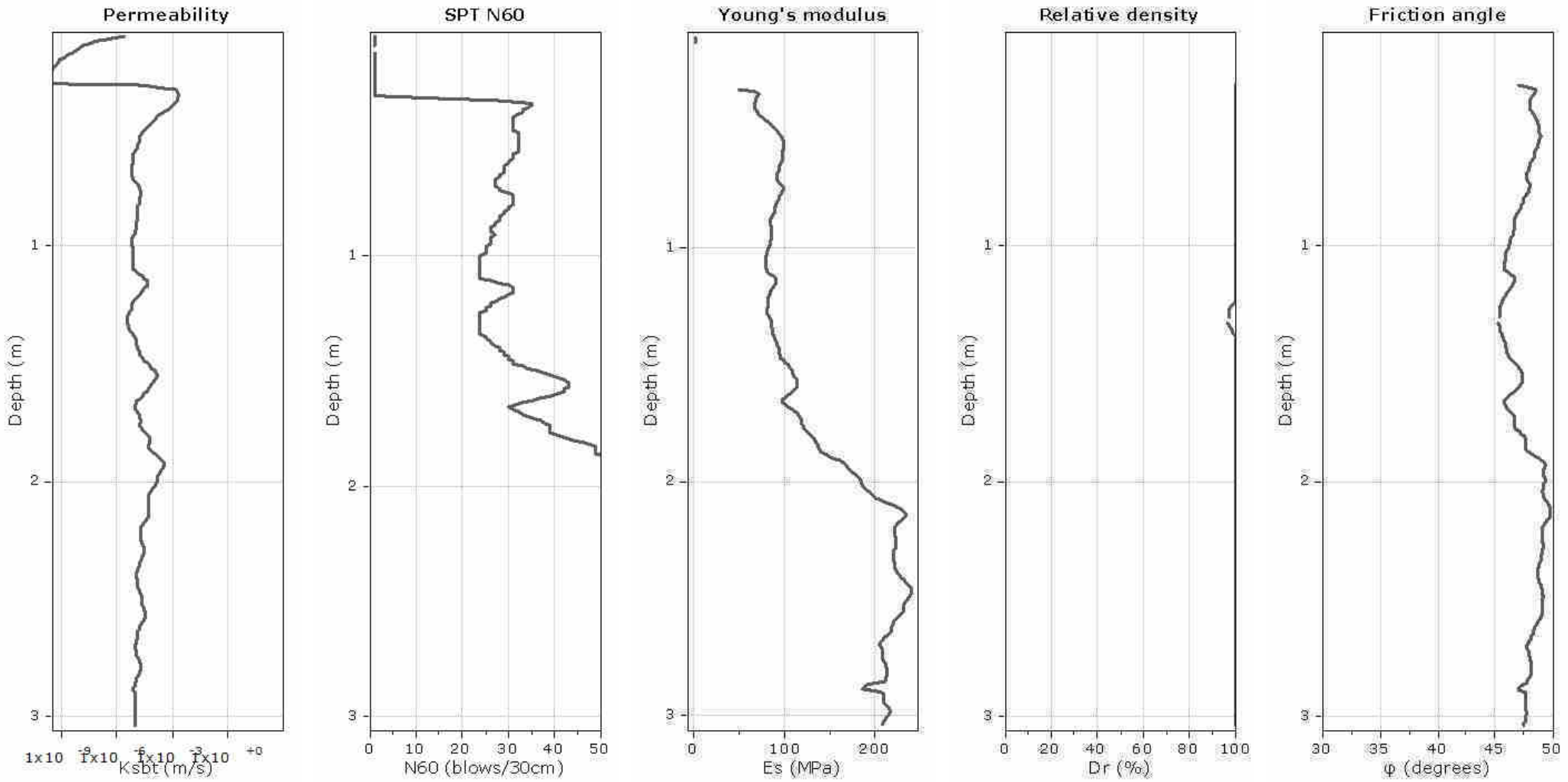
Location:

CPT: CPT 17
Total depth: 3.04 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

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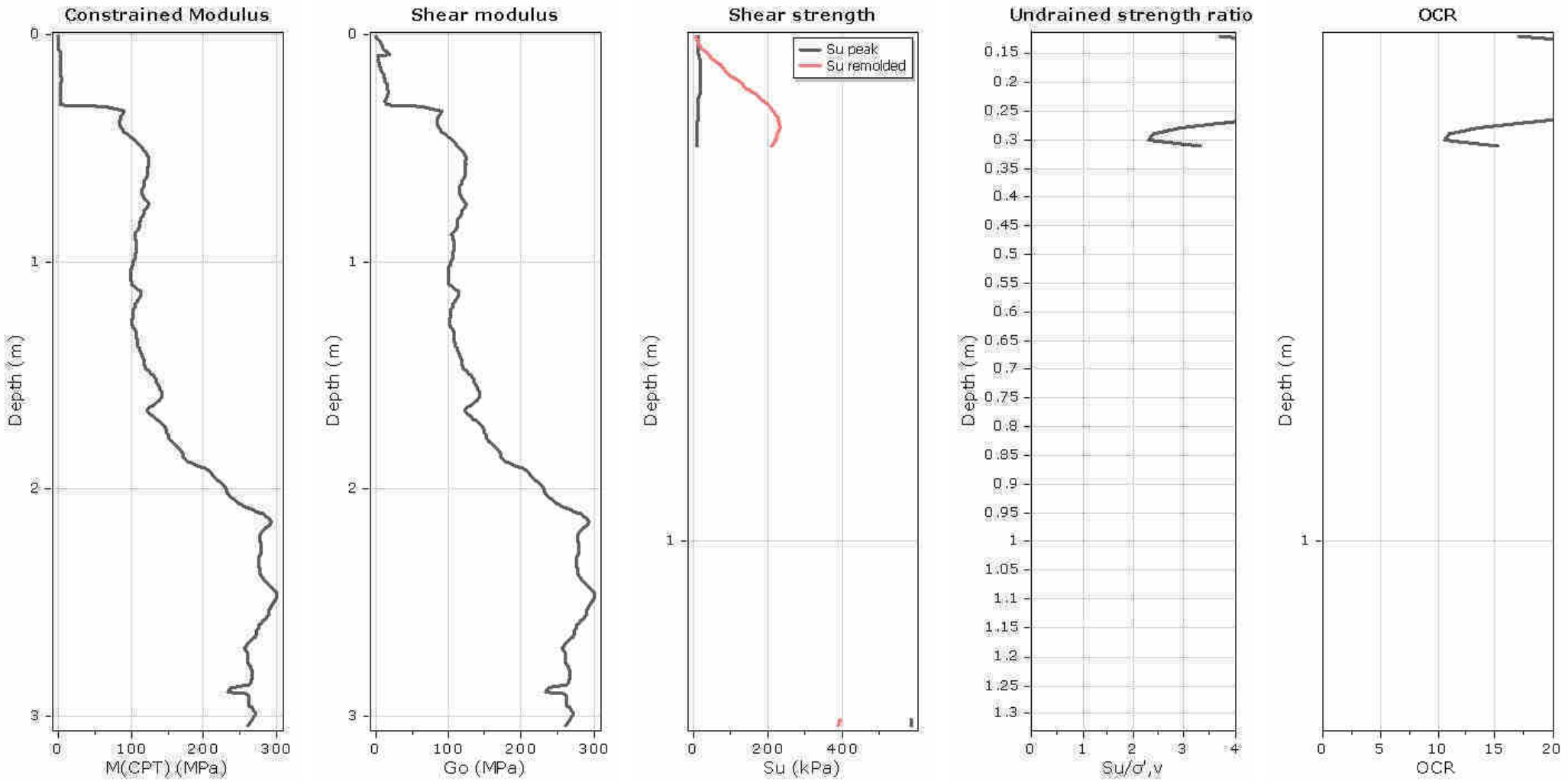
Project:
Location:

CPT: CPT 17
Total depth: 3.04 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



Calculation parameters

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Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14

OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

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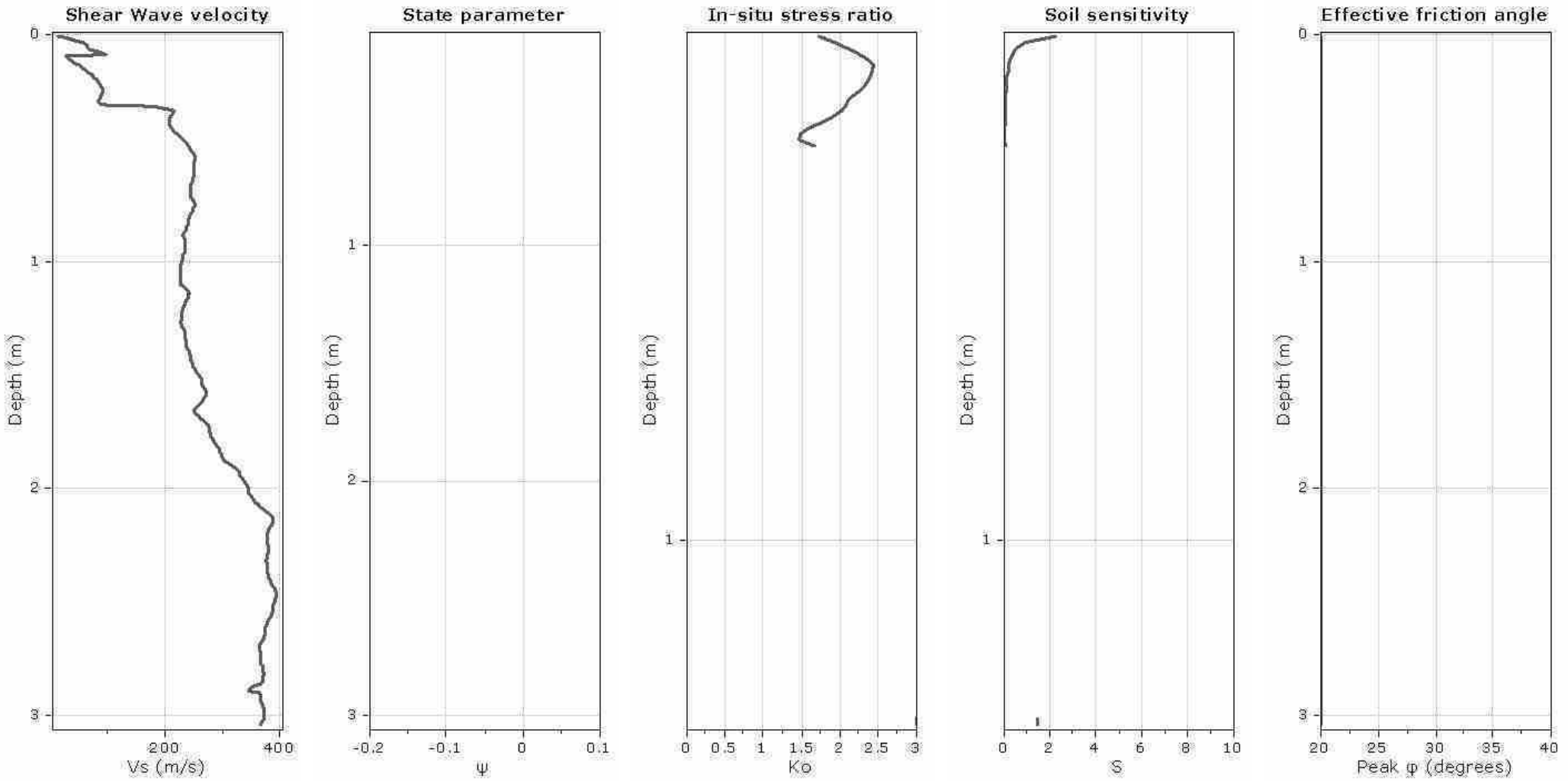
CPT: CPT 17
Total depth: 3.04 m, Date: 4/12/2017
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



Calculation parameters

Soil Sensitivity factor, N_S: 7.00
User defined estimation data

Appendix E

Geotechnical Field Investigation Laboratory Test Results and Certificates
(MHA Geotechnical Pty Ltd)

Analytical Laboratory	Certificate Number(s)	Analytes	Sample				
			Number	Location	Easting	Northing	Description
Structerre	S865847-A-1	Grading	TP01_0.0-0.2m	TSF West	-33.685685	120.206652	TSF West Test Pit Bulk Sample
Structerre	S865847-A-2	Grading	TP01_0.2-0.75m	TSF West	-33.685685	120.206652	TSF West Test Pit Bulk Sample
Structerre	S865847-A-3	Grading	TP01_0.75-1.6m	TSF West	-33.685685	120.206652	TSF West Test Pit Bulk Sample
Structerre	S865847-A-4	Grading and Multistage UU Triaxial	TP02_0.1-0.5m	TSF West	-33.6864494	120.2067161	TSF West Test Pit Bulk Sample
Structerre	S865847-A-5	Grading, Permeability, Atterberg Limits, Modified Compaction and Emerson Class Number	TP02_0.5-1.1m	TSF West	-33.6864494	120.2067161	TSF West Test Pit Bulk Sample
Structerre	S865847-A-6	Grading	TP02_1.1-2.7m	TSF West	-33.6864494	120.2067161	TSF West Test Pit Bulk Sample
Structerre	S865847-A-7	Grading, Permeability, Atterberg Limits, Modified Compaction and Emerson Class Number	TP03_0.0-0.7m	TSF West	-33.6873212	120.2068039	TSF West Test Pit Bulk Sample
Structerre	S865847-A-8	Grading	TP03_0.7-3.0m	TSF West	-33.6873212	120.2068039	TSF West Test Pit Bulk Sample
Structerre	S865847-A-9	Grading	TP04_0.0-0.25m	TSF West	-33.6883154	120.2069192	TSF West Test Pit Bulk Sample
Structerre	S865847-A-10	Grading	TP04_0.25-1.0m	TSF West	-33.6883154	120.2069192	TSF West Test Pit Bulk Sample
Structerre	S865847-A-11	Grading	TP04_1.0-3.1m	TSF West	-33.6883154	120.2069192	TSF West Test Pit Bulk Sample
Structerre	S865847-A-12	Grading	TP05_0.1-0.8m	TSF West	-33.688971	120.2069675	TSF West Test Pit Bulk Sample
Structerre	S865847-A-13	Grading	TP05_0.8-1.8m	TSF West	-33.688971	120.2069675	TSF West Test Pit Bulk Sample
Structerre	S865847-A-14	Grading	TP05_1.8-2.9m	TSF West	-33.688971	120.2069675	TSF West Test Pit Bulk Sample
Structerre	S865847-A-15	Grading	TP06_0.0-0.6m	TSF South	-33.6889939	120.2084628	TSF South Test Pit Bulk Sample
Structerre	S865847-A-16	Grading, Permeability, Atterberg Limits, Modified Compaction and Emerson Class Number	TP06_0.6-2.7m	TSF South	-33.6889939	120.2084628	TSF South Test Pit Bulk Sample
Structerre	S865847-A-17	Grading	TP07_0.1-0.2m	TSF South	-33.6889501	120.2091173	TSF South Test Pit Bulk Sample
Structerre	S865847-A-18	Grading	TP07_0.2-2.5m	TSF South	-33.6889501	120.2091173	TSF South Test Pit Bulk Sample
Structerre	S865847-A-19	Grading	TP08_0.1-0.4m	TSF South	-33.6889116	120.2096444	TSF South Test Pit Bulk Sample
Structerre	S865847-A-20	Grading	TP08_0.4-2.2m	TSF South	-33.6889116	120.2096444	TSF South Test Pit Bulk Sample
Structerre	S865847-A-21	Grading	TP09_0.1-0.2m	TSF South	-33.6888324	120.2104839	TSF South Test Pit Bulk Sample
Structerre	S865847-A-22	Grading	TP09_0.2-2.2m	TSF South	-33.6888324	120.2104839	TSF South Test Pit Bulk Sample
Structerre	S865847-A-23	Grading	TP10_0.1-2.5m	TSF South	-33.6888137	120.2109811	TSF South Test Pit Bulk Sample
Structerre	S865847-A-24	Grading	TP11_0.2-2.8m	TSF East	-33.6885004	120.2113023	TSF East Test Pit Bulk Sample

Structerre	S865847-A-25	Grading	TP12_0.1-2.8m	TSF East	-33.6877109	120.2112202	TSF East Test Pit Bulk Sample
Structerre	S865847-A-26	Grading and Multistage UU Triaxial	TP13_0.1-0.7m	TSF East	-33.6867749	120.2111142	TSF East Test Pit Bulk Sample
Structerre	S865847-A-27	Grading, Permeability, Atterberg Limits, Modified Compaction and Emerson Class Number	TP13_0.7-2.8m	TSF East	-33.6867749	120.2111142	TSF East Test Pit Bulk Sample
Structerre	S865847-A-28	Grading	TP14_0.2-1.0m	TSF East	-33.6861255	120.2110391	TSF East Test Pit Bulk Sample
Structerre	S865847-A-29	Grading	TP15_0.2-2.7m	TSF East	-33.6856138	120.2109576	TSF East Test Pit Bulk Sample
Structerre	S865847-A-30	Grading	TP16_0.2-0.6m	TSF North	-33.6852333	120.210323	TSF North Test Pit Bulk Sample
Structerre	S865847-A-31	Grading	TP16_0.6-1.0m	TSF North	-33.6852333	120.210323	TSF North Test Pit Bulk Sample
Structerre	S865847-A-32	Grading, Permeability, Atterberg Limits, Modified Compaction and Emerson Class Number	TP16_1.0-2.8m	TSF North	-33.6852333	120.210323	TSF North Test Pit Bulk Sample
Structerre	S865847-A-33	Grading	TP17_0.6-1.2m	TSF North	-33.6852913	120.2093694	TSF North Test Pit Bulk Sample
Structerre	S865847-A-34	Grading	TP17_1.2-2.7m	TSF North	-33.6852913	120.2093694	TSF North Test Pit Bulk Sample
Structerre	S865847-A-35	Grading	TP18_0.2-0.6m	TSF North	-33.6853516	120.2085011	TSF North Test Pit Bulk Sample
Structerre	S865847-A-36	Grading	TP18_0.6-1.2m	TSF North	-33.6853516	120.2085011	TSF North Test Pit Bulk Sample
Structerre	S865847-A-37	Grading	TP18_1.2-2.8m	TSF North	-33.6853516	120.2085011	TSF North Test Pit Bulk Sample
Structerre	S865847-A-38	Grading	TP19_0.2-0.6m	TSF North	-33.6854116	120.2077879	TSF North Test Pit Bulk Sample
Structerre	S865847-A-39	Grading	TP19_0.6-2.8m	TSF North	-33.6854116	120.2077879	TSF North Test Pit Bulk Sample
Structerre	S865847-A-40	Grading	TP20_0.2-0.4m	TSF North	-33.6854699	120.206819	TSF North Test Pit Bulk Sample
Structerre	S865847-A-41	Grading	TP20_0.4-1.0m	TSF North	-33.6854699	120.206819	TSF North Test Pit Bulk Sample
Structerre	S865847-B-1	Grading, Atterberg Limits, Modified Compaction and Emerson Class Number and Multistage UU Triaxial	B1	Stockpile	-	-	Stockpile Bulk Sample
Structerre	S865847-B-2	Grading, Atterberg Limits, Modified Compaction and Emerson Class Number	B2	Stockpile	-	-	Stockpile Bulk Sample
Structerre	S865847-B-3	Grading, Atterberg Limits, Modified Compaction and Emerson Class Number	B3	Stockpile	-	-	Stockpile Bulk Sample

MHA GEOTECHNICAL

Ravensthorpe Gold Particle Size Distributions			Sieve Analysis													Soil Classification		
			+75µm		+300µm	+425µm	+600µm	+1180µm	+2.36mm	+4.75mm	+9.5mm	+19.0mm	+26.5mm	+37.5mm	+75.0mm	Fines (<75 µm)	Sand (>75 µm)	Gravel (>2mm)
% Passing Units			Sand						Gravel						Cobble	%		
LoR																		
Sample Number	Sample Location	Sample Description																
TP01_0.0-0.2m	TSF West	TSF West Test Pit Bulk Sample	35	47	56	58	60	64	74	87	95	99	-	100	100	35	39	26
TP01_0.2-0.75m	TSF West	TSF West Test Pit Bulk Sample	58	66	72	74	76	81	88	93	96	99	-	100	100	58	30	12
TP01_0.75-1.6m	TSF West	TSF West Test Pit Bulk Sample	34	42	53	57	59	66	76	83	88	89	-	100	97	34	42	24
TP02_0.1-0.5m	TSF West	TSF West Test Pit Bulk Sample	36	52	62	65	67	70	76	87	97	100	-	100	100	36	40	24
TP02_0.5-1.1m	TSF West	TSF West Test Pit Bulk Sample	44	49	57	59	61	66	72	81	89	93	97	100	-	44	28	28
TP02_1.1-2.7m	TSF West	TSF West Test Pit Bulk Sample	56	61	67	71	74	84	94	98	100	100	-	100	100	56	38	6
TP03_0.0-0.7m	TSF West	TSF West Test Pit Bulk Sample	41	45	51	53	55	61	68	82	92	98	99	100	-	41	27	32
TP03_0.7-3.0m	TSF West	TSF West Test Pit Bulk Sample	41	45	52	56	61	75	90	97	100	100	-	100	100	41	49	10
TP04_0.0-0.25m	TSF West	TSF West Test Pit Bulk Sample	63	66	69	71	73	77	82	89	97	100	-	100	100	63	19	18
TP04_0.25-1.0m	TSF West	TSF West Test Pit Bulk Sample	50	53	58	61	64	72	73	89	95	96	-	100	100	50	23	27
TP04_1.0-3.1m	TSF West	TSF West Test Pit Bulk Sample	55	59	66	70	73	83	93	97	99	100	-	100	100	55	38	7
TP05_0.1-0.8m	TSF West	TSF West Test Pit Bulk Sample	57	81	89	90	91	93	94	98	100	100	-	100	100	57	37	6
TP05_0.8-1.8m	TSF West	TSF West Test Pit Bulk Sample	51	70	75	76	77	82	91	99	100	100	-	100	100	51	40	9
TP05_1.8-2.9m	TSF West	TSF West Test Pit Bulk Sample	40	50	60	64	67	75	85	93	96	99	-	100	100	40	45	15
TP06_0.0-0.6m	TSF South	TSF South Test Pit Bulk Sample	52	58	63	66	69	77	87	96	98	99	-	100	100	52	35	13
TP06_0.6-2.7m	TSF South	TSF South Test Pit Bulk Sample	56	59	63	66	70	80	91	96	100	-	-	-	-	56	35	9
TP07_0.1-0.2m	TSF South	TSF South Test Pit Bulk Sample	30	40	49	53	56	63	73	84	98	100	-	100	100	30	43	27
TP07_0.2-2.5m	TSF South	TSF South Test Pit Bulk Sample	53	57	63	68	72	84	98	99	100	100	-	100	100	53	45	2
TP08_0.1-0.4m	TSF South	TSF South Test Pit Bulk Sample	62	68	74	76	78	84	90	93	96	97	-	100	100	62	28	10
TP08_0.4-2.2m	TSF South	TSF South Test Pit Bulk Sample	50	54	59	63	66	75	89	93	95	96	-	100	97	50	39	11
TP09_0.1-0.2m	TSF South	TSF South Test Pit Bulk Sample	56	63	69	72	74	80	84	92	96	99	-	100	100	56	28	16

TP09_0.2-2.2m	TSF South	TSF South Test Pit Bulk Sample	45	49	56	59	62	70	79	90	98	100	-	100	100	45	34	21
TP10_0.1-2.5m	TSF South	TSF South Test Pit Bulk Sample	38	40	44	46	49	55	64	75	80	81	-	100	85	38	26	36
TP11_0.2-2.8m	TSF East	TSF East Test Pit Bulk Sample	45	49	54	57	60	68	85	87	94	98	-	100	100	45	40	15
TP12_0.1-2.8m	TSF East	TSF East Test Pit Bulk Sample	47	50	54	56	58	64	72	89	95	96	-	100	100	47	25	28
TP13_0.1-0.7m	TSF East	TSF East Test Pit Bulk Sample	54	57	58	59	60	63	65	83	90	90	-	100	90	54	11	35
TP13_0.7-2.8	TSF East	TSF East Test Pit Bulk Sample	64	65	67	68	70	76	81	86	91	97	98	99	100	64	17	19
TP14_0.2-1.0m	TSF East	TSF East Test Pit Bulk Sample	12	19	36	44	47	53	59	71	84	94	-	100	96	12	47	41
TP15_0.2-2.7m	TSF East	TSF East Test Pit Bulk Sample	43	46	52	57	61	72	84	95	99	99	-	100	100	43	41	16
TP16_0.2-0.6m	TSF North	TSF North Test Pit Bulk Sample	54	59	64	66	67	69	73	93	98	98	-	100	100	54	19	27
TP16_0.6-1.0m	TSF North	TSF North Test Pit Bulk Sample	57	60	66	70	74	82	90	98	100	100	-	100	100	57	33	10
TP16_1.0-2.8m	TSF North	TSF North Test Pit Bulk Sample	55	57	60	62	64	70	77	84	90	99	100	-	-	55	22	23
TP17_0.6-1.2m	TSF North	TSF North Test Pit Bulk Sample	28	30	36	42	44	49	54	75	91	98	-	100	100	28	26	46
TP17_1.2-2.7m	TSF North	TSF North Test Pit Bulk Sample	40	44	52	56	62	74	86	97	100	100	-	100	100	40	46	14
TP18_0.2-0.6m	TSF North	TSF North Test Pit Bulk Sample	56	59	64	66	68	73	80	92	96	100	-	100	100	56	24	20
TP18_0.6-1.2m	TSF North	TSF North Test Pit Bulk Sample	60	64	70	74	7	85	93	99	100	100	-	100	100	60	33	7
TP18_1.2-2.8m	TSF North	TSF North Test Pit Bulk Sample	43	44	49	53	56	64	74	81	93	98	-	100	100	43	31	26
TP19_0.2-0.6m	TSF North	TSF North Test Pit Bulk Sample	55	60	66	68	69	72	76	92	97	100	-	100	100	55	21	24
TP19_0.6-2.8m	TSF North	TSF North Test Pit Bulk Sample	54	58	63	66	68	73	77	94	99	100	-	100	100	54	23	23
TP20_0.2-0.4m	TSF North	TSF North Test Pit Bulk Sample	59	67	75	78	80	85	92	96	97	99	-	100	100	59	33	8
TP20_0.4-1.0m	TSF North	TSF North Test Pit Bulk Sample	32	38	43	45	47	53	64	84	98	100	-	100	100	32	32	36
B1	Stockpile	Stockpile Bulk Sample	60	69	76	80	84	88	91	92	94	96	97	98	100	60	31	9
B2	Stockpile	Stockpile Bulk Sample	48	57	67	76	87	98	100	-	-	-	-	-	-	48	52	0
B3	Stockpile	Stockpile Bulk Sample	46	56	67	76	87	95	96	96	98	99	100	-	-	46	50	4
Minimum			**12**	**19**	**36**	**42**	**7**	**49**	**54**	**71**	**80**	**81**	**97**	**98**	**85**	**12**	**11**	**0**
Maximum			**64**	**81**	**89**	**90**	**91**	**98**	**100**	**99**	**100**	**100**	**100**	**100**	**100**	**64**	**52**	**46**

MHA GEOTECHNICAL

Ravensthorpe Gold Particle Size Distributions			Hydrometer Analysis													
			+1µm	+2µm	+3µm	+3µm	+4µm	+4µm	+6µm	+8µm	+11µm	+16µm	+21µm	+30µm	+42µm	+59µm
		% Passing Units	Clay		Silt											
		LoR														
Sample Number	**Sample Location**	**Sample Description**														
TP02_0.5-1.1m	TSF West	TSF West Test Pit Bulk Sample	36	36	36	36	36	37	37	38	39	40	41	43	43	44
TP03_0.0-0.7m	TSF West	TSF West Test Pit Bulk Sample	22	25	26	27	29	31	33	36	37	37	38	39	39	41
TP06_0.6-2.7m	TSF South	TSF South Test Pit Bulk Sample	8	10	11	16	21	29	40	44	48	50	52	53	54	55
TP13_0.7-2.8	TSF East	TSF East Test Pit Bulk Sample	7	8	10	15	23	32	40	48	53	56	60	61	62	63
TP16_1.0-2.8m	TSF North	TSF North Test Pit Bulk Sample	10	13	14	18	23	28	36	40	44	47	50	51	52	54
B1	Stockpile	Stockpile Bulk Sample	9	10	12	14	16	21	28	32	37	42	46	50	55	59
B2	Stockpile	Stockpile Bulk Sample	6	7	7	8	11	12	15	19	24	30	32	39	42	47
B3	Stockpile	Stockpile Bulk Sample	5	6	7	8	9	11	16	19	24	29	34	37	41	44
		Minimum	**5**	**6**	**7**	**8**	**9**	**11**	**15**	**19**	**24**	**29**	**32**	**37**	**41**	**44**
		Maximum	**36**	**36**	**36**	**36**	**36**	**37**	**40**	**48**	**53**	**56**	**60**	**61**	**62**	**63**

MHA GEOTECHNICAL

Ravensthorpe Gold Soil Physical Parameters			MDD and CBR					Atterberg Limits				Permeability		Dispersivity	
			Maximum Dry Density (Standard)	Optimum Moisture Content (Standard)	Maximum Dry Density (Modified)	Optimum Moisture Content (Modified)	CBR	Liquid Limit	Plastic Limit	Plastic Index	Linear Shrinkage	Coeff. Of Permeability (Remoulded Falling Head)	Coeff. Of Permeability (Core Constant Head)	Emerson Class Number	Pinhole Dispersion Classification
Units			(t/m^3)	(%)	(t/m^3)	(%)	(%)	(%)	(%)	(%)	(%)	(m/s)	(m/s)	(No.)	(No)
Sample Number	**Sample Location**	**Sample Description**													
TP02_0.5-1.1m	TSF West	TSF West Test Pit Bulk Sample	2.05	9.00	-	-	-	38	18	20	7.0	6.50E-09	-	3	-
TP03_0.0-0.7m	TSF West	TSF West Test Pit Bulk Sample	1.88	14.00	-	-	-	28	15	13	5.6	1.60E-08	-	2	-
TP06_0.6-2.7m	TSF South	TSF South Test Pit Bulk Sample	1.84	14.50	-	-	-	32	23	9	2.4	5.20E-09	-	2	-
TP13_0.7-2.8m	TSF East	TSF East Test Pit Bulk Sample	1.69	16.00	-	-	-	N.O	N.O	N.P	2.0	4.10E-09	-	2	-
TP16_1.0-2.8m	TSF North	TSF North Test Pit Bulk Sample	1.72	15.50	-	-	-	N.O	N.O	N.P	1.6	6.20E-09	-	6	-
B1	Stockpile	Stockpile Bulk Sample	1.69	15.50	1.82	12.00	-	N.O	N.O	N.P	2.0	-	-	5	D1
B2	Stockpile	Stockpile Bulk Sample	1.74	14.00	1.82	11.50	-	N.O	N.O	N.P	1.6	-	-	6	D1
B3	Stockpile	Stockpile Bulk Sample	1.77	12.50	1.83	12.00	-	N.O	N.O	N.P	1.6	-	-	6	D2
Notes:	**N.O denotes Non Obtainable and N.P denotes Non Plastic.**														

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Ravensthorpe Gold Project Triaxial Testing		Laboratory Measurements													
		Multi Stage Triaxial Testing													
		Stage 1				Stage 2				Stage 3				Results	
		Sigma 1	Sigma 3	Effective Stress	Shear Stress	Sigma 1	Sigma 3	Effective Stress	Shear Stress	Sigma 1	Sigma 3	Effective Stress	Shear Stress	Effective Cohesion	Effective Angle of Friction
Units		(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(°)
Sample Location	**Sample Description**														
Sample 1	Multistage UU TP02 0.5m	519.0	75.0	444.0	11.5	672.0	150.0	522.0	19.3	-	-	-	-	120.0	20.0
Sample 2	Multistage UU TP13 0.7m	195.0	75.0	120.0	5.4	341.0	150.0	191.0	9.8	601.0	300.0	301.0	15.1	24.1	16.5
Sample 3	Multistage UU Borrow Material	283.0	75.0	208.0	5.8	443.0	150.0	293.0	10.2	746.0	300.0	446.0	15.2	46.1	21.0
Sample 4	Single Stage CU TP02 0.5m			477	7.36										
Sample 5	Single Stage CU TP13 0.5m			484	7.68										
Sample 6	Single Stage CU Borrow Material			578	10.46										
Notes:	NO denotes not obtainable														

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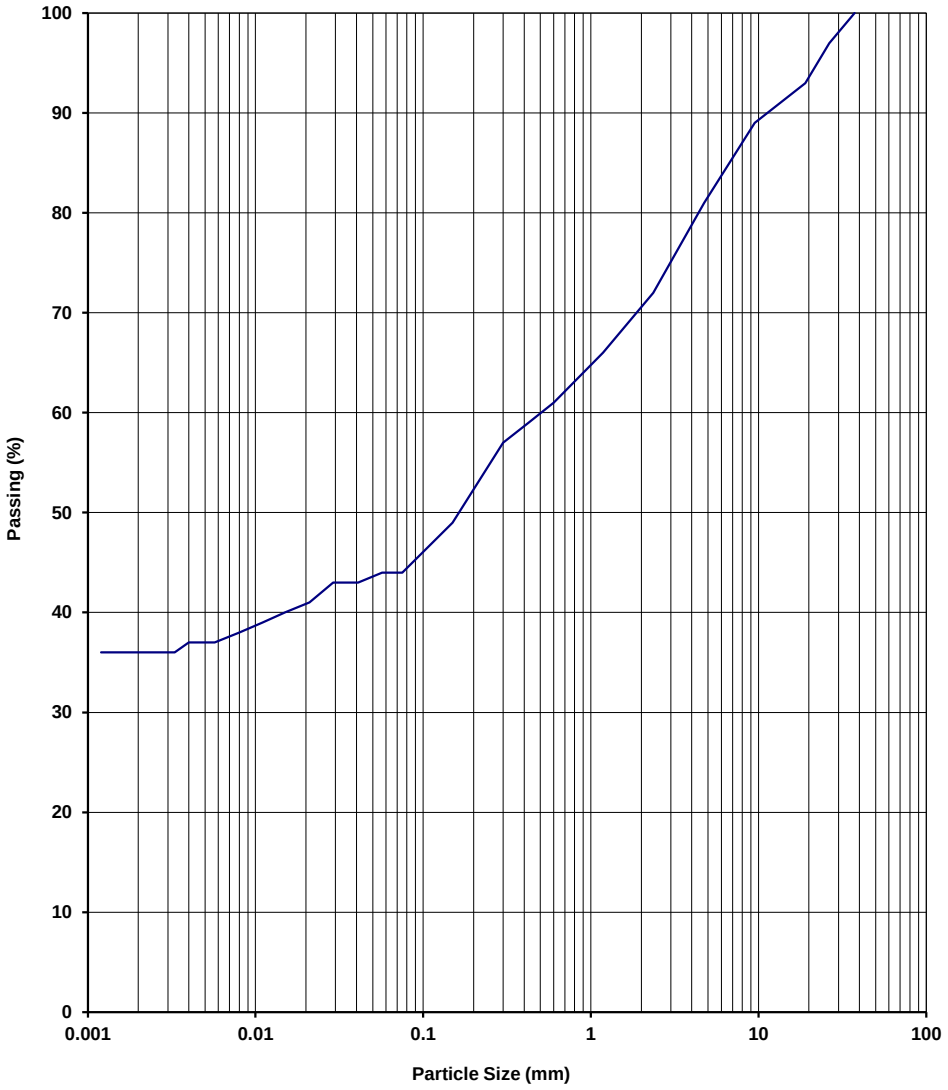
PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1

Client	Structerre Consulting Engineers	**Report No.**	P 17120138-G
Address	PO Box 792 BALCATTA WA 6914		
Project	Ravensthorpe Gold Project - Geotech Investigation Foundation & Borrow Samples	**Test Date**	20/12/2017
		Report Date	2/01/2018
Client ID	A5 TP02	**Depth (m)**	0.50-1.10

Sieve Size (mm)	Passing %
150.0	
75.0	
53.0	
37.5	100
26.5	97
19.0	93
9.5	89
4.75	81
2.36	72
1.18	66
0.600	61
0.425	59
0.300	57
0.150	49
0.075	44
0.057	44
0.041	43
0.029	43
0.021	41
0.015	40
0.011	39
0.008	38
0.006	37
0.004	37
0.003	36
0.003	36
0.002	36
0.002	36
0.001	36



NOTES/REMARKS:

Moisture Content 8.5%

-2.36mm Soil Particle Density(t/m^3) 2.63

Sample/s supplied by the client

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Tested at Trilab Perth Laboratory

Authorised Signatory

C. Channon

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Laboratory No. 9926

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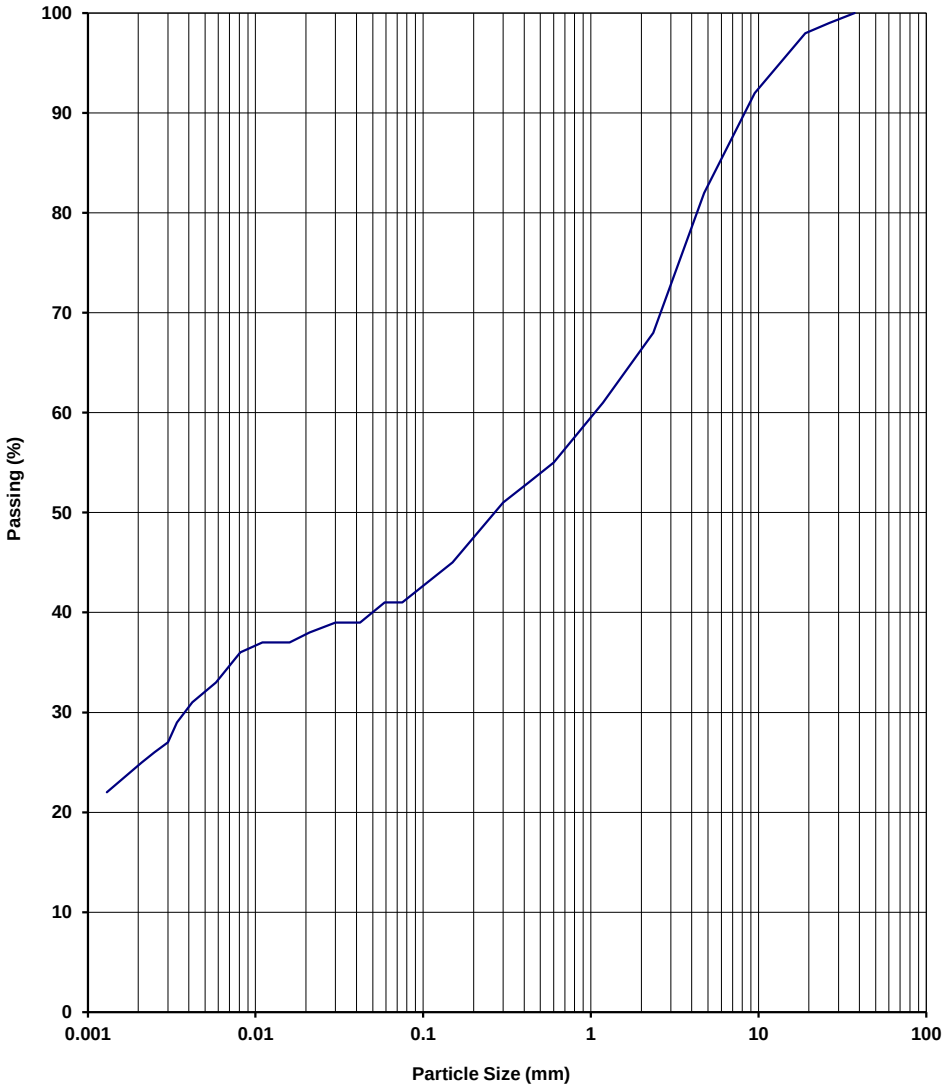
PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1

Client	Structerre Consulting Engineers	**Report No.**	P 17120139-G
Address	PO Box 792 BALCATTA WA 6914		
Project	Ravensthorpe Gold Project - Geotech Investigation Foundation & Borrow Samples	**Test Date**	21/12/2017
		Report Date	8/01/2018
Client ID	A7 TP03	**Depth (m)**	0.00-0.70

Sieve Size (mm)	Passing %
150.0	
75.0	
53.0	
37.5	100
26.5	99
19.0	98
9.5	92
4.75	82
2.36	68
1.18	61
0.600	55
0.425	53
0.300	51
0.150	45
0.075	41
0.059	41
0.042	39
0.03	39
0.021	38
0.016	37
0.011	37
0.008	36
0.006	33
0.004	31
0.003	29
0.003	27
0.003	26
0.002	25
0.001	22



NOTES/REMARKS:

Moisture Content 7.8%

-2.36mm Soil Particle Density(t/m^3) 2.61

Sample/s supplied by the client

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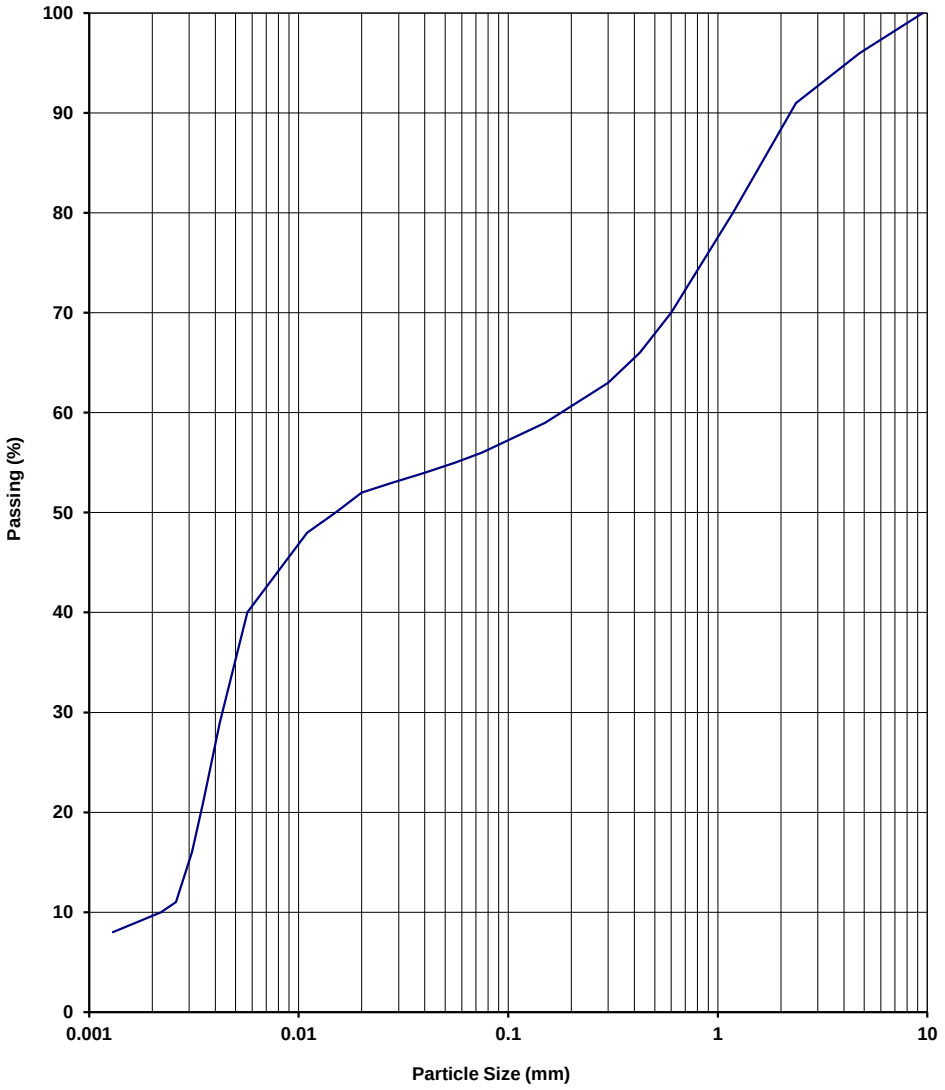
PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1

Client	Structerre Consulting Engineers	**Report No.**	P 17120140-G
Address	PO Box 792 BALCATTA WA 6914		
Project	Ravensthorpe Gold Project - Geotech Investigation Foundation & Borrow Samples	**Test Date**	21/12/2017
		Report Date	8/01/2018
Client ID	A16 TP06	**Depth (m)**	0.60-2.70

Sieve Size (mm)	Passing %
150.0	
75.0	
53.0	
37.5	
26.5	
19.0	
9.5	100
4.75	96
2.36	91
1.18	80
0.600	70
0.425	66
0.300	63
0.150	59
0.075	56
0.056	55
0.04	54
0.028	53
0.02	52
0.015	50
0.011	48
0.008	44
0.006	40
0.004	29
0.004	21
0.003	16
0.003	11
0.002	10
0.001	8



NOTES/REMARKS:

Moisture Content 8.9%

-2.36mm Soil Particle Density(t/m^3) 2.72

Sample/s supplied by the client

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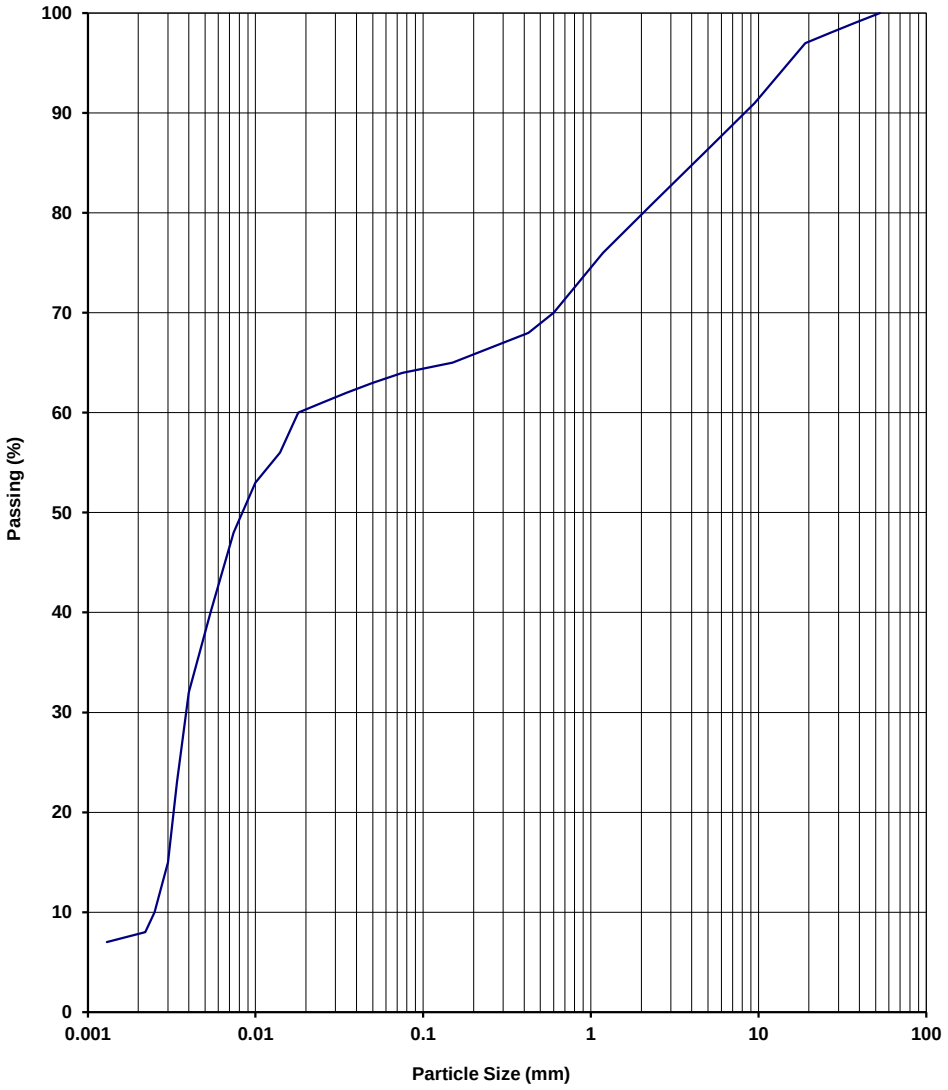
PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1

Client	Structerre Consulting Engineers	**Report No.**	P 17120141-G
Address	PO Box 792 BALCATTA WA 6914		
Project	Ravensthorpe Gold Project - Geotech Investigation Foundation & Borrow Samples	**Test Date**	20/12/2017
		Report Date	5/01/2018
Client ID	A27 TP13	**Depth (m)**	0.70-2.80

Sieve Size (mm)	Passing %
150.0	
75.0	
53.0	100
37.5	99
26.5	98
19.0	97
9.5	91
4.75	86
2.36	81
1.18	76
0.600	70
0.425	68
0.300	67
0.150	65
0.075	64
0.05	63
0.035	62
0.025	61
0.018	60
0.014	56
0.01	53
0.007	48
0.005	40
0.004	32
0.003	23
0.003	15
0.003	10
0.002	8
0.001	7



NOTES/REMARKS:

Moisture Content 11.1%

-2.36mm Soil Particle Density(t/m^3) 2.75

Sample/s supplied by the client

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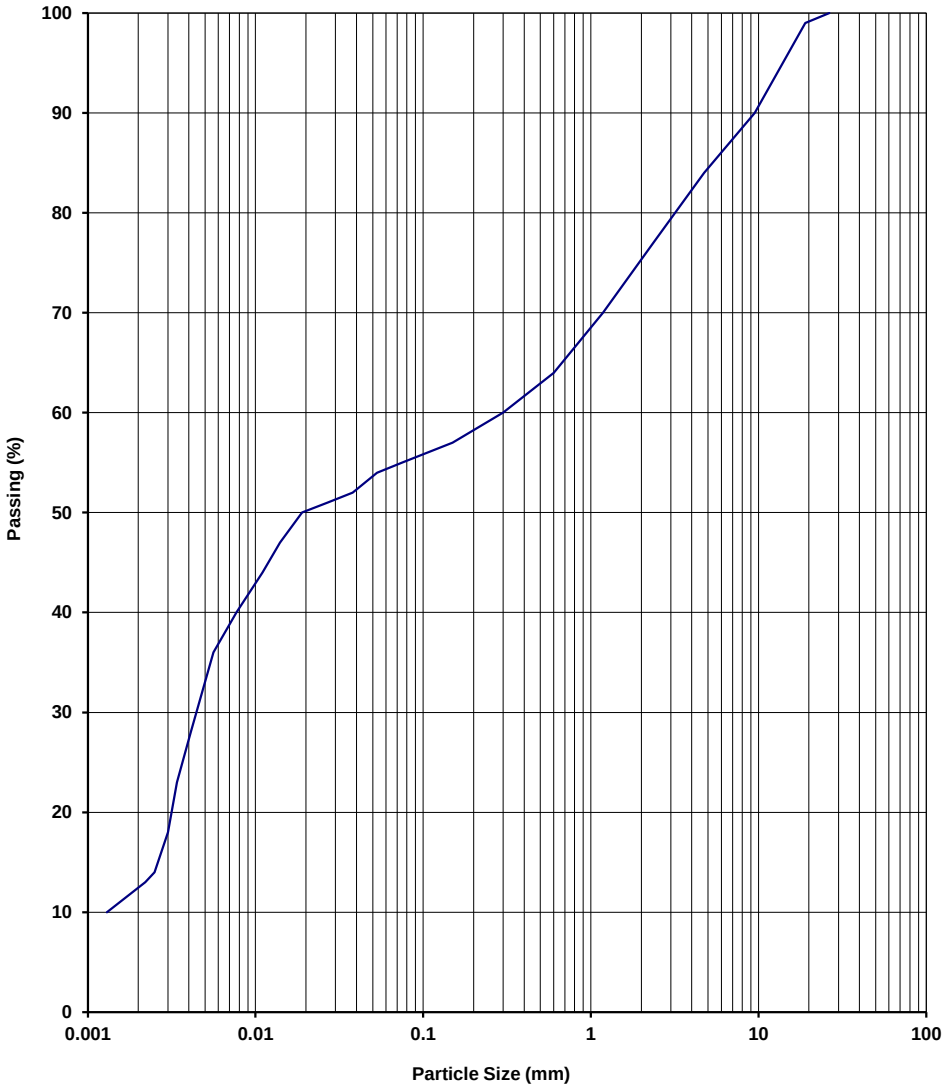
PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1

Client	Structerre Consulting Engineers	**Report No.**	P 17120142-G
Address	PO Box 792 BALCATTA WA 6914		
Project	Ravensthorpe Gold Project - Geotech Investigation Foundation & Borrow Samples	**Test Date**	21/12/2017
		Report Date	8/01/2018
Client ID	A32 TP16	**Depth (m)**	1.00-2.80

Sieve Size (mm)	Passing %
150.0	
75.0	
53.0	
37.5	
26.5	100
19.0	99
9.5	90
4.75	84
2.36	77
1.18	70
0.600	64
0.425	62
0.300	60
0.150	57
0.075	55
0.053	54
0.038	52
0.027	51
0.019	50
0.014	47
0.011	44
0.008	40
0.006	36
0.004	28
0.003	23
0.003	18
0.003	14
0.002	13
0.001	10



NOTES/REMARKS:

Moisture Content 12.4%

-2.36mm Soil Particle Density(t/m^3) 2.71

Sample/s supplied by the client

Page 1 of 1 REP33901

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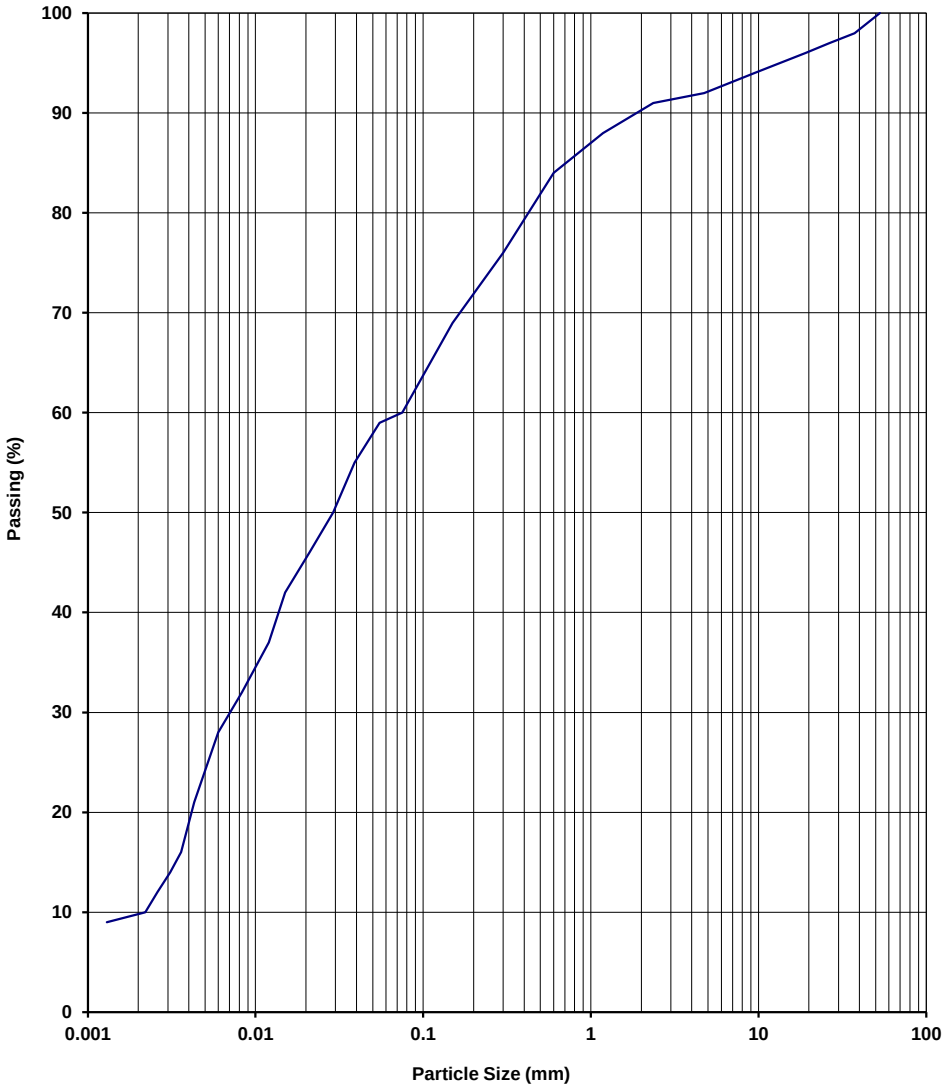
PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1

Client	Structerre Consulting Engineers	**Report No.**	P 17120143-G
Address	PO Box 792 BALCATTA WA 6914		
Project	Ravensthorpe Gold Project - Geotech Investigation Foundation & Borrow Samples	**Test Date**	20/12/2017
		Report Date	5/01/2018
Client ID	B1	**Depth (m)**	Not Supplied

Sieve Size (mm)	Passing %
150.0	
75.0	
53.0	100
37.5	98
26.5	97
19.0	96
9.5	94
4.75	92
2.36	91
1.18	88
0.600	84
0.425	80
0.300	76
0.150	69
0.075	60
0.055	59
0.039	55
0.029	50
0.021	46
0.015	42
0.012	37
0.008	32
0.006	28
0.004	21
0.004	16
0.003	14
0.003	12
0.002	10
0.001	9



NOTES/REMARKS:

Moisture Content 8.2%

-2.36mm Soil Particle Density(t/m^3) 2.68

Sample/s supplied by the client

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Tested at Trilab Perth Laboratory

Authorised Signatory

C. Channon

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Laboratory No. 9926

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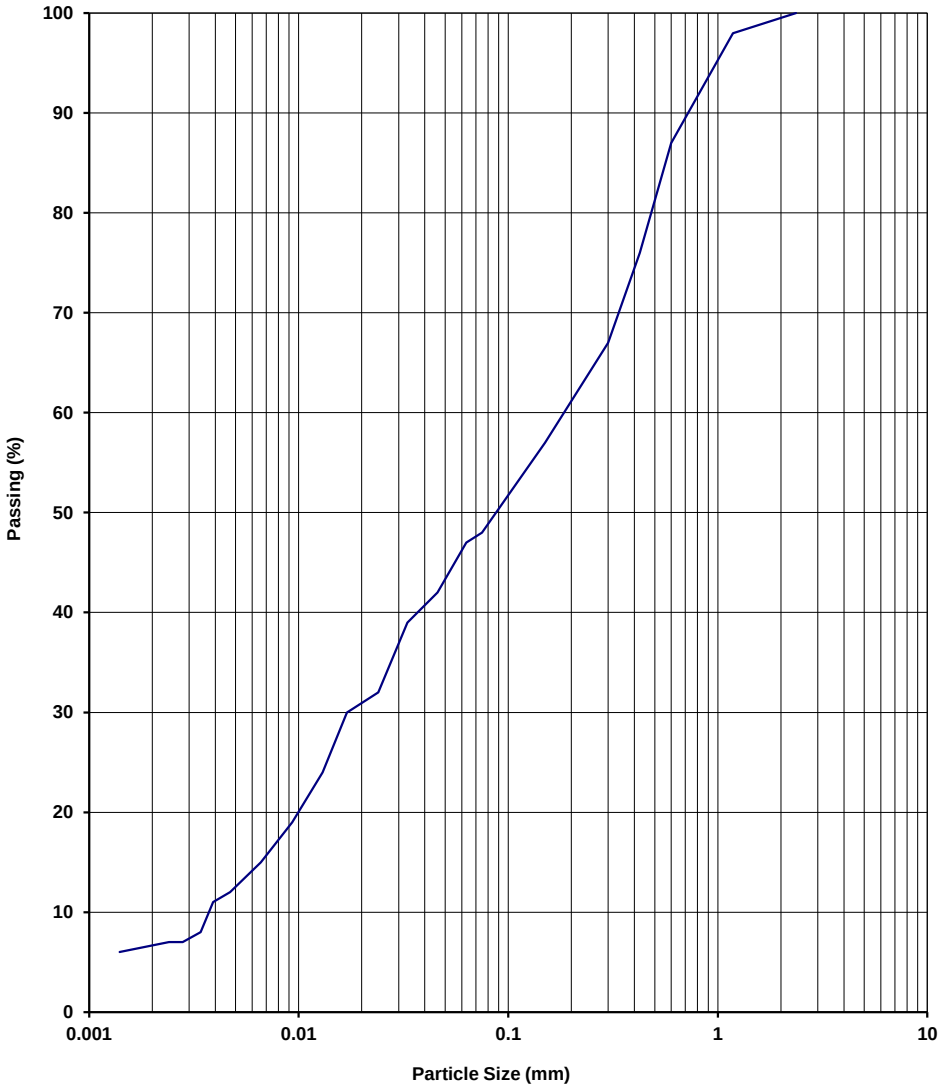
PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1

Client	Structerre Consulting Engineers	**Report No.**	P 17120144-G
Address	PO Box 792 BALCATTA WA 6914		
Project	Ravensthorpe Gold Project - Geotech Investigation Foundation & Borrow Samples	**Test Date**	21/12/2017
		Report Date	8/01/2018
Client ID	B2	**Depth (m)**	Not Supplied

Sieve Size (mm)	Passing %
150.0	
75.0	
53.0	
37.5	
26.5	
19.0	
9.5	
4.75	
2.36	100
1.18	98
0.600	87
0.425	76
0.300	67
0.150	57
0.075	48
0.063	47
0.046	42
0.033	39
0.024	32
0.017	30
0.013	24
0.009	19
0.007	15
0.005	12
0.004	11
0.003	8
0.003	7
0.002	7
0.001	6



NOTES/REMARKS:

Moisture Content 4%

Sample/s supplied by the client

-2.36mm Soil Particle Density(t/m^3) 2.69

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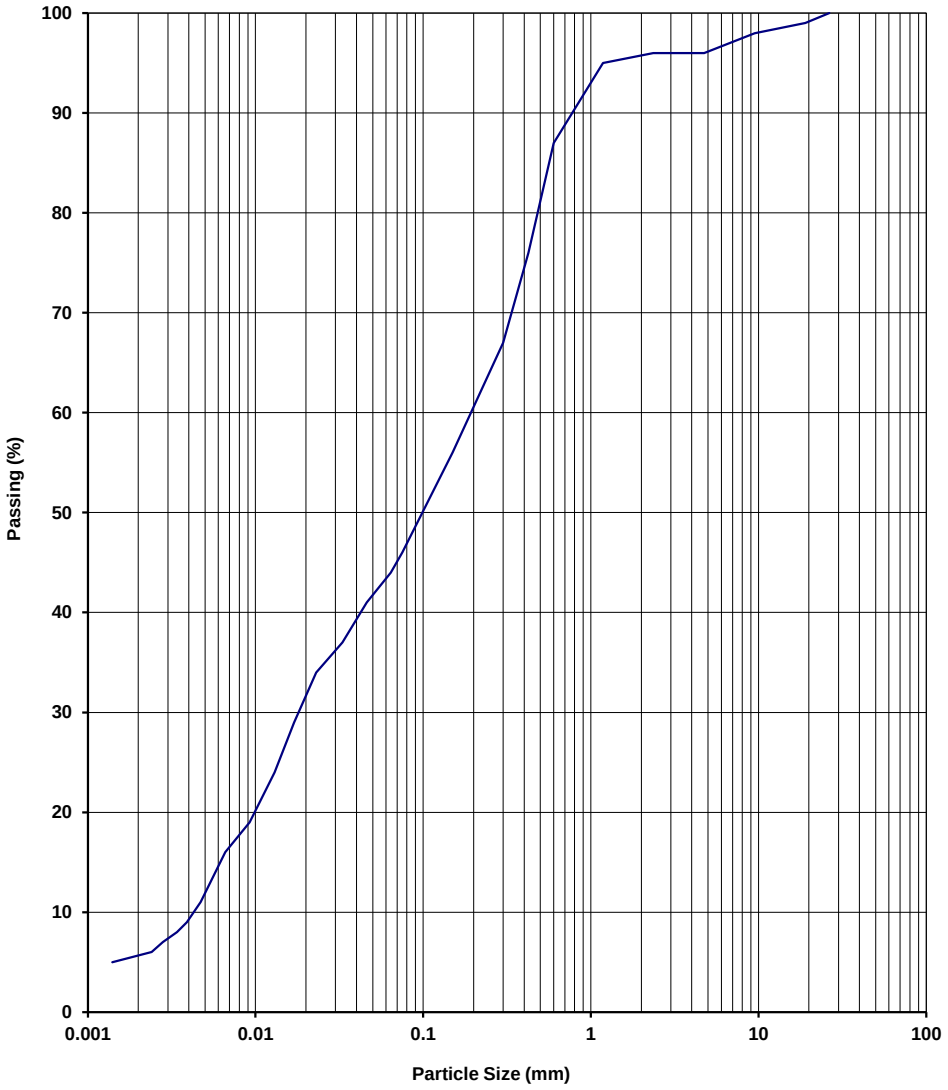
PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1

Client	Structerre Consulting Engineers	**Report No.**	P 17120145-G
Address	PO Box 792 BALCATTA WA 6914		
Project	Ravensthorpe Gold Project - Geotech Investigation Foundation & Borrow Samples	**Test Date**	21/12/2018
		Report Date	8/01/2018
Client ID	B3	**Depth (m)**	Not Supplied

Sieve Size (mm)	Passing %
150.0	
75.0	
53.0	
37.5	
26.5	100
19.0	99
9.5	98
4.75	96
2.36	96
1.18	95
0.600	87
0.425	76
0.300	67
0.150	56
0.075	46
0.064	44
0.046	41
0.033	37
0.023	34
0.017	29
0.013	24
0.009	19
0.007	16
0.005	11
0.004	9
0.003	8
0.003	7
0.002	6
0.001	5



NOTES/REMARKS:

Moisture Content 7%

Sample/s supplied by the client

-2.36mm Soil Particle Density(t/m^3) 2.69

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PERMEABILITY BY FALLING HEAD TEST REPORT

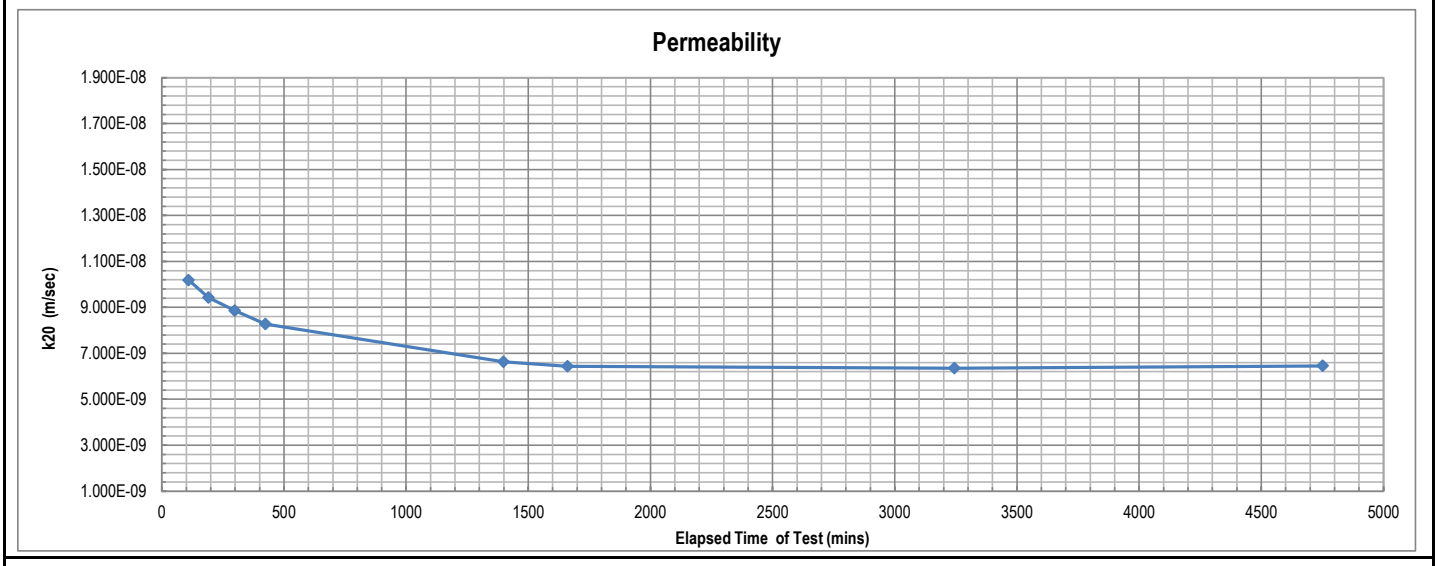
Test Method AS 1289 6.7.2, 5.1.1 , KH2 (Based on K H Head (1988) Manual of Laboratory Testing,10.7)

Client	Structerre Consulting Engineers	**Report No.**	P 17120138-FHPT
Address	PO Box 792 BALCATTA WA 6914		
Project	Ravensthorpe Gold Project - Geotech Investigation Foundation & Borrow Samples	**Test Date**	3/01/2018
		Report Date	9/01/2018
Client ID	A5 TP02	**Depth (m)**	0.50-1.10
Description	GRAVELLY SANDY SILT - pale brown	**Sample Type**	Remoulded Soil Specimen

RESULTS OF TESTING

Compaction Method	**AS1289.5.1.1 - Standard Compaction**		
Maximum Dry Density (t/m^3)	**2.05**	Hydraulic Gradient	**10.1**
Optimum Moisture Content (%)	**9.0**	Surcharge (kPa)	**2.9**
Placement Moisture Content (%)	**9.4**	Head Pressure Applied (kPa)	**11.58**
Moisture Ratio (%)	**104.2**	Water Type	**Distilled**
Placement Wet Density (t/m^3)	**2.12**	Percentage Material Retained/Sieve Size (mm)	**11 / 9.5**
Density Ratio (%)	**94.7**	Sample Height and Diameter (mm)	**116.6 / 101.1**

PERMEABILITY $k_{(20)}$ = 6.5E-09 (m/sec)



Remarks: The above specimen was remoulded to a target of 95% of Standard Dry Density and at Optimum Moisture Content.

Sample/s supplied by client — The compaction data was supplied by the client. **Page: 1 of 1** REP36301

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PERMEABILITY BY FALLING HEAD TEST REPORT

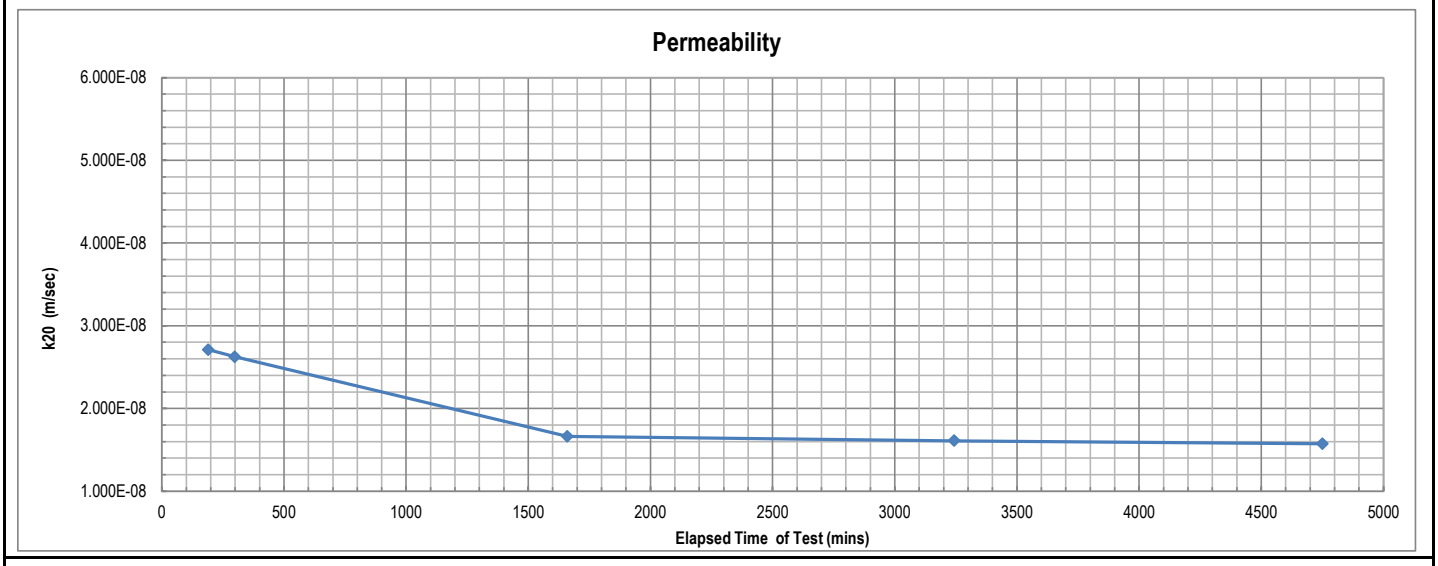
Test Method AS 1289 6.7.2, 5.1.1 , KH2 (Based on K H Head (1988) Manual of Laboratory Testing,10.7)

Client	Structerre Consulting Engineers	**Report No.**	P 17120139-FHPT
Address	PO Box 792 BALCATTA WA 6914		
Project	Ravensthorpe Gold Project - Geotech Investigation Foundation & Borrow Samples	**Test Date**	3/01/2018
		Report Date	11/01/2018
Client ID	A7 TP03	**Depth (m)**	0.00-0.70
Description	SILTY CLAYEY GRAVEL - grey	**Sample Type**	Remoulded Soil Specimen

RESULTS OF TESTING

Compaction Method	**AS1289.5.1.1 - Standard Compaction**		
Maximum Dry Density (t/m^3)	**1.88**	Hydraulic Gradient	**10.1**
Optimum Moisture Content (%)	**14.0**	Surcharge (kPa)	**2.9**
Placement Moisture Content (%)	**14.1**	Head Pressure Applied (kPa)	**11.58**
Moisture Ratio (%)	**100.8**	Water Type	**Distilled**
Placement Wet Density (t/m^3)	**2.04**	Percentage Material Retained/Sieve Size (mm)	**8 / 9.5**
Density Ratio (%)	**94.9**	Sample Height and Diameter (mm)	**116.6 / 101**

PERMEABILITY $k_{(20)}$ = 1.6E-08 (m/sec)



Remarks: The above specimen was remoulded to a target of 95% of Standard Dry Density and at Optimum Moisture Content.

Sample/s supplied by client — The compaction data was supplied by the client. **Page: 1 of 1** REP36301

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PERMEABILITY BY FALLING HEAD TEST REPORT

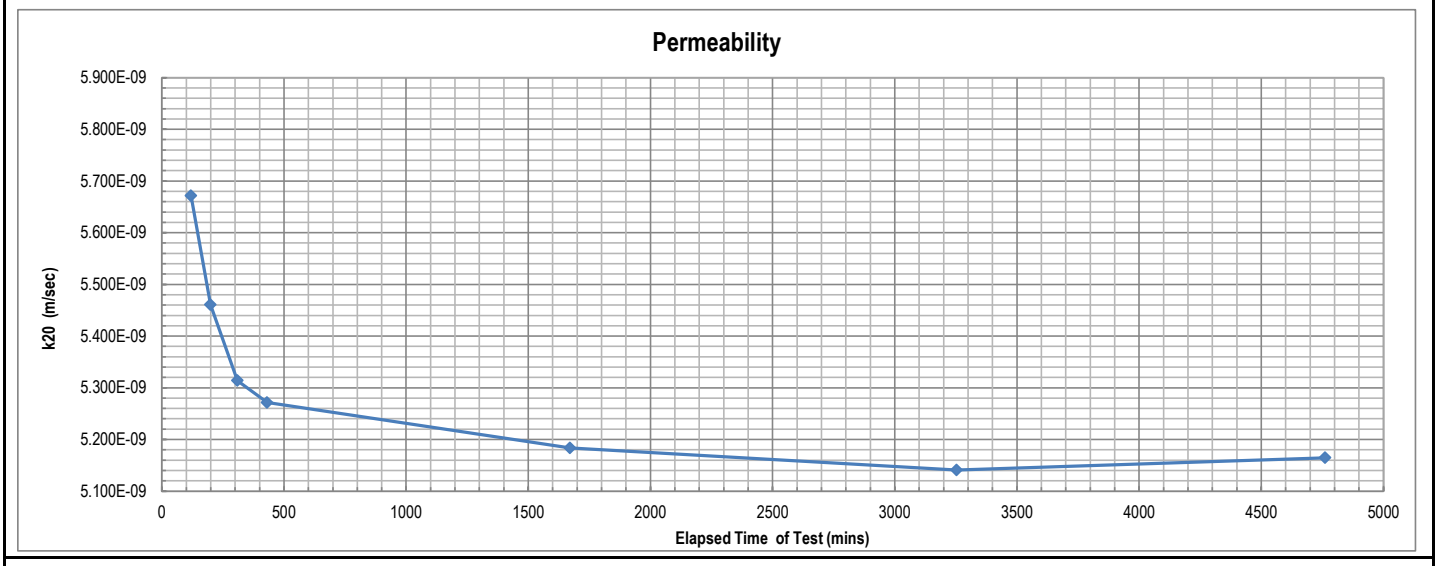
Test Method AS 1289 6.7.2, 5.1.1 , KH2 (Based on K H Head (1988) Manual of Laboratory Testing,10.7)

Client	Structerre Consulting Engineers	**Report No.**	P 17120140-FHPT
Address	PO Box 792 BALCATTA WA 6914		
Project	Ravensthorpe Gold Project - Geotech Investigation Foundation & Borrow Samples	**Test Date**	3/01/2018
		Report Date	11/01/2018
Client ID	A16 TP06	**Depth (m)**	0.60-2.70
Description	SANDY CLAYEY SILT - pale brown	**Sample Type**	Remoulded Soil Specimen

RESULTS OF TESTING

Compaction Method	**AS1289.5.1.1 - Standard Compaction**		
Maximum Dry Density (t/m^3)	**1.84**	Hydraulic Gradient	**10.1**
Optimum Moisture Content (%)	**14.5**	Surcharge (kPa)	**3.0**
Placement Moisture Content (%)	**15.2**	Head Pressure Applied (kPa)	**11.58**
Moisture Ratio (%)	**104.8**	Water Type	**Distilled**
Placement Wet Density (t/m^3)	**2.01**	Percentage Material Retained/Sieve Size (mm)	**0 / 9.5**
Density Ratio (%)	**94.7**	Sample Height and Diameter (mm)	**116.4 / 101.3**

PERMEABILITY $k_{(20)}$ = 5.2E-09 (m/sec)



Remarks: The above specimen was remoulded to a target of 95% of Standard Dry Density and at Optimum Moisture Content.

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PERMEABILITY BY FALLING HEAD TEST REPORT

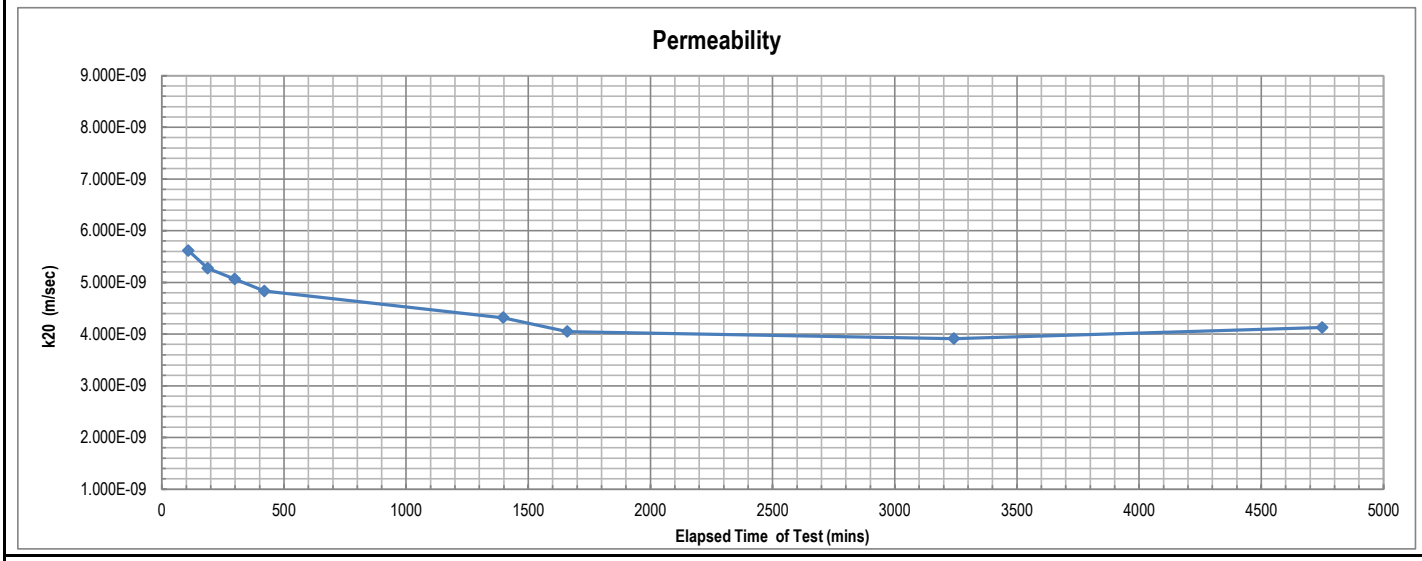
Test Method AS 1289 6.7.2, 5.1.1 , KH2 (Based on K H Head (1988) Manual of Laboratory Testing,10.7)

Client	Structerre Consulting Engineers	**Report No.**	P 17120141-FHPT
Address	PO Box 792 BALCATTA WA 6914		
Project	Ravensthorpe Gold Project - Geotech Investigation Foundation & Borrow Samples	**Test Date**	3/01/2018
		Report Date	11/01/2018
Client ID	A27 TP13	**Depth (m)**	0.70-2.80
Description	GRAVELLY SANDY SILT - white	**Sample Type**	Remoulded Soil Specimen

RESULTS OF TESTING

Compaction Method	**AS1289.5.1.1 - Standard Compaction**		
Maximum Dry Density (t/m^3)	**1.69**	Hydraulic Gradient	**10.1**
Optimum Moisture Content (%)	**16.0**	Surcharge (kPa)	**3.0**
Placement Moisture Content (%)	**16.1**	Head Pressure Applied (kPa)	**11.58**
Moisture Ratio (%)	**100.8**	Water Type	**Distilled**
Placement Wet Density (t/m^3)	**1.87**	Percentage Material Retained/Sieve Size (mm)	**9 / 9.5**
Density Ratio (%)	**95.1**	Sample Height and Diameter (mm)	**116.5 / 101.1**

PERMEABILITY $k_{(20)}$ = 4.1E-09 (m/sec)



Remarks: The above specimen was remoulded to a target of 95% of Standard Dry Density and at Optimum Moisture Content.

Sample/s supplied by client — The compaction data was supplied by the client. **Page: 1 of 1** REP36301

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PERMEABILITY BY FALLING HEAD TEST REPORT

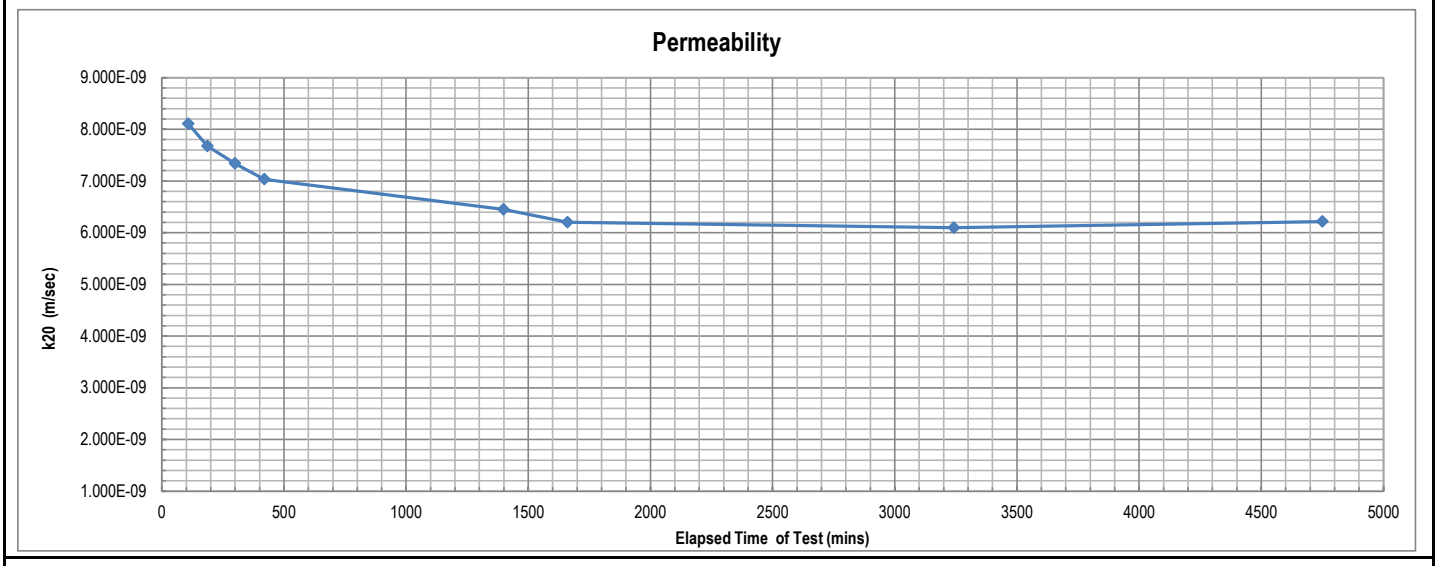
Test Method AS 1289 6.7.2, 5.1.1 , KH2 (Based on K H Head (1988) Manual of Laboratory Testing,10.7)

Client	Structerre Consulting Engineers	**Report No.**	P 17120142-FHPT
Address	PO Box 792 BALCATTA WA 6914		
Project	Ravensthorpe Gold Project - Geotech Investigation Foundation & Borrow Samples	**Test Date**	3/01/2018
		Report Date	11/01/2018
Client ID	A32 TP16	**Depth (m)**	1.00-2.80
Description	GRAVELLY SILT - pale brown	**Sample Type**	Remoulded Soil Specimen

RESULTS OF TESTING

Compaction Method	**AS1289.5.1.1 - Standard Compaction**		
Maximum Dry Density (t/m^3)	**1.72**	Hydraulic Gradient	**10.1**
Optimum Moisture Content (%)	**15.5**	Surcharge (kPa)	**3.0**
Placement Moisture Content (%)	**15.6**	Head Pressure Applied (kPa)	**11.58**
Moisture Ratio (%)	**100.8**	Water Type	**Distilled**
Placement Wet Density (t/m^3)	**1.89**	Percentage Material Retained/Sieve Size (mm)	**0 / 9.5**
Density Ratio (%)	**95.2**	Sample Height and Diameter (mm)	**116.5 / 101.1**

PERMEABILITY $k_{(20)}$ = 6.2E-09 (m/sec)



Remarks: The above specimen was remoulded to a target of 95% of Standard Dry Density and at Optimum Moisture Content.

Sample/s supplied by client — The compaction data was supplied by the client. **Page: 1 of 1** REP36301

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PINHOLE DISPERSION TEST REPORT

Test Method: AS 1289 3.8.3

Client	Structerre Consulting Engineers	**Report No.**	P 17120143-PHD
Address	PO Box 792 BALCATTA WA 6914		
Project	Ravensthorpe Gold Project - Geotech Investigation Foundation & Borrow Samples	**Test Date**	2/01/2018
		Report Date	5/01/2018

Sample No.	17120143	17120143	
Client ID	B1	B1	
Depth (m)	Not Supplied	Not Supplied	
Description	SILTY GRAVEL - white	SILTY GRAVEL - white	
Method of Moisture Determination for Remoulding	Optimum Moisture Content	Optimum Moisture Content	
Initial Moisture Content (%)	8.2	8.2	
Placement Wet Density (t/m³)	1.866	1.922	
Placement Moisture Content (%)	15.9	15.9	
Density Ratio (%)	95.7	98.1	
Variation from Optimum Moisture Content (%)	Nil	Nil	
Curing Time (Days)	2	2	
Source of Water	Distilled	Distilled	
Hole Reformed at 50mm Head Height	Yes	Yes	
PINHOLE DISPERSION CLASSIFICATION: **DESIGNATION**	D1	D1	
DESCRIPTION	Highly dispersive	Highly dispersive	

NOTES/REMARKS:

Sample/s supplied by the client

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PINHOLE DISPERSION TEST REPORT

Test Method: AS 1289 3.8.3

Client	Structerre Consulting Engineers	**Report No.**	P 17120144-PHD
Address	PO Box 792 BALCATTA WA 6914		
Project	Ravensthorpe Gold Project - Geotech Investigation Foundation & Borrow Samples	**Test Date**	2/01/2018
		Report Date	5/01/2018

Sample No.	17120144	17120144	
Client ID	B2	B2	
Depth (m)	Not Supplied	Not Supplied	
Description	GRAVELLY SILT - white	GRAVELLY SILT - white	
Method of Moisture Determination for Remoulding	Optimum Moisture Content	Optimum Moisture Content	
Initial Moisture Content (%)	4.0	4.0	
Placement Wet Density (t/m³)	1.96	2.02	
Placement Moisture Content (%)	13.6	13.6	
Density Ratio (%)	95.2	98.1	
Variation from Optimum Moisture Content (%)	Nil	Nil	
Curing Time (Days)	2	2	
Source of Water	Distilled	Distilled	
Hole Reformed at 50mm Head Height	No	No	
PINHOLE DISPERSION CLASSIFICATION: **DESIGNATION**	D1	D1	
DESCRIPTION	Highly dispersive	Highly dispersive	

NOTES/REMARKS:

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PINHOLE DISPERSION TEST REPORT

Test Method: AS 1289 3.8.3

Client	Structerre Consulting Engineers	**Report No.**	P 17120145-PHD
Address	PO Box 792 BALCATTA WA 6914		
Project	Ravensthorpe Gold Project - Geotech Investigation Foundation & Borrow Samples	**Test Date**	2/01/2018
		Report Date	5/01/2018

Sample No.	17120145	17120145	
Client ID	B3	B3	
Depth (m)	Not Supplied	Not Supplied	
Description	SANDY SILT- yellow	SANDY SILT- yellow	
Method of Moisture Determination for Remoulding	Optimum Moisture Content	Optimum Moisture Content	
Initial Moisture Content (%)	7.0	7.0	
Placement Wet Density (t/m³)	1.89	1.96	
Placement Moisture Content (%)	12.7	12.7	
Density Ratio (%)	94.9	98.1	
Variation from Optimum Moisture Content (%)	Nil	Nil	
Curing Time (Days)	2	2	
Source of Water	Distilled	Distilled	
Hole Reformed at 50mm Head Height	No	No	
PINHOLE DISPERSION CLASSIFICATION: **DESIGNATION**	D2	D2	
DESCRIPTION	Dispersive	Dispersive	

NOTES/REMARKS:

Sample/s supplied by the client

Accredited for compliance with ISO/IES 17025.
The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.

Tested at Trilab Perth Laboratory.

Authorised Signatory

C. Channon

NATA ACCREDITED FOR TECHNICAL COMPETENCE

Laboratory No. 9926

The results of calibrations and tests performed apply only to the specific instrument or sample at the time of test unless otherwise clearly stated.
Reference should be made to Trilab's "Standard Terms and Conditions of Business" for further details.
Trilab Pty Ltd ABN 25 065 630 506

ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

Material Test Certificate

AS 1289.2.1.1 Determination of the moisture content of a soil - Oven drying method (standard method)

Report Number	S865847-A Issue 1	**Client**	MHA GEOTECHNICAL
Job Number	S865847	**Project**	Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Lab No	S865847-A			**Date tested**	1 December 2007
Sample ID	-			**Time Tested**	-
Proposed Use	Foundation			**Layer Thickness mm**	-
Material Description	Various			**Test Depth mm**	-
Sampling Method	Client	**Site Selection Method**	Client		

Sample No.	Sample ID	Moisture Content %
S865847-A-1	TP01_0.0-0.2m	6.4
S865847-A-2	TP01_0.2-0.75m	11.5
S865847-A-3	TP01_0.75-1.6m	8.9
S865847-A-4	TP02_0.1-0.5m	6.7
S865847-A-5	TP02_0.5-1.1m	5.5
S865847-A-6	TP02_1.2-2.7m	13.2
S865847-A-7	TP03_0.0-0.7m	8.8
S865847-A-8	TP03_0.7-3.0m	9.4
S865847-A-9	TP04_0.0-0.25m	12.2
S865847-A-10	TP04_0.25-1.0m	13.5

Remarks

Accredited for compliance with ISO/IEC 17025 - Testing
STRUCTERRE CONSULTING ENGINEERS BALCATTA LABORATORY ACCREDITATION NUMBER 18742

Authorised Signatory

Date 16 January 2018

Wayne Rozmianiec
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MATERIAL TEST CERTIFICATE

Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

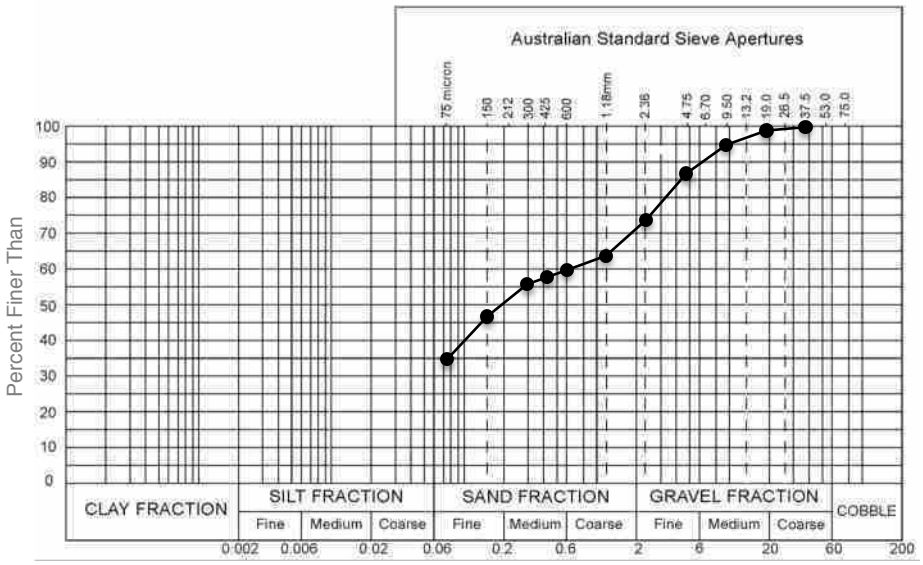
Sample Details

Laboratory Number	S865847-A-1	**Date tested**	05 Dec 2017
Sample ID	TP01 0.0-0.2m	**Tested by**	JWS
Proposed Use	Foundation	**Layer Thickness**	-
Material Description	AS 1726 - 2017 Sandy FINES with gravel	**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	64	**Liquid Limit %**	
37.5 mm	100	0.6 mm	60	**Plastic Limit %**	
19 mm	99	0.425 mm	58	**Plasticity Index %**	
9.5 mm	95	0.3 mm	56	**Linear Shrinkage %**	
4.75 mm	87	0.15 mm	47	**Nature Of Shrinkage**	
2.36 mm	74	0.075 mm	35	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Particle Size Distribution & Atterberg Limits of a Soil

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Issue 1

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Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

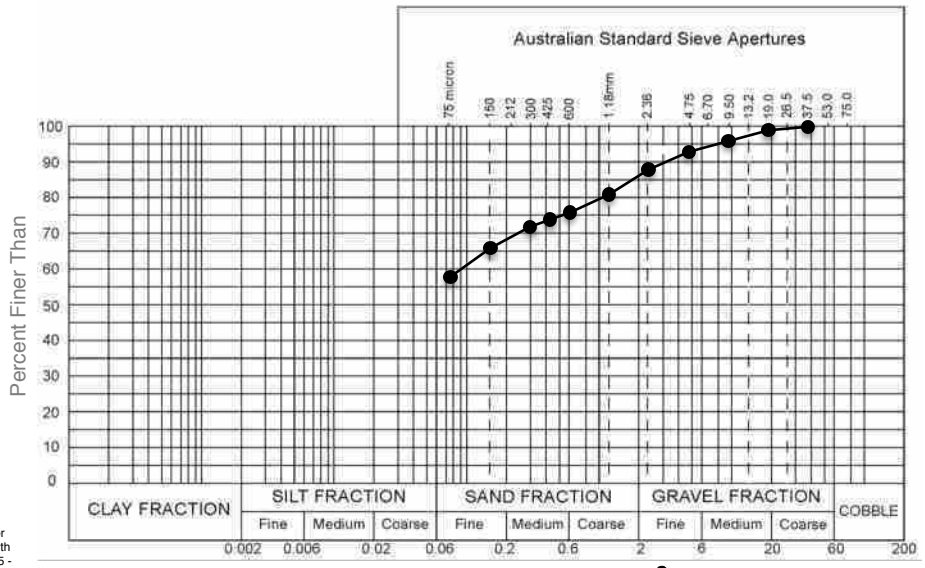
Sample Details

Laboratory Number	S865847-A-2	**Date tested**	05 Dec 2017		
Sample ID	TP01 0.2-0.75m			**Tested by**	JWS
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	AS 1726 - 2017 FINES trace gravel, with sand			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	81	**Liquid Limit %**	
37.5 mm	100	0.6 mm	76	**Plastic Limit %**	
19 mm	99	0.425 mm	74	**Plasticity Index %**	
9.5 mm	96	0.3 mm	72	**Linear Shrinkage %**	
4.75 mm	93	0.15 mm	66	**Nature Of Shrinkage**	
2.36 mm	88	0.075 mm	58	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

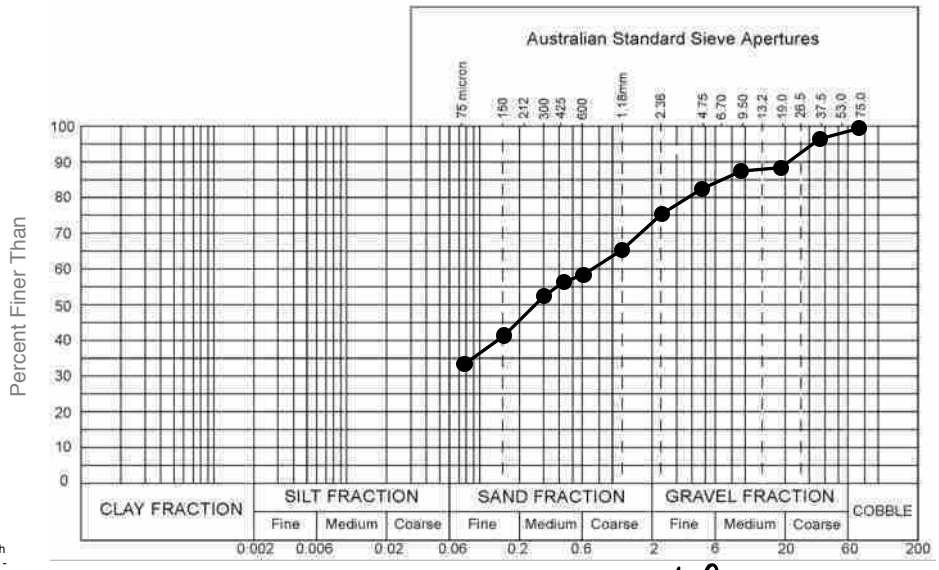
Sample Details

Laboratory Number	S865847-A-3	**Date tested**	05 Dec 2017
Sample ID	TP01 0.75-1.6m	**Tested by**	JWS
Proposed Use	Foundation	**Layer Thickness**	-
Material Description	AS 1726 - 2017 SM Silty or clayey SAND with gravel	**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm	100	1.18 mm	66	**Liquid Limit %**	
37.5 mm	97	0.6 mm	59	**Plastic Limit %**	
19 mm	89	0.425 mm	57	**Plasticity Index %**	
9.5 mm	88	0.3 mm	53	**Linear Shrinkage %**	
4.75 mm	83	0.15 mm	42	**Nature Of Shrinkage**	
2.36 mm	76	0.075 mm	34	**Sample History**	

Particle Size Distribution Graph



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Particle Size Distribution & Atterberg Limits of a Soil

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Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

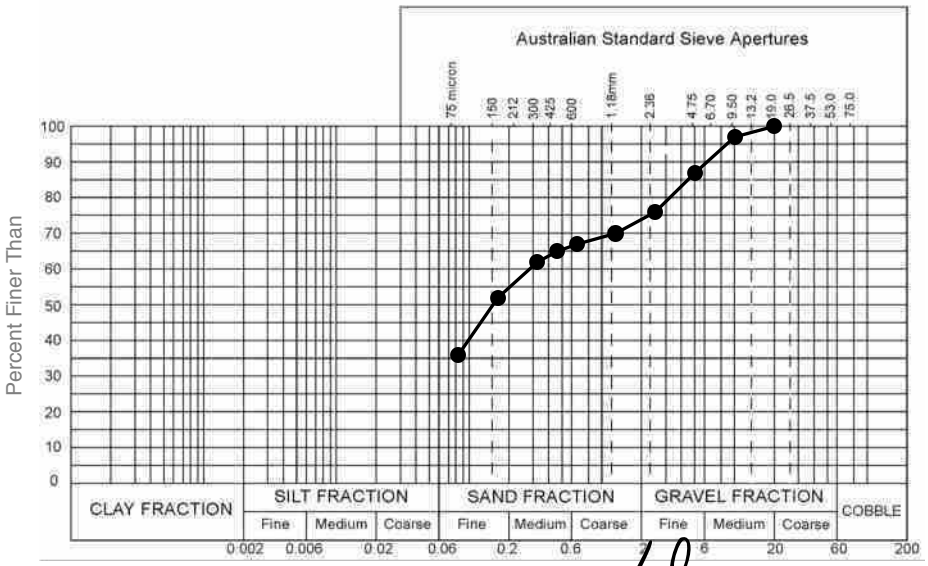
Sample Details

Laboratory Number	S865847-A-4	**Date tested**	05 Dec 2017
Sample ID	TP02 0.1-0.5m	**Tested by**	JWS
Proposed Use	Foundation	**Layer Thickness**	-
Material Description	AS 1726 - 2017 Sandy FINES with gravel	**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	70	**Liquid Limit %**	
37.5 mm		0.6 mm	67	**Plastic Limit %**	
19 mm	100	0.425 mm	65	**Plasticity Index %**	
9.5 mm	97	0.3 mm	62	**Linear Shrinkage %**	
4.75 mm	87	0.15 mm	52	**Nature Of Shrinkage**	
2.36 mm	76	0.075 mm	36	**Sample History**	

Particle Size Distribution Graph



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Particle Size Distribution & Atterberg Limits of a Soil

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Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

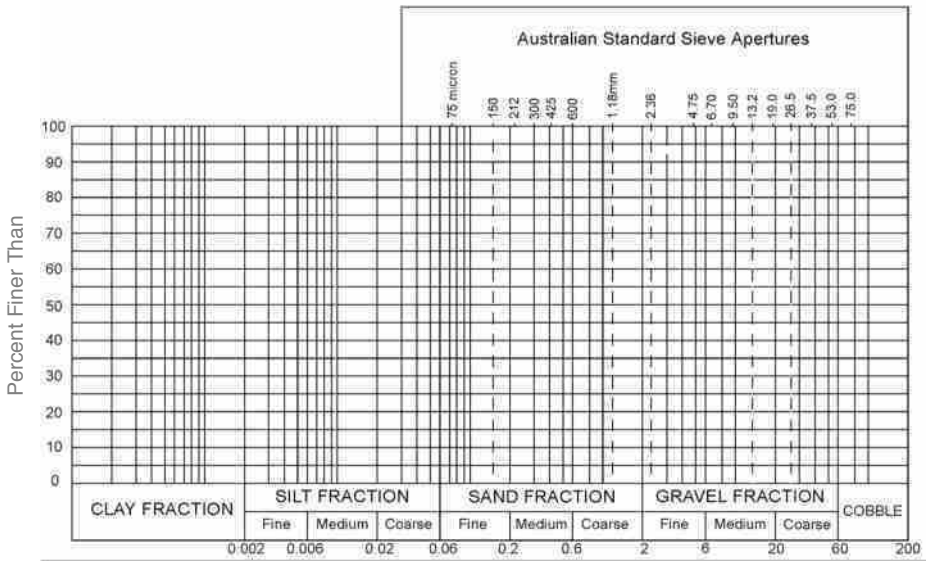
Sample Details

Laboratory Number	S865847-A-5	**Date tested**	7 December 2017		
Sample ID	TP02 0.5-1.1m			**Tested by**	CF
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	Clay or Silt			**Test Depth**	0.5-1.1m
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm		**Liquid Limit %**	38
37.5 mm		0.6 mm		**Plastic Limit %**	18
19 mm		0.425 mm		**Plasticity Index %**	20
9.5 mm		0.3 mm		**Linear Shrinkage %**	7.0
4.75 mm		0.15 mm		**Nature Of Shrinkage**	Normal
2.36 mm		0.075 mm		**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Particle Size Distribution & Atterberg Limits of a Soil

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Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

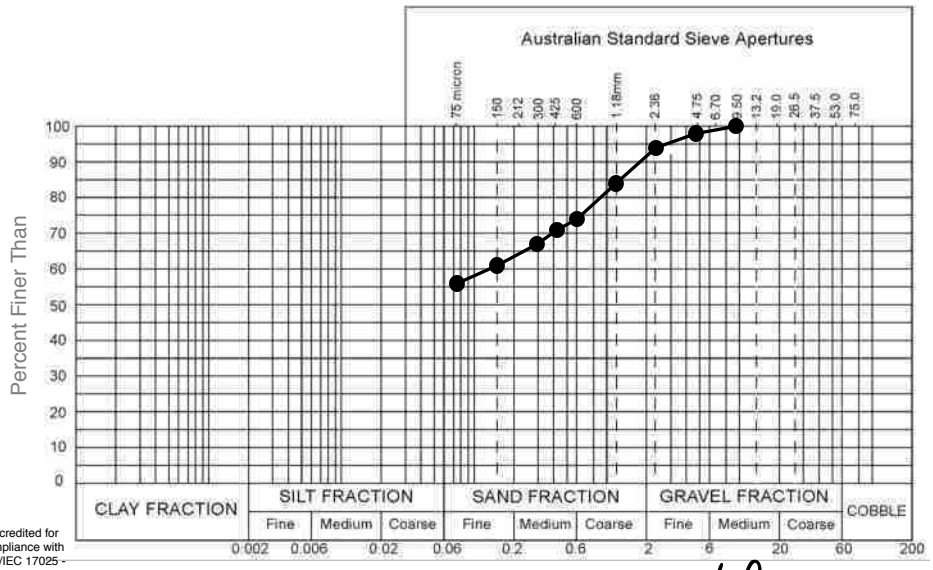
Sample Details

Laboratory Number	S865847-A-6	**Date tested**	07 Dec 2017		
Sample ID	TP02 1.1-2.7m			**Tested by**	JWS
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	AS 1726 - 2017 Sandy FINES trace gravel			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	84	**Liquid Limit %**	
37.5 mm		0.6 mm	74	**Plastic Limit %**	
19 mm		0.425 mm	71	**Plasticity Index %**	
9.5 mm	100	0.3 mm	67	**Linear Shrinkage %**	
4.75 mm	98	0.15 mm	61	**Nature Of Shrinkage**	
2.36 mm	94	0.075 mm	56	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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MATERIAL TEST CERTIFICATE

Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
Issue 1

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Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

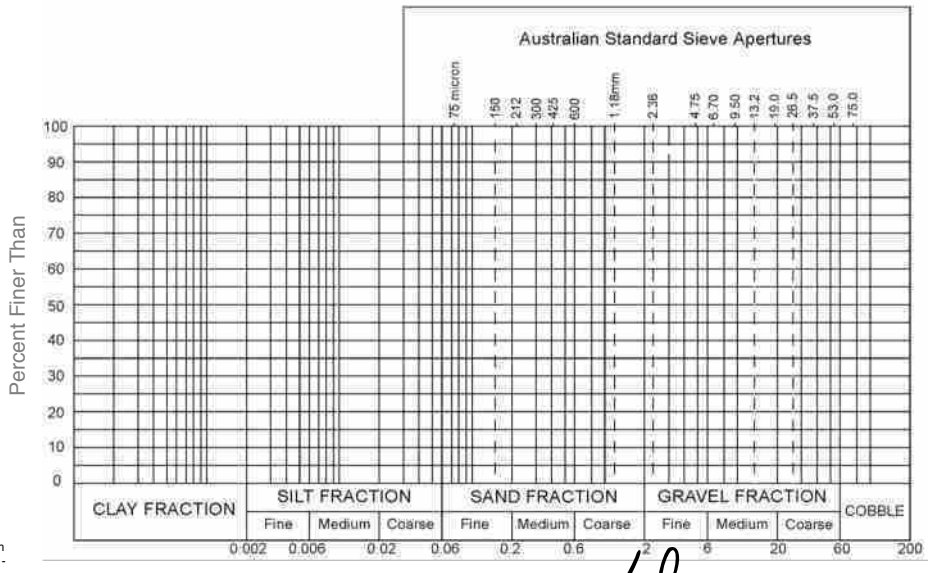
Sample Details

Laboratory Number	S865847-A-7	**Date tested**	11 December 2017
Sample ID	TP03_0.0-0.7m	**Tested by**	JWS
Proposed Use	Foundation	**Layer Thickness**	-
Material Description	AS 1726 - 2017 - -	**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm		**Liquid Limit %**	28
37.5 mm		0.6 mm		**Plastic Limit %**	15
19 mm		0.425 mm		**Plasticity Index %**	13
9.5 mm		0.3 mm		**Linear Shrinkage %**	5.5
4.75 mm		0.15 mm		**Nature Of Shrinkage**	Normal
2.36 mm		0.075 mm		**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Job Number S865847

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Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

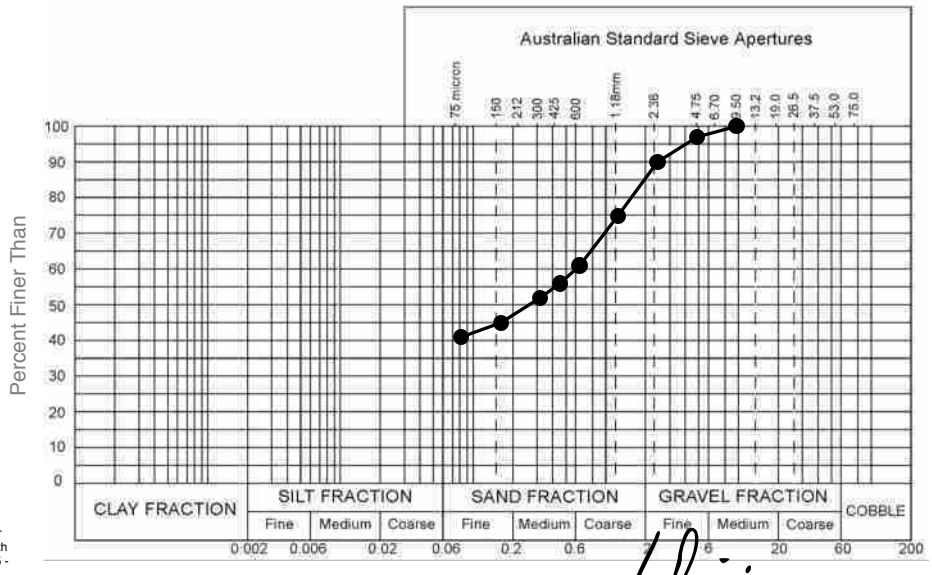
Sample Details

Laboratory Number	S865847-A-8	**Date tested**	07 Dec 2017		
Sample ID	TP03_0.7-3.0m			**Tested by**	JWS
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	AS 1726 - 2017 Sandy FINES trace gravel			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	75	**Liquid Limit %**	
37.5 mm		0.6 mm	61	**Plastic Limit %**	
19 mm		0.425 mm	56	**Plasticity Index %**	
9.5 mm	100	0.3 mm	52	**Linear Shrinkage %**	
4.75 mm	97	0.15 mm	45	**Nature Of Shrinkage**	
2.36 mm	90	0.075 mm	41	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Report Number S865847-A
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Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

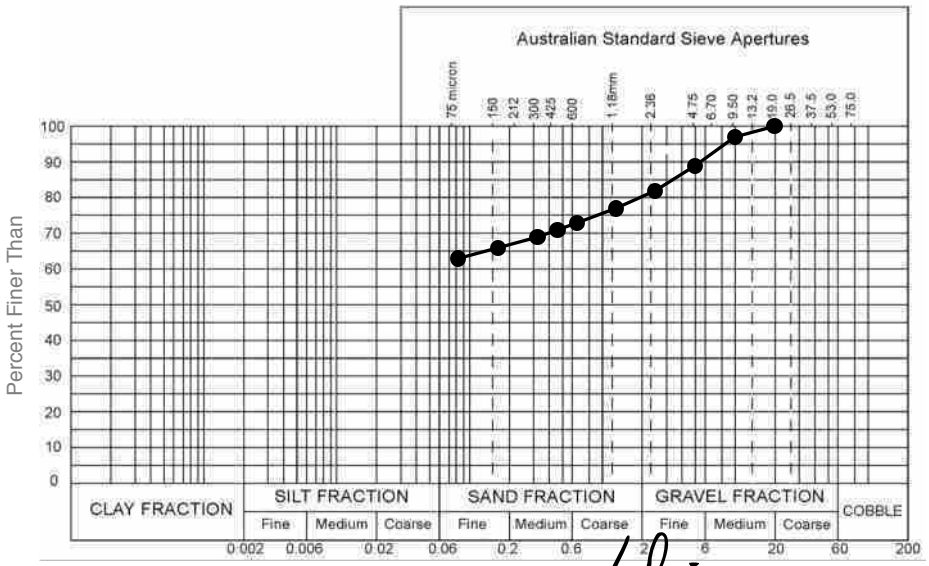
Sample Details

Laboratory Number	S865847-A-9	**Date tested**	11 Dec 2017
Sample ID	TP04_0.0-0.25m	**Tested by**	JWS
Proposed Use	Foundation	**Layer Thickness**	-
Material Description	AS 1726 - 2017 FINES with gravel, with sand	**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	77	**Liquid Limit %**	
37.5 mm		0.6 mm	73	**Plastic Limit %**	
19 mm	100	0.425 mm	71	**Plasticity Index %**	
9.5 mm	97	0.3 mm	69	**Linear Shrinkage %**	
4.75 mm	89	0.15 mm	66	**Nature Of Shrinkage**	
2.36 mm	82	0.075 mm	63	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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STRUCTERRE CONSULTING ENGINEERS
BALCATTA LABORATORY
ACCREDITATION NUMBER 18742

Remarks

Authorised Signatory

Date 16 January 2018

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MATERIAL TEST CERTIFICATE

Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

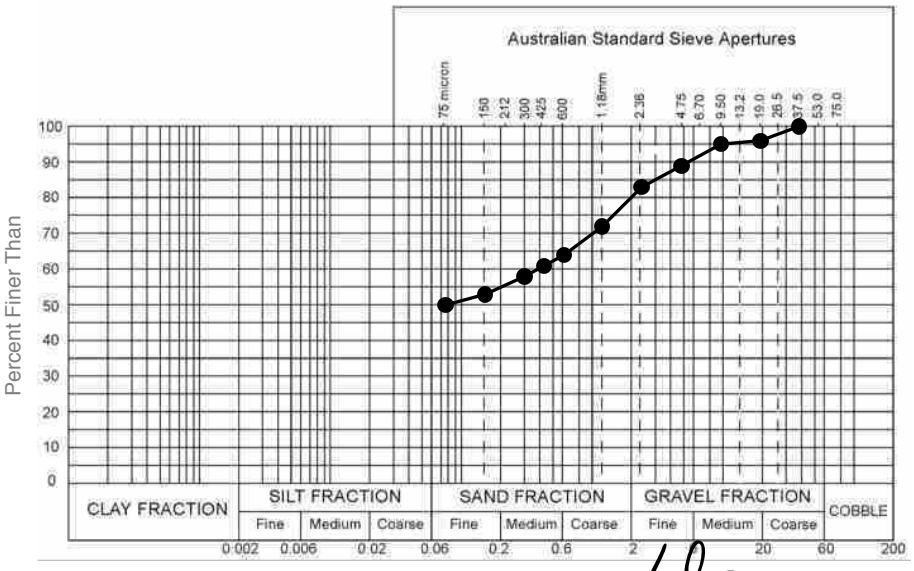
Sample Details

Laboratory Number	S865847-A-10	**Date tested**	11 Dec 2017		
Sample ID	TP04_0.25-1.0m			**Tested by**	JWS
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	AS 1726 - 2017 Sandy FINES with gravel			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	72	**Liquid Limit %**	
37.5 mm	100	0.6 mm	64	**Plastic Limit %**	
19 mm	96	0.425 mm	61	**Plasticity Index %**	
9.5 mm	95	0.3 mm	58	**Linear Shrinkage %**	
4.75 mm	89	0.15 mm	53	**Nature Of Shrinkage**	
2.36 mm	83	0.075 mm	50	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Material Test Certificate

AS 1289.5.1.1 Determination of the dry density/moisture content relation of a soil using standard compactive effort

Report Number	S865847-A Issue 1	**Client**	MHA GEOTECHNICAL
Job Number	S865847	**Project**	Ravensthorpe Gold Project - MURRAY ST PERTH

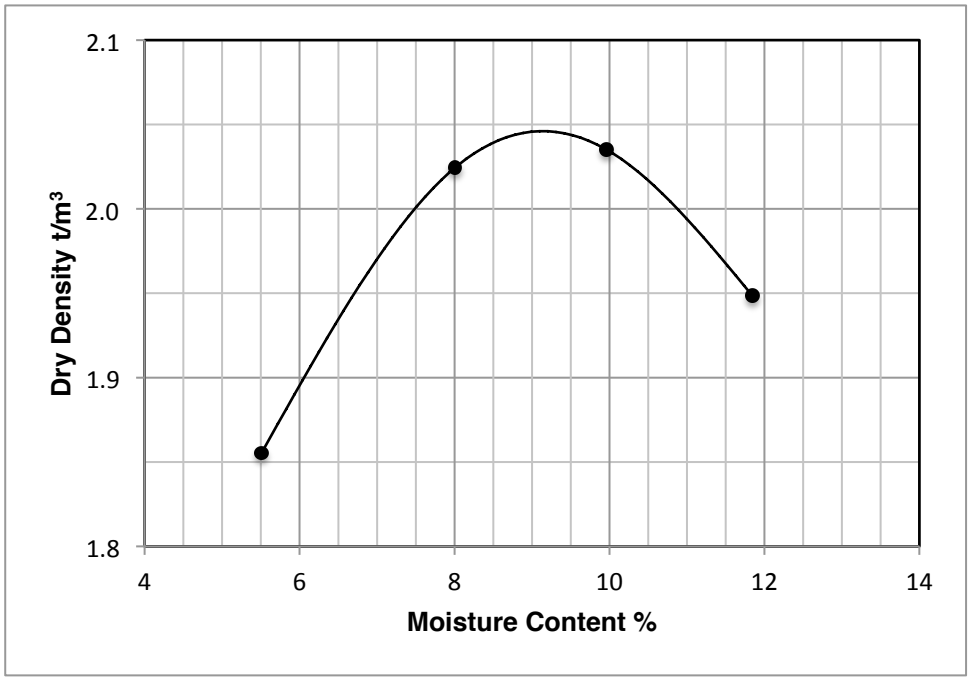
Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Laboratory Number	S865847-A-5	**Date tested**	Friday, 1 December 2017
Sample ID	TP02 0.5-1.1m		
Proposed Use	Foundation		
Material Description	Gravelly Clay		
Sampling Method	Client	**Site Selection Method**	Client

AS 1289.2.1.1 Determination of the moisture content of a soil - Oven drying method (standard method)

Maximum Dry Density t/m^3	2.05	**Optimum Moisture Content %**	9.0
% Retained 19mm Sieve	1	**% Retained 37.5mm Sieve**	0
Curing Time (hrs)	2	**Method used to determine LL**	Visual/Tactile



Remarks

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Date 16 January 2018

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Material Test Certificate

AS 1289.5.1.1 Determination of the dry density/moisture content relation of a soil using standard compactive effort

Report Number	S865847-A Issue 1	**Client**	MHA GEOTECHNICAL
Job Number	S865847	**Project**	Ravensthorpe Gold Project - MURRAY ST PERTH

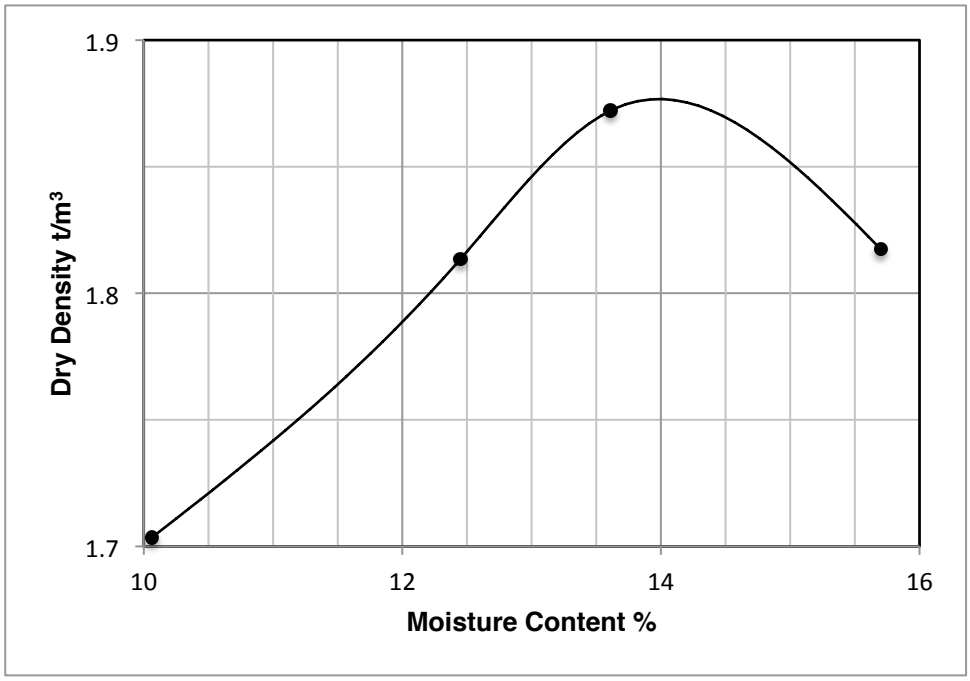
Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Laboratory Number	S865847-A-7	**Date tested**	Monday, 11 December 2017
Sample ID	TP03 0.0-0.7m		
Proposed Use	Foundation		
Material Description	Clay		
Sampling Method	Client	**Site Selection Method**	Client

AS 1289.2.1.1 Determination of the moisture content of a soil - Oven drying method (standard method)

Maximum Dry Density t/m³	1.88	**Optimum Moisture Content %**	14.0
% Retained 19mm Sieve	2	**% Retained 37.5mm Sieve**	0
Curing Time (hrs)	2	**Method used to determine LL**	Visual/Tactile



Remarks

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Material Test Certificate

AS 1289.3.8.1 Determination of the Emerson class number of a soil

Report Number S865847-A Issue 1
Client MHA GEOTECHNICAL

Job Number S865847
Project Ravensthorpe Gold Project - MURRAY ST PERTH
Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Lab No	S865847-A			**Date tested**	12 December 2017
Sample ID	-			**Time Tested**	-
Proposed Use	Foundation			**Layer Thickness mm**	-
Material Description	Various			**Test Depth mm**	-
Sampling Method	Client	**Site Selection Method**	Client		

Sample No.	Sample ID	Emerson Class No.
S865847-A-5	TP02_0.5-1.1m	3
S865847-A-7	TP03_0.0-0.7m	3

Authorised Signatory

Date 16 January 2018

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Material Test Certificate

AS 1289.2.1.1 Determination of the moisture content of a soil - Oven drying method (standard method)

Report Number	S865847-A Issue 1	**Client**	MHA GEOTECHNICAL
Job Number	S865847	**Project**	Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Lab No	S865847-A			**Date tested**	1 December 2007
Sample ID	-			**Time Tested**	-
Proposed Use	Foundation			**Layer Thickness mm**	-
Material Description	Various			**Test Depth mm**	-
Sampling Method	Client	**Site Selection Method**	Client		

Sample No.	Sample ID	Moisture Content %
S865847-A-11	TP04_1.0-3.1m	9.5
S865847-A-12	TP05_0.1-0.8m	9.7
S865847-A-13	TP05_0.8-1.8m	9.2
S865847-A-14	TP05_1.8-2.9m	8.6
S865847-A-15	TP06_0.0-0.6m	8.5
S865847-A-16	TP06_0.6-2.7m	7.4
S865847-A-17	TP07_0.1-0.2m	3.3
S865847-A-18	TP07_0.2-2.5m	10.4
S865847-A-19	TP08_0.1-0.4m	9.4
S865847-A-20	TP08_0.4-2.2m	10.2

Remarks

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MATERIAL TEST CERTIFICATE

Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

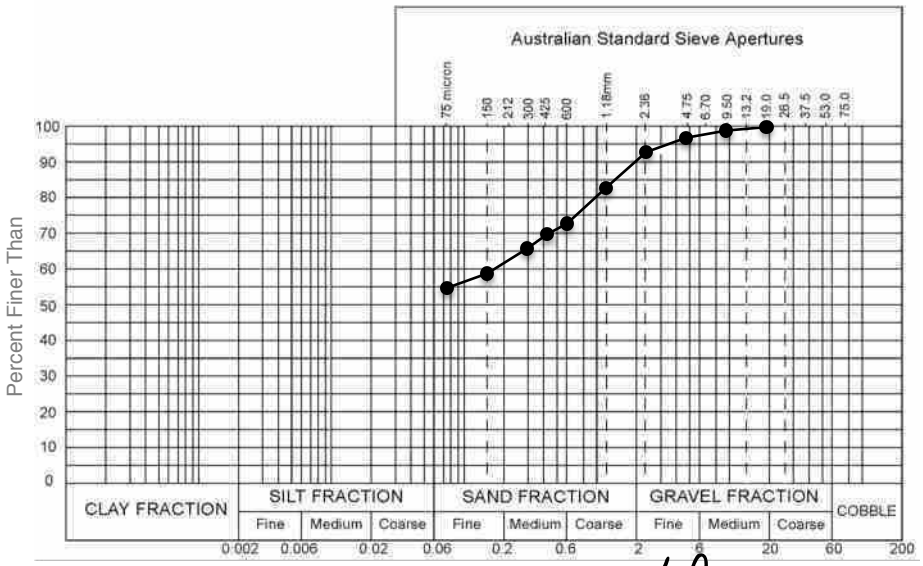
Sample Details

Laboratory Number	S865847-A-11	**Date tested**	11 Dec 2017		
Sample ID	TP04_1.0-3.1m			**Tested by**	JWS
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	AS 1726 - 2017 Sandy FINES trace gravel			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	83	**Liquid Limit %**	
37.5 mm		0.6 mm	73	**Plastic Limit %**	
19 mm	100	0.425 mm	70	**Plasticity Index %**	
9.5 mm	99	0.3 mm	66	**Linear Shrinkage %**	
4.75 mm	97	0.15 mm	59	**Nature Of Shrinkage**	
2.36 mm	93	0.075 mm	55	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

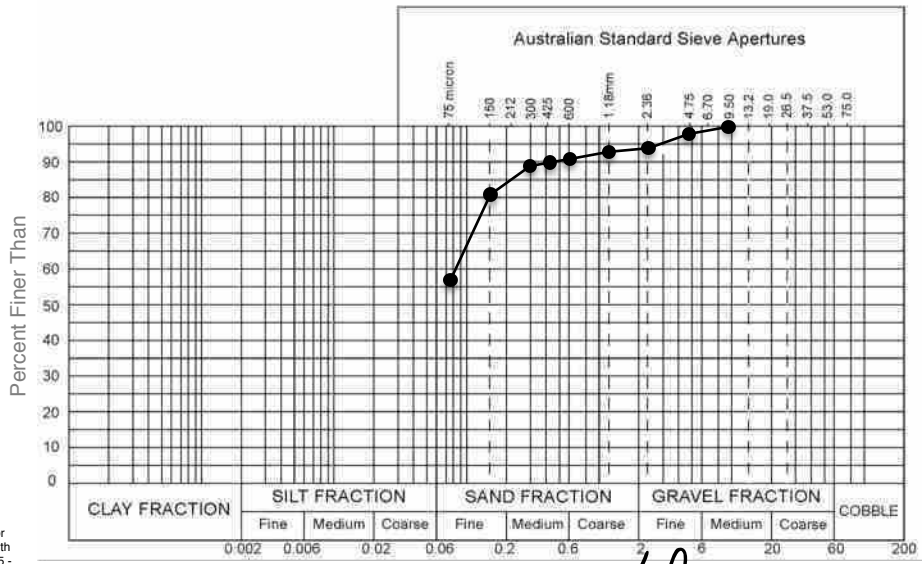
Sample Details

Laboratory Number	S865847-A-12	**Date tested**	11 Dec 2017
Sample ID	TP05_0.1-0.8m	**Tested by**	JWS
Proposed Use	Foundation	**Layer Thickness**	-
Material Description	AS 1726 - 2017 Sandy FINES trace gravel	**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	93	**Liquid Limit %**	
37.5 mm		0.6 mm	91	**Plastic Limit %**	
19 mm		0.425 mm	90	**Plasticity Index %**	
9.5 mm	100	0.3 mm	89	**Linear Shrinkage %**	
4.75 mm	98	0.15 mm	81	**Nature Of Shrinkage**	
2.36 mm	94	0.075 mm	57	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

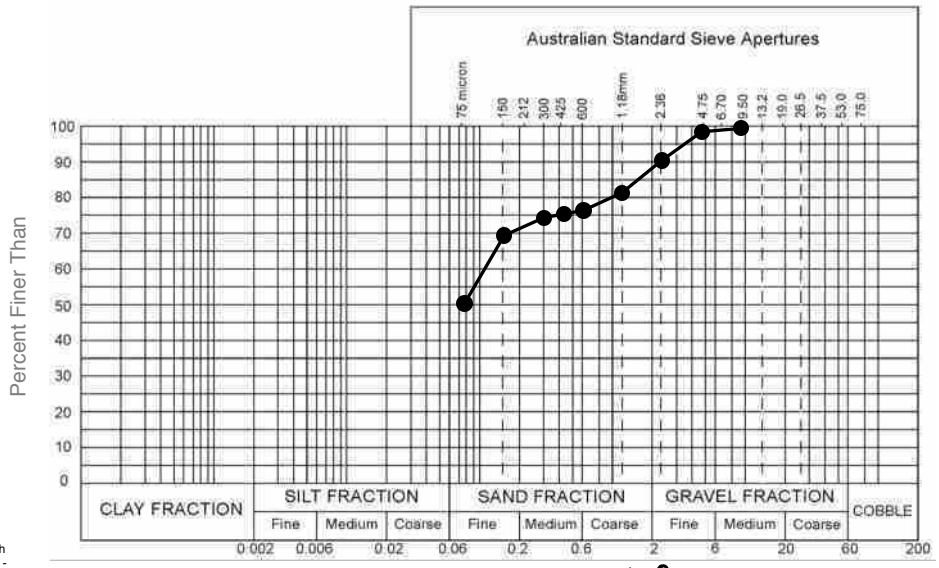
Sample Details

Laboratory Number	S865847-A-13	**Date tested**	11 Dec 2017		
Sample ID	TP05_0.8-1.8m			**Tested by**	JWS
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	AS 1726 - 2017 Sandy FINES trace gravel			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	82	**Liquid Limit %**	
37.5 mm		0.6 mm	77	**Plastic Limit %**	
19 mm		0.425 mm	76	**Plasticity Index %**	
9.5 mm	100	0.3 mm	75	**Linear Shrinkage %**	
4.75 mm	99	0.15 mm	70	**Nature Of Shrinkage**	
2.36 mm	91	0.075 mm	51	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Particle Size Distribution & Atterberg Limits of a Soil

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Job Number S865847

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Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

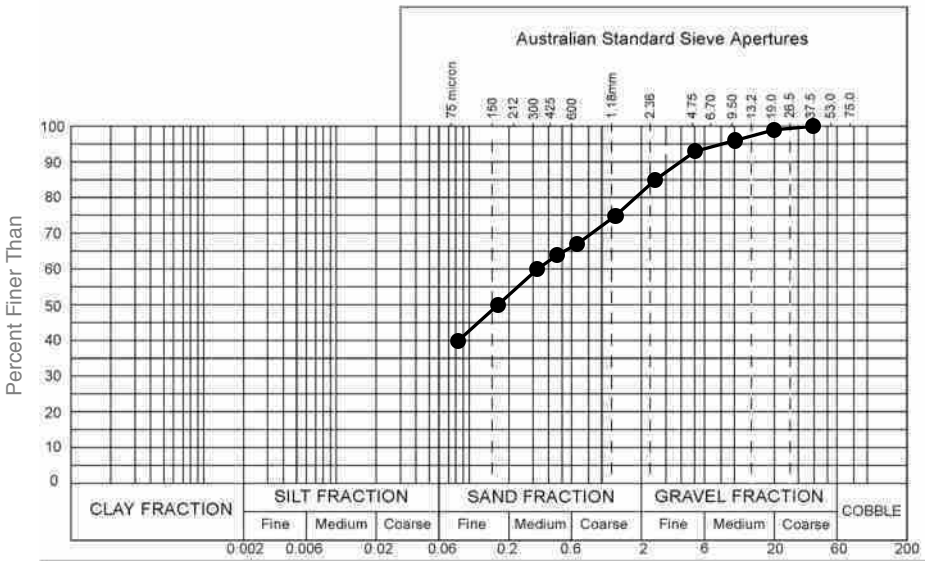
Sample Details

Laboratory Number	S865847-A-14	**Date tested**	11 Dec 2017		
Sample ID	TP05_1.8-2.9m			**Tested by**	JWS
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	AS 1726 - 2017 Sandy FINES trace gravel			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	75	**Liquid Limit %**	
37.5 mm	100	0.6 mm	67	**Plastic Limit %**	
19 mm	99	0.425 mm	64	**Plasticity Index %**	
9.5 mm	96	0.3 mm	60	**Linear Shrinkage %**	
4.75 mm	93	0.15 mm	50	**Nature Of Shrinkage**	
2.36 mm	85	0.075 mm	40	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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MATERIAL TEST CERTIFICATE

Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
Issue 1

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Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

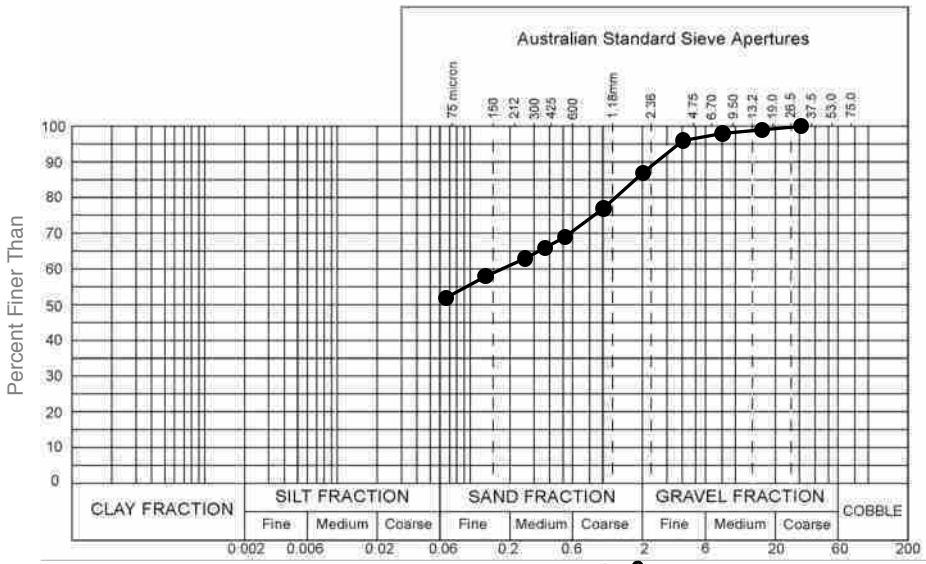
Sample Details

Laboratory Number	S865847-A-15	**Date tested**	12 Dec 2017		
Sample ID	TP06_0.0-0.6m			**Tested by**	JWS
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	AS 1726 - 2017 Sandy FINES trace gravel			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	77	**Liquid Limit %**	
37.5 mm	100	0.6 mm	69	**Plastic Limit %**	
19 mm	99	0.425 mm	66	**Plasticity Index %**	
9.5 mm	98	0.3 mm	63	**Linear Shrinkage %**	
4.75 mm	96	0.15 mm	58	**Nature Of Shrinkage**	
2.36 mm	87	0.075 mm	52	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Particle Size Distribution & Atterberg Limits of a Soil

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Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

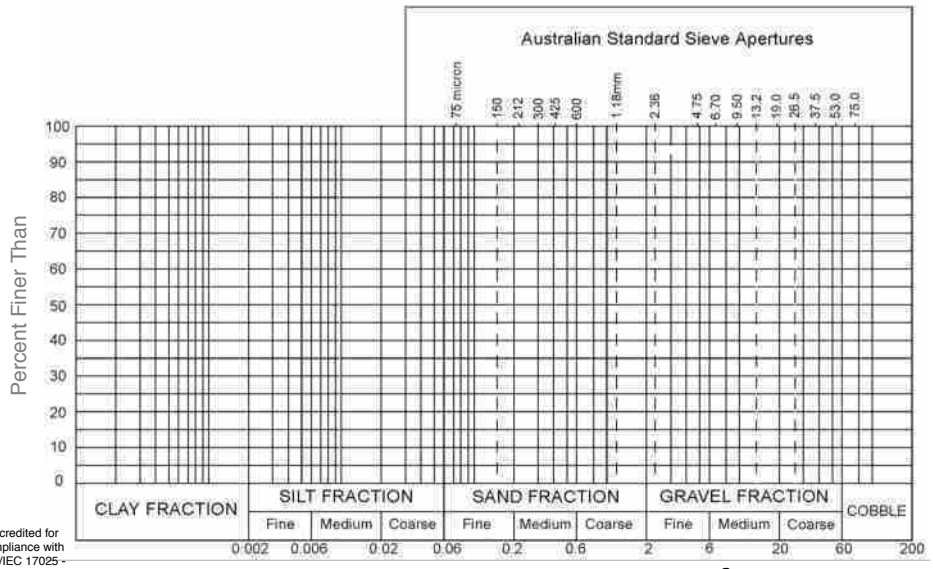
Sample Details

Laboratory Number	S865847-A-16	**Date tested**			
Sample ID	TP06 0.6-2.7m			**Tested by**	CF
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	Clayey Silt			**Test Depth**	0.6-2.7m
Sampling Method	AS 1289.1.4.1	**Drying Method**		Dried to constant mass	

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm		**Liquid Limit %**	32
37.5 mm		0.6 mm		**Plastic Limit %**	23
19 mm		0.425 mm		**Plasticity Index %**	9
9.5 mm		0.3 mm		**Linear Shrinkage %**	2.5
4.75 mm		0.15 mm		**Nature Of Shrinkage**	Normal
2.36 mm		0.075 mm		**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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BALCATTA LABORATORY
ACCREDITATION NUMBER 18742

Remarks

Date 16 January 2018

Authorised Signatory

Wayne Rozmianiec
Laboratory Manager

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MATERIAL TEST CERTIFICATE

Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

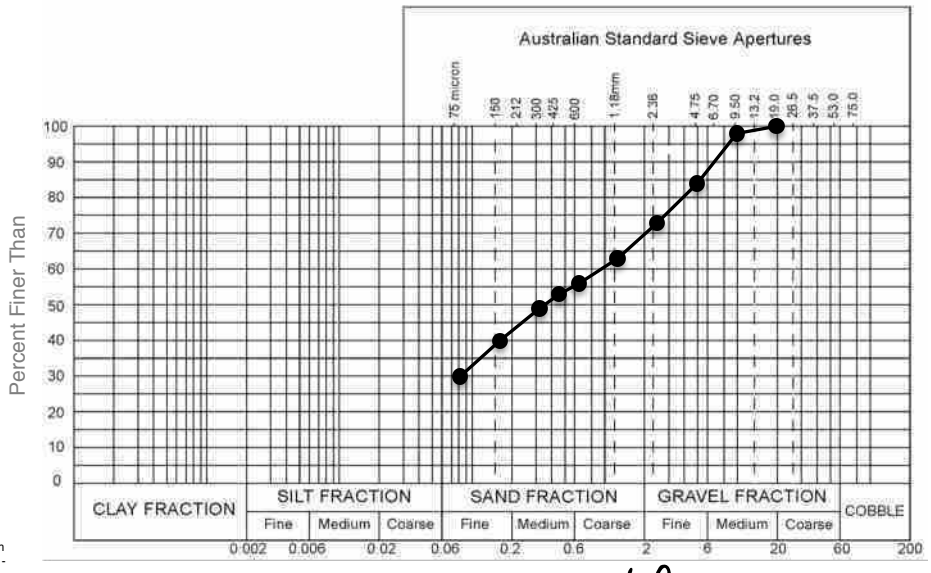
Sample Details

Laboratory Number	S865847-A-17	**Date tested**	12 Dec 2017
Sample ID	TP07_0.1-0.2m	**Tested by**	JSO
Proposed Use	Foundation	**Layer Thickness**	-
Material Description	AS 1726 - 2017 SM Silty or clayey SAND with gravel	**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	63	**Liquid Limit %**	
37.5 mm		0.6 mm	56	**Plastic Limit %**	
19 mm	100	0.425 mm	53	**Plasticity Index %**	
9.5 mm	98	0.3 mm	49	**Linear Shrinkage %**	
4.75 mm	84	0.15 mm	40	**Nature Of Shrinkage**	
2.36 mm	73	0.075 mm	30	**Sample History**	

Particle Size Distribution Graph



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Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

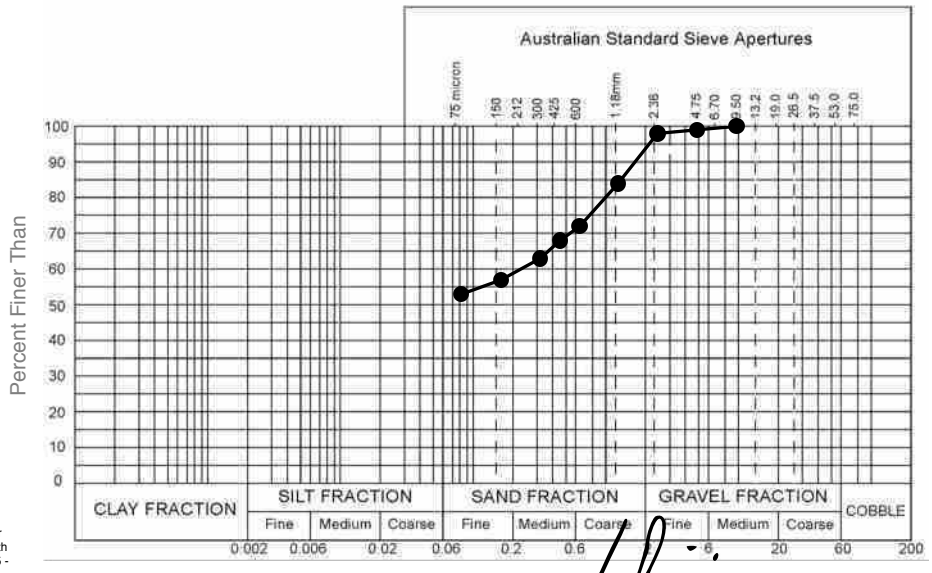
Sample Details

Laboratory Number	S865847-A-18	**Date tested**	12 Dec 2017
Sample ID	TP07_0.2-2.5m	**Tested by**	JWS
Proposed Use	Foundation	**Layer Thickness**	-
Material Description	AS 1726 - 2017 Sandy FINES trace gravel	**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	84	**Liquid Limit %**	
37.5 mm		0.6 mm	72	**Plastic Limit %**	
19 mm		0.425 mm	68	**Plasticity Index %**	
9.5 mm	100	0.3 mm	63	**Linear Shrinkage %**	
4.75 mm	99	0.15 mm	57	**Nature Of Shrinkage**	
2.36 mm	98	0.075 mm	53	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Particle Size Distribution & Atterberg Limits of a Soil

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Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

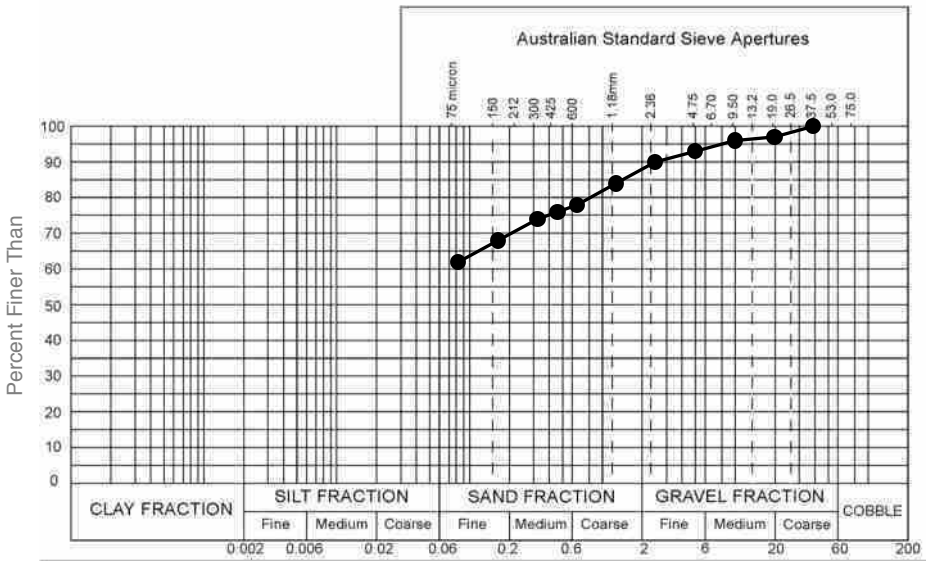
Sample Details

Laboratory Number	S865847-A-19	**Date tested**	13 Dec 2017		
Sample ID	TP08_0.1-0.4m			**Tested by**	JSO
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	AS 1726 - 2017 FINES trace gravel, with sand			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	84	**Liquid Limit %**	
37.5 mm	100	0.6 mm	78	**Plastic Limit %**	
19 mm	97	0.425 mm	76	**Plasticity Index %**	
9.5 mm	96	0.3 mm	74	**Linear Shrinkage %**	
4.75 mm	93	0.15 mm	68	**Nature Of Shrinkage**	
2.36 mm	90	0.075 mm	62	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

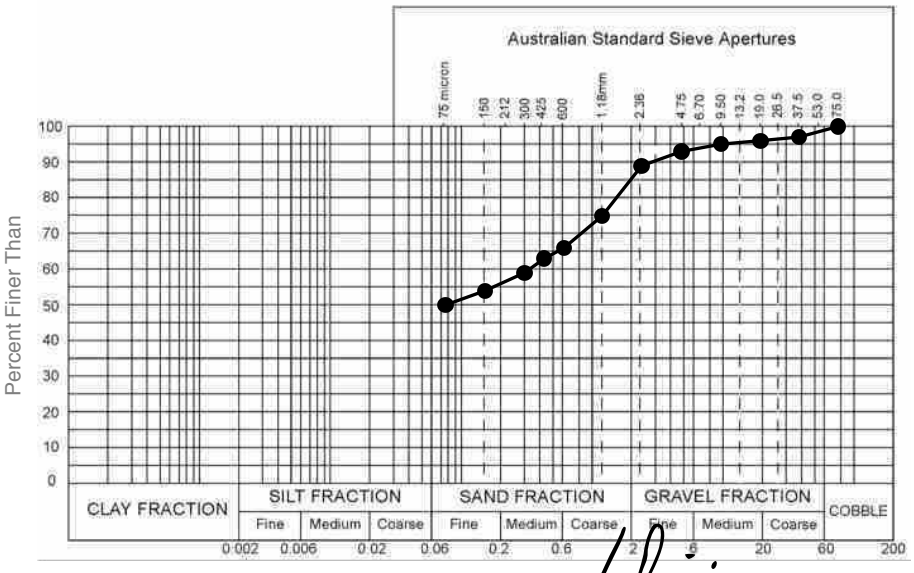
Sample Details

Laboratory Number	S865847-A-20	**Date tested**	13 Dec 2017		
Sample ID	TP08_0.4-2.2m			**Tested by**	JSO
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	AS 1726 - 2017 Sandy FINES trace gravel			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm	100	1.18 mm	75	**Liquid Limit %**	
37.5 mm	97	0.6 mm	66	**Plastic Limit %**	
19 mm	96	0.425 mm	63	**Plasticity Index %**	
9.5 mm	95	0.3 mm	59	**Linear Shrinkage %**	
4.75 mm	93	0.15 mm	54	**Nature Of Shrinkage**	
2.36 mm	89	0.075 mm	50	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Material Test Certificate

AS 1289.5.1.1 Determination of the dry density/moisture content relation of a soil using standard compactive effort

Report Number	S865847-A Issue 1	**Client**	MHA GEOTECHNICAL
Job Number	S865847	**Project**	Ravensthorpe Gold Project - MURRAY ST PERTH

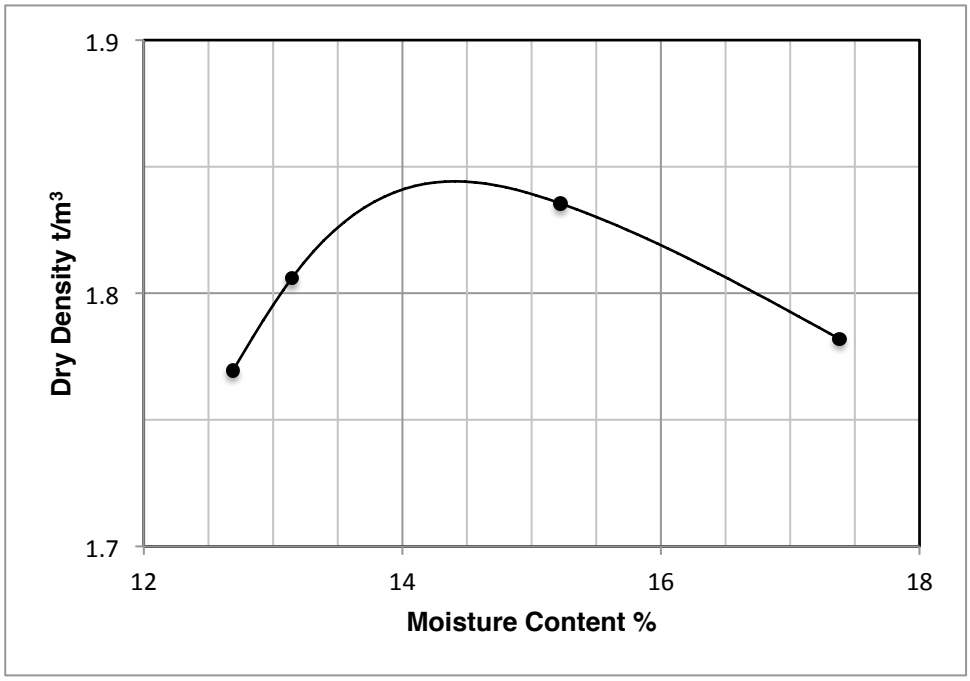
Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Laboratory Number	S865847-A-16	**Date tested**	Monday, 11 December 2017
Sample ID	TP06 0.6 - 2.7m		
Proposed Use	Foundation		
Material Description	Clay		
Sampling Method	AS 1289.1.2.1	**Site Selection Method**	AS 1289.1.4.1

AS 1289.2.1.1 Determination of the moisture content of a soil - Oven drying method (standard method)

Maximum Dry Density t/m^3	1.84	**Optimum Moisture Content %**	14.5
% Retained 19mm Sieve	0	**% Retained 37.5mm Sieve**	0
Curing Time (hrs)	2	**Method used to determine LL**	Visual/Tactile



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Material Test Certificate

AS 1289.3.8.1 Determination of the Emerson class number of a soil

Report Number S865847-A Issue 1
Client MHA GEOTECHNICAL

Job Number S865847
Project Ravensthorpe Gold Project - MURRAY ST PERTH
Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Lab No	S865847-A			**Date tested**	12 December 2017
Sample ID	-			**Time Tested**	-
Proposed Use	Foundation			**Layer Thickness mm**	-
Material Description	Various			**Test Depth mm**	-
Sampling Method	Client	**Site Selection Method**	Client		

Sample No.	Sample ID	Emerson Class No.
S865847-A-16	TP06_0.6-2.7m	2

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Date 16 January 2018

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Material Test Certificate

AS 1289.2.1.1 Determination of the moisture content of a soil - Oven drying method (standard method)

Report Number	S865847-A Issue 1	**Client**	MHA GEOTECHNICAL
Job Number	S865847	**Project**	Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Lab No	S865847-A			**Date tested**	1 December 2007
Sample ID	-			**Time Tested**	-
Proposed Use	Foundation			**Layer Thickness mm**	-
Material Description	Various			**Test Depth mm**	-
Sampling Method	Client	**Site Selection Method**	Client		

Sample No.	Sample ID	Moisture Content %
S865847-A-21	TP09_0.1-0.2m	5.9
S865847-A-22	TP09_0.2-2.2m	6.5
S865847-A-23	TP10_0.1-2.5m	10.6
S865847-A-24	TP11_0.2-2.8m	13.4
S865847-A-25	TP12_0.1-2.8m	15.1
S865847-A-26	TP13_0.1-0.7m	9.9
S865847-A-27	TP13_0.7-2.8m	10.8
S865847-A-28	TP14_0.2-1.0m	6.3
S865847-A-29	TP15_0.2-2.7m	10.0
S865847-A-30	TP16_0.2-0.6m	12.9

Remarks

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MATERIAL TEST CERTIFICATE

Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

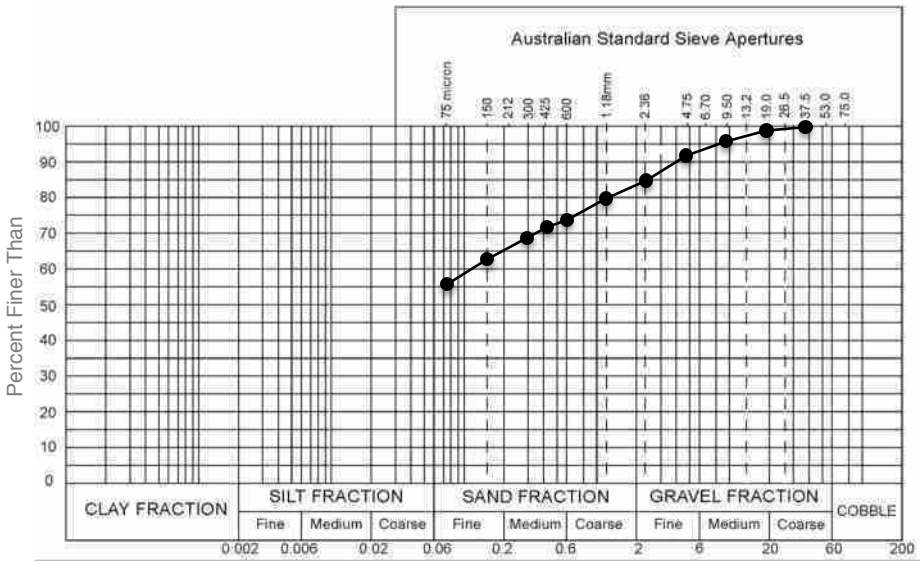
Sample Details

Laboratory Number	S865847-A-21	**Date tested**	13 Dec 2017		
Sample ID	TP09_0.1-0.2m			**Tested by**	JWS
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	AS 1726 - 2017 FINES with gravel, with sand			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	80	**Liquid Limit %**	
37.5 mm	100	0.6 mm	74	**Plastic Limit %**	
19 mm	99	0.425 mm	72	**Plasticity Index %**	
9.5 mm	96	0.3 mm	69	**Linear Shrinkage %**	
4.75 mm	92	0.15 mm	63	**Nature Of Shrinkage**	
2.36 mm	85	0.075 mm	56	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

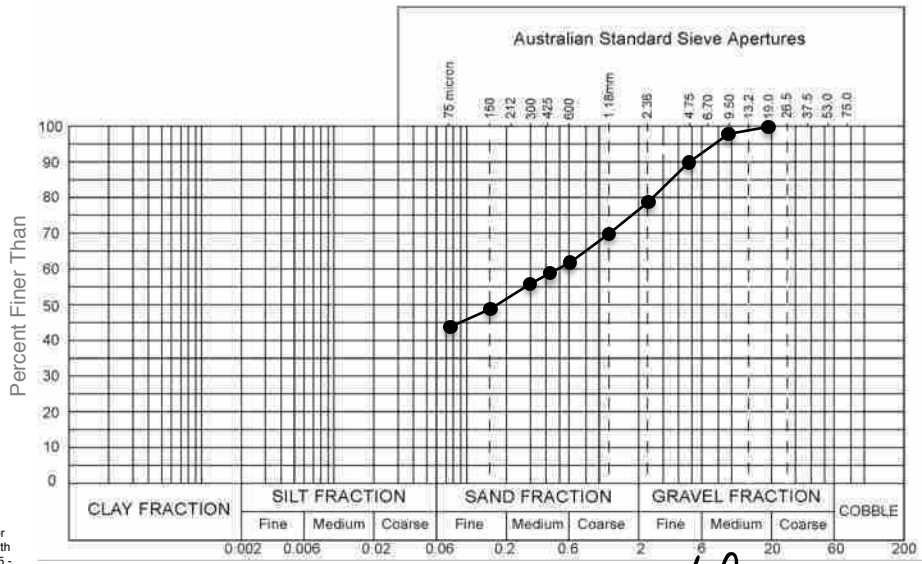
Sample Details

Laboratory Number	S865847-A-22	**Date tested**	13 Dec 2017		
Sample ID	TP09_0.2-2.2m			**Tested by**	JWS
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	AS 1726 - 2017 Sandy FINES with gravel			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	70	**Liquid Limit %**	
37.5 mm		0.6 mm	62	**Plastic Limit %**	
19 mm	100	0.425 mm	59	**Plasticity Index %**	
9.5 mm	98	0.3 mm	56	**Linear Shrinkage %**	
4.75 mm	90	0.15 mm	49	**Nature Of Shrinkage**	
2.36 mm	79	0.075 mm	44	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

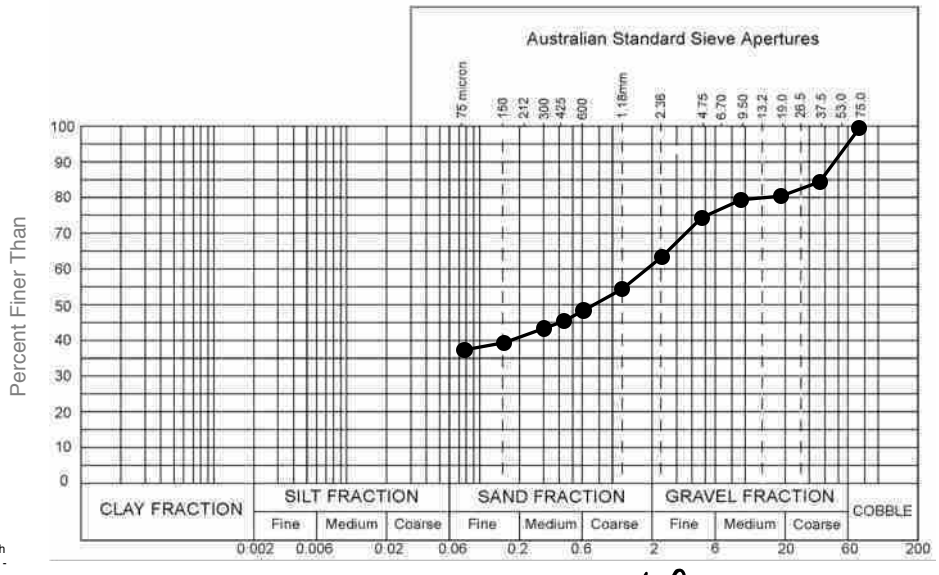
Sample Details

Laboratory Number	S865847-A-23	**Date tested**	20 Dec 2017
Sample ID	TP10_0.1-2.5m	**Tested by**	JWS
Proposed Use	Foundation	**Layer Thickness**	-
Material Description	AS 1726 - 2017 Gravelly FINES with sand	**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm	100	1.18 mm	55	**Liquid Limit %**	
37.5 mm	85	0.6 mm	49	**Plastic Limit %**	
19 mm	81	0.425 mm	46	**Plasticity Index %**	
9.5 mm	80	0.3 mm	44	**Linear Shrinkage %**	
4.75 mm	75	0.15 mm	40	**Nature Of Shrinkage**	
2.36 mm	64	0.075 mm	38	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

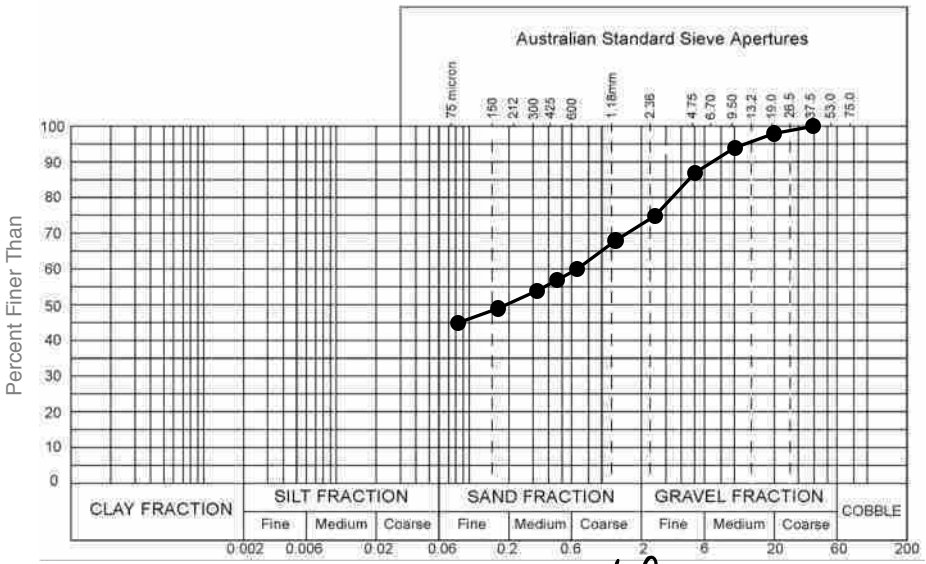
Sample Details

Laboratory Number	S865847-A-24	**Date tested**	20 Dec 2017		
Sample ID	TP11_0.2-2.8m			**Tested by**	JWS
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	AS 1726 - 2017 FINES with gravel, with sand			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	68	**Liquid Limit %**	
37.5 mm	100	0.6 mm	60	**Plastic Limit %**	
19 mm	98	0.425 mm	57	**Plasticity Index %**	
9.5 mm	94	0.3 mm	54	**Linear Shrinkage %**	
4.75 mm	87	0.15 mm	49	**Nature Of Shrinkage**	
2.36 mm	75	0.075 mm	45	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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BALCATTA LABORATORY
ACCREDITATION NUMBER 18742

Remarks

Date 16 January 2018

Authorised Signatory

Wayne Rozmianiec
Laboratory Manager

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MATERIAL TEST CERTIFICATE

Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

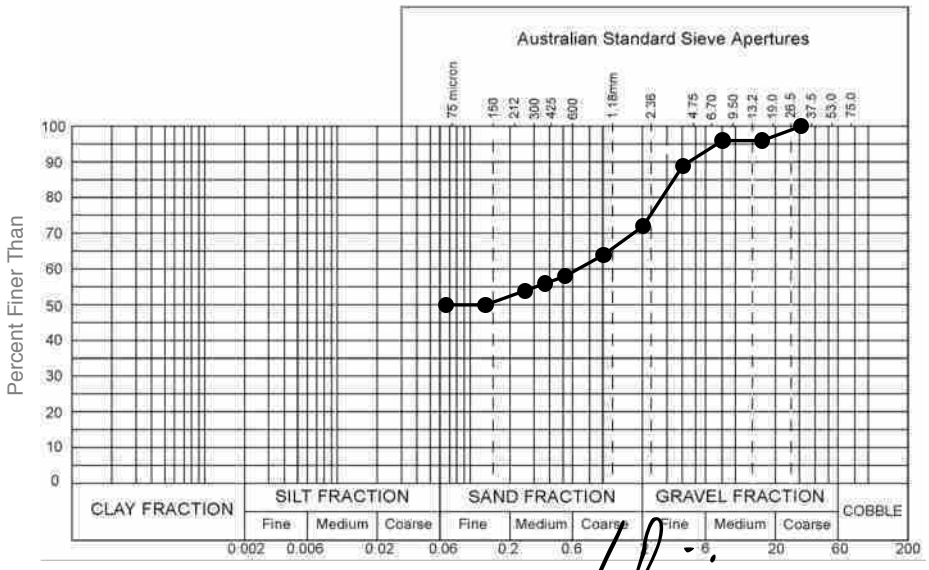
Sample Details

Laboratory Number	S865847-A-25	**Date tested**	20 Dec 2017
Sample ID	TP12_0.1-2.8m	**Tested by**	JWS
Proposed Use	Foundation	**Layer Thickness**	-
Material Description	AS 1726 - 2017 FINES with gravel, with sand	**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	64	**Liquid Limit %**	
37.5 mm	100	0.6 mm	58	**Plastic Limit %**	
19 mm	96	0.425 mm	56	**Plasticity Index %**	
9.5 mm	96	0.3 mm	54	**Linear Shrinkage %**	
4.75 mm	89	0.15 mm	50	**Nature Of Shrinkage**	
2.36 mm	72	0.075 mm	50	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

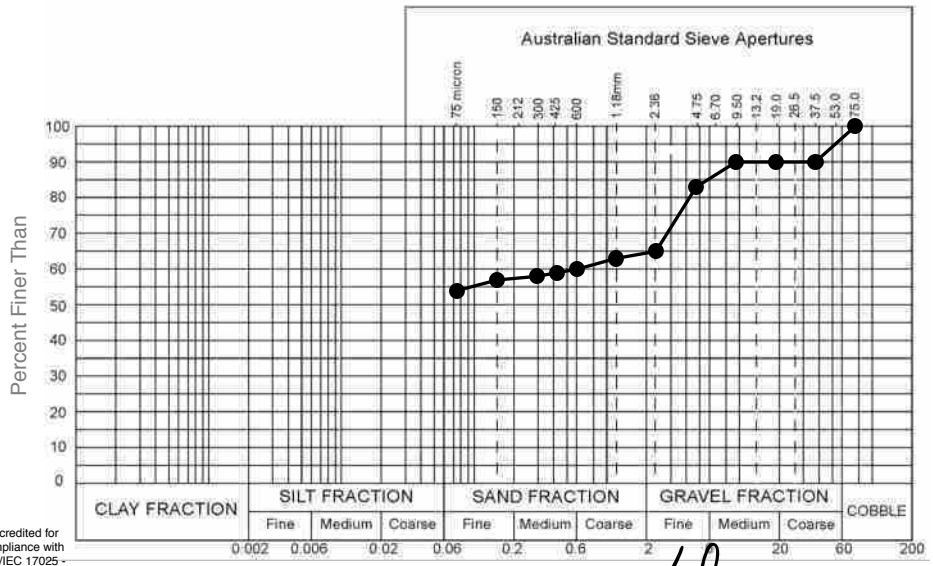
Sample Details

Laboratory Number	S865847-A-26	**Date tested**	20 Dec 2017		
Sample ID	TP13_0.1-0.7m			**Tested by**	JWS
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	AS 1726 - 2017 Gravelly FINES trace sand			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm	100	1.18 mm	63	**Liquid Limit %**	
37.5 mm	90	0.6 mm	60	**Plastic Limit %**	
19 mm	90	0.425 mm	59	**Plasticity Index %**	
9.5 mm	90	0.3 mm	58	**Linear Shrinkage %**	
4.75 mm	83	0.15 mm	57	**Nature Of Shrinkage**	
2.36 mm	65	0.075 mm	54	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

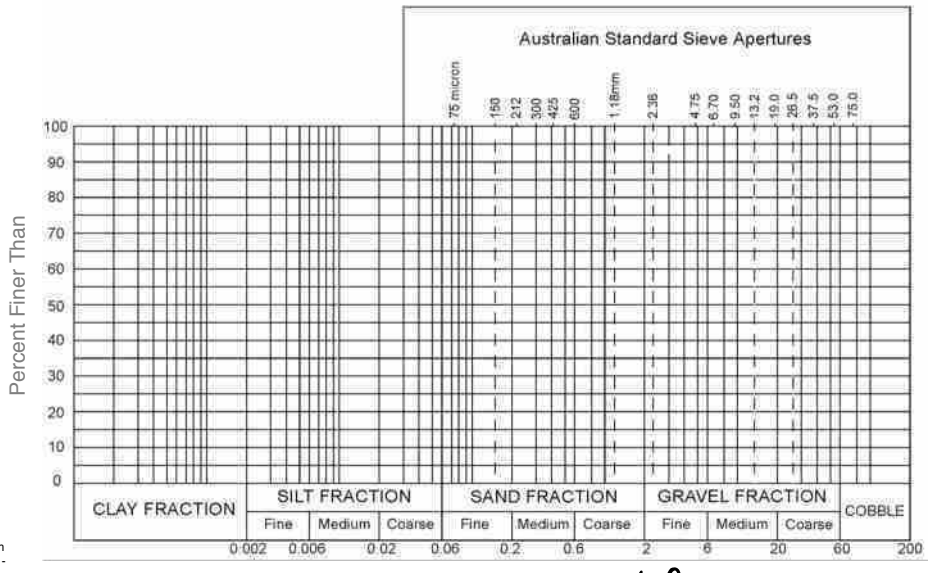
Sample Details

Laboratory Number	S865847-A-27	**Date tested**	11 December 2018		
Sample ID	TP13_0.7-2.8m			**Tested by**	CF
Proposed Use	Foundation		**Layer Thickness**		-
Material Description	Clayey Silt		**Test Depth**		
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm		**Liquid Limit %**	Not obtained
37.5 mm		0.6 mm		**Plastic Limit %**	Not obtained
19 mm		0.425 mm		**Plasticity Index %**	NP
9.5 mm		0.3 mm		**Linear Shrinkage %**	2.0
4.75 mm		0.15 mm		**Nature Of Shrinkage**	Normal
2.36 mm		0.075 mm		**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Particle Size Distribution & Atterberg Limits of a Soil

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Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

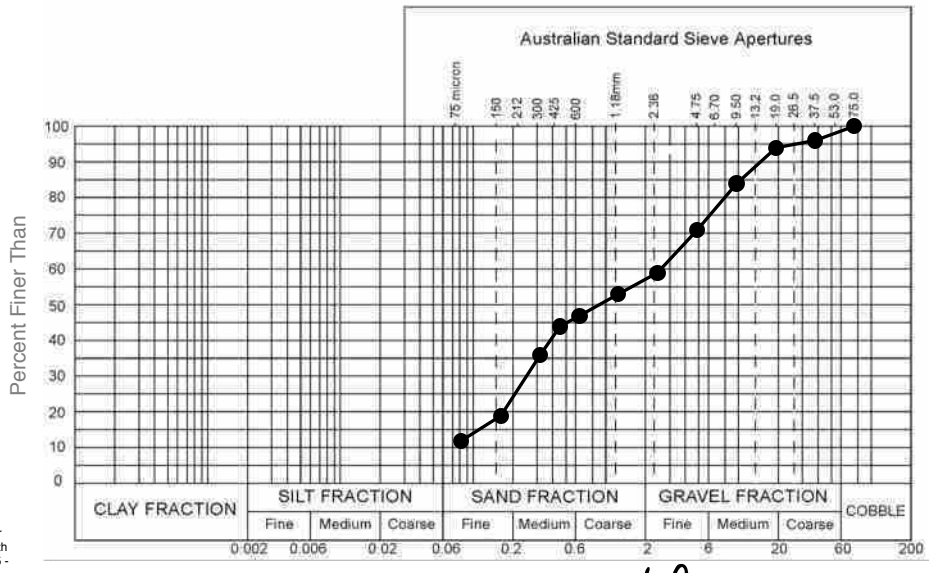
Sample Details

Laboratory Number	S865847-A-28	**Date tested**	20 Dec 2017
Sample ID	TP14_0.2-1.0m	**Tested by**	JWS
Proposed Use	Foundation	**Layer Thickness**	-
Material Description	AS 1726 - 2017 SM Silty or clayey, gravelly SAND	**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm	100	1.18 mm	53	**Liquid Limit %**	
37.5 mm	96	0.6 mm	47	**Plastic Limit %**	
19 mm	94	0.425 mm	44	**Plasticity Index %**	
9.5 mm	84	0.3 mm	36	**Linear Shrinkage %**	
4.75 mm	71	0.15 mm	19	**Nature Of Shrinkage**	
2.36 mm	59	0.075 mm	12	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

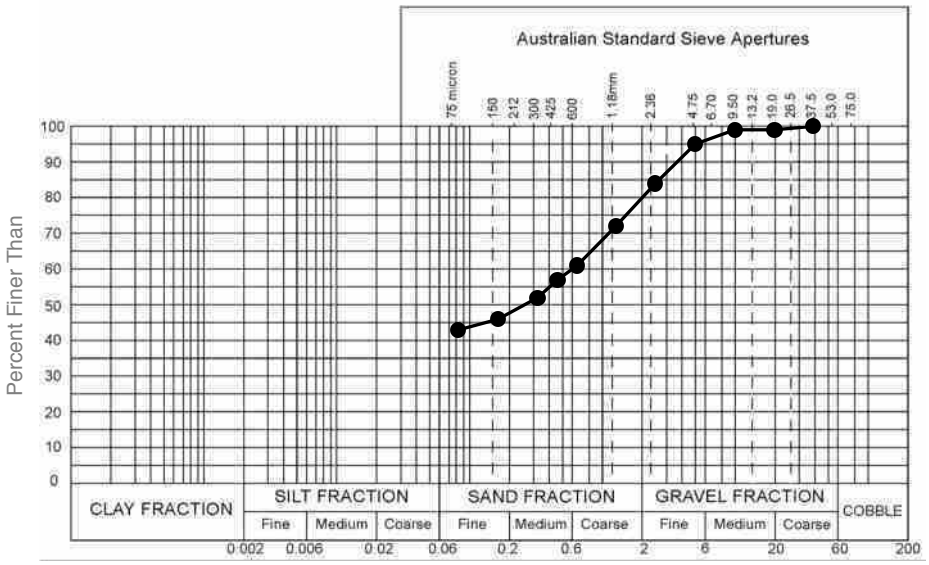
Sample Details

Laboratory Number	S865847-A-29	**Date tested**	20 Dec 2017		
Sample ID	TP15_0.2-2.7m			**Tested by**	JWS
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	AS 1726 - 2017 Sandy FINES with gravel			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	72	**Liquid Limit %**	
37.5 mm	100	0.6 mm	61	**Plastic Limit %**	
19 mm	99	0.425 mm	57	**Plasticity Index %**	
9.5 mm	99	0.3 mm	52	**Linear Shrinkage %**	
4.75 mm	95	0.15 mm	46	**Nature Of Shrinkage**	
2.36 mm	84	0.075 mm	43	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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MATERIAL TEST CERTIFICATE

Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

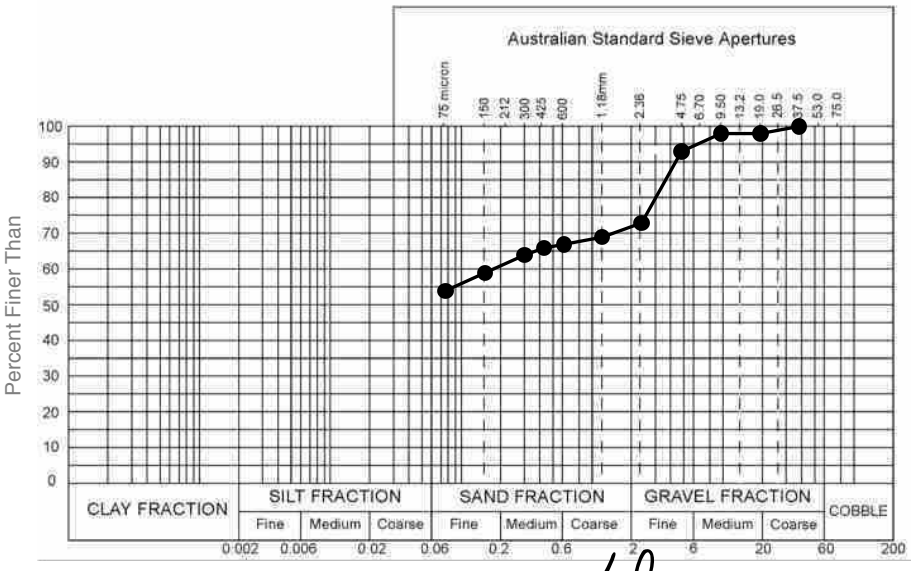
Sample Details

Laboratory Number	S865847-A-30	**Date tested**	20 Dec 2017
Sample ID	TP16_0.2-0.6m	**Tested by**	JWS
Proposed Use	Foundation	**Layer Thickness**	-
Material Description	AS 1726 - 2017 FINES with gravel, with sand	**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	69	**Liquid Limit %**	
37.5 mm	100	0.6 mm	67	**Plastic Limit %**	
19 mm	98	0.425 mm	66	**Plasticity Index %**	
9.5 mm	98	0.3 mm	64	**Linear Shrinkage %**	
4.75 mm	93	0.15 mm	59	**Nature Of Shrinkage**	
2.36 mm	73	0.075 mm	54	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Material Test Certificate

AS 1289.5.1.1 Determination of the dry density/moisture content relation of a soil using standard compactive effort

Report Number S865847-A Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

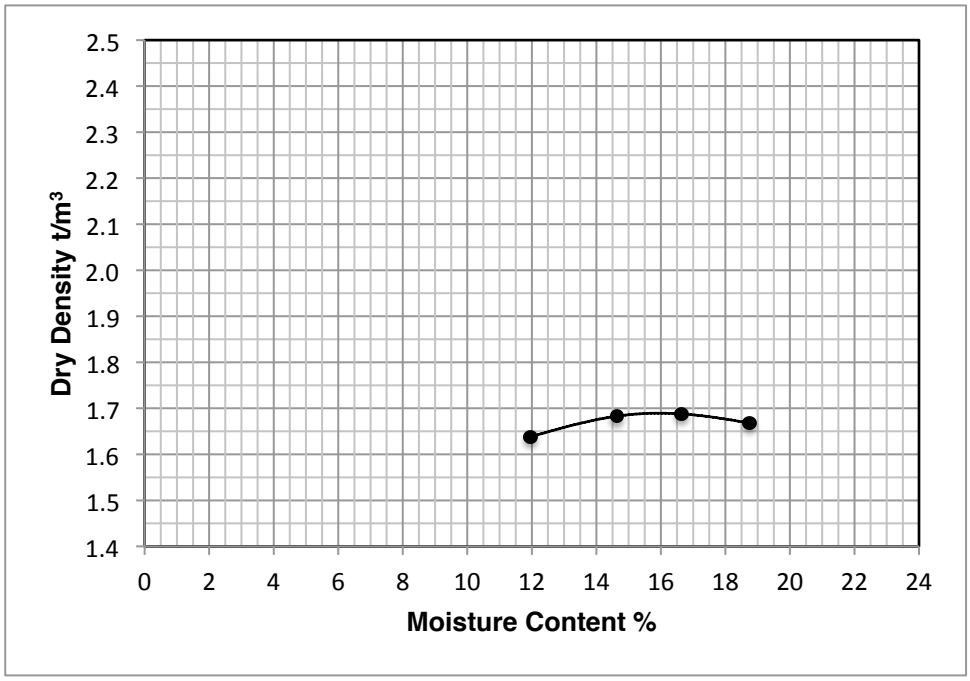
Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Laboratory Number	S865847-A-27	**Date tested**	13 Dec 2017
Sample ID	TP13_0.7-2.8m		
Proposed Use	Foundation		
Material Description	SILT with Clay		
Sampling Method	AS 1289.1.2.1	**Site Selection Method**	AS 1289.1.4.1

AS 1289.2.1.1 Determination of the moisture content of a soil - Oven drying method (standard method)

Maximum Dry Density t/m^3	1.69	**Optimum Moisture Content %**	16.0
% Retained 19mm Sieve	0	**% Retained 37.5mm Sieve**	0
Curing Time (hrs)	2	**Method used to determine LL**	Visual/Tactile



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Material Test Certificate

AS 1289.3.8.1 Determination of the Emerson class number of a soil

Report Number S865847-A Issue 1
Client MHA GEOTECHNICAL

Job Number S865847
Project Ravensthorpe Gold Project - MURRAY ST PERTH
Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Lab No	S865847-A			**Date tested**	12 December 2017
Sample ID	-			**Time Tested**	-
Proposed Use	Foundation			**Layer Thickness mm**	-
Material Description	Various			**Test Depth mm**	-
Sampling Method	Client	**Site Selection Method**		Client	

Sample No.	Sample ID	Emerson Class No.
S865847-A-27	TP13_0.7-2.8m	2

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ACCREDITATION NUMBER 18742

Date 16 January 2018

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Laboratory Manager

NDM Spec 201 Report

AS 1289.5.4.3 Rep2 Rev. 2.0 Feb-16

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Material Test Certificate

AS 1289.2.1.1 Determination of the moisture content of a soil - Oven drying method (standard method)

Report Number	S865847-A Issue 1	**Client**	MHA GEOTECHNICAL
Job Number	S865847	**Project**	Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Lab No	S865847-A			**Date tested**	1 December 2007
Sample ID	-			**Time Tested**	-
Proposed Use	Foundation			**Layer Thickness mm**	-
Material Description	Various			**Test Depth mm**	-
Sampling Method	Client	**Site Selection Method**	Client		

Sample No.	Sample ID	Moisture Content %
S865847-A-21	TP09_0.1-0.2m	5.9
S865847-A-22	TP09_0.2-2.2m	6.5
S865847-A-23	TP10_0.1-2.5m	10.6
S865847-A-24	TP11_0.2-2.8m	13.4
S865847-A-25	TP12_0.1-2.8m	15.1
S865847-A-26	TP13_0.1-0.7m	9.9
S865847-A-27	TP13_0.7-2.8m	10.8
S865847-A-28	TP14_0.2-1.0m	6.3
S865847-A-29	TP15_0.2-2.7m	10.0
S865847-A-30	TP16_0.2-0.6m	12.9

Remarks

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MATERIAL TEST CERTIFICATE

Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

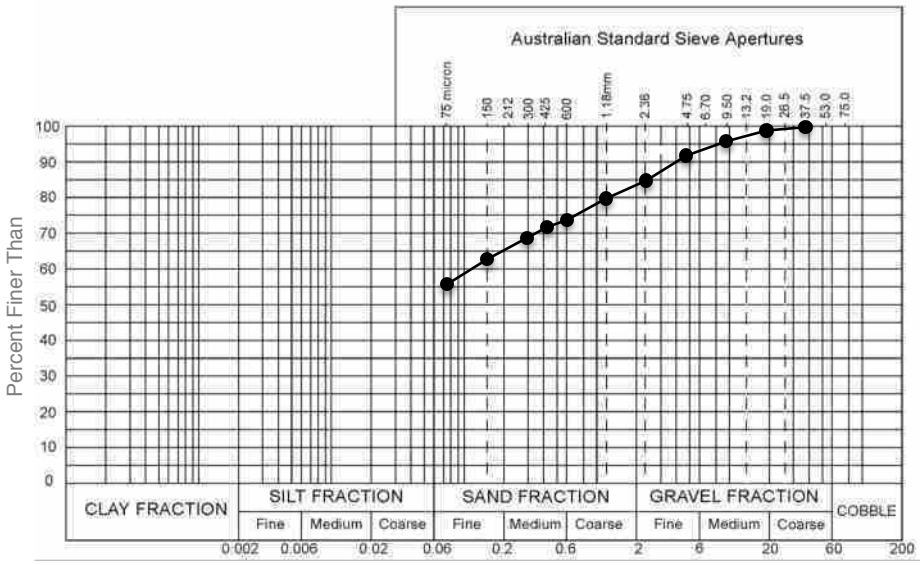
Sample Details

Laboratory Number	S865847-A-21	**Date tested**	13 Dec 2017		
Sample ID	TP09_0.1-0.2m			**Tested by**	JWS
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	AS 1726 - 2017 FINES with gravel, with sand			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	80	**Liquid Limit %**	
37.5 mm	100	0.6 mm	74	**Plastic Limit %**	
19 mm	99	0.425 mm	72	**Plasticity Index %**	
9.5 mm	96	0.3 mm	69	**Linear Shrinkage %**	
4.75 mm	92	0.15 mm	63	**Nature Of Shrinkage**	
2.36 mm	85	0.075 mm	56	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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MATERIAL TEST CERTIFICATE

Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

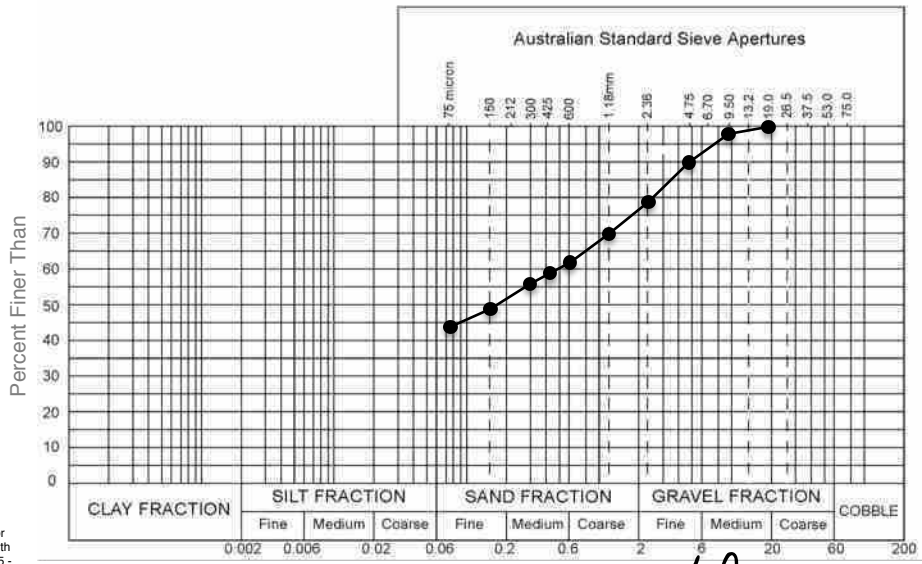
Sample Details

Laboratory Number	S865847-A-22	**Date tested**	13 Dec 2017		
Sample ID	TP09_0.2-2.2m			**Tested by**	JWS
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	AS 1726 - 2017 Sandy FINES with gravel			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	70	**Liquid Limit %**	
37.5 mm		0.6 mm	62	**Plastic Limit %**	
19 mm	100	0.425 mm	59	**Plasticity Index %**	
9.5 mm	98	0.3 mm	56	**Linear Shrinkage %**	
4.75 mm	90	0.15 mm	49	**Nature Of Shrinkage**	
2.36 mm	79	0.075 mm	44	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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STRUCTERRE CONSULTING ENGINEERS
BALCATTA LABORATORY
ACCREDITATION NUMBER 18742

Remarks

Date 16 January 2018

Authorised Signatory

Wayne Rozmianiec
Laboratory Manager

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Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

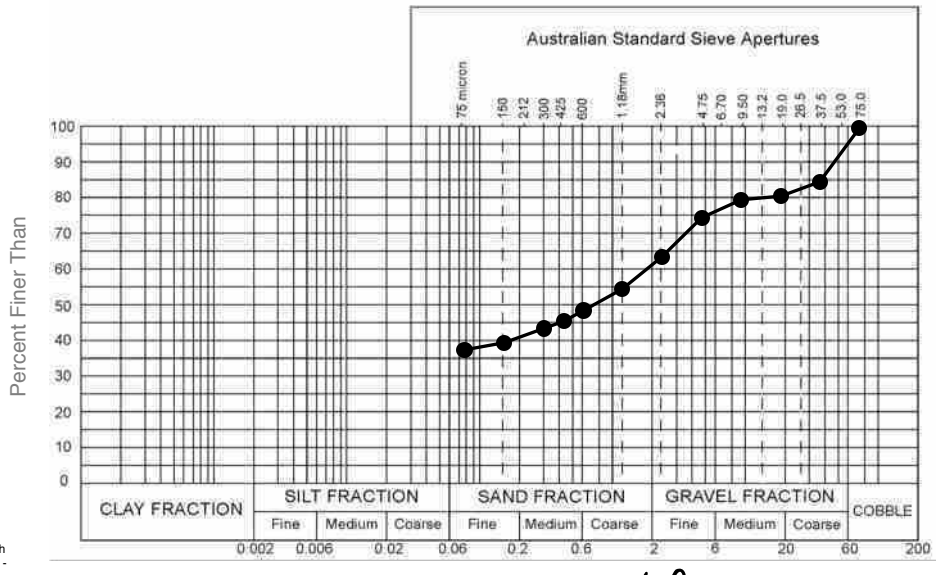
Sample Details

Laboratory Number	S865847-A-23	**Date tested**	20 Dec 2017
Sample ID	TP10_0.1-2.5m	**Tested by**	JWS
Proposed Use	Foundation	**Layer Thickness**	-
Material Description	AS 1726 - 2017 Gravelly FINES with sand	**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm	100	1.18 mm	55	**Liquid Limit %**	
37.5 mm	85	0.6 mm	49	**Plastic Limit %**	
19 mm	81	0.425 mm	46	**Plasticity Index %**	
9.5 mm	80	0.3 mm	44	**Linear Shrinkage %**	
4.75 mm	75	0.15 mm	40	**Nature Of Shrinkage**	
2.36 mm	64	0.075 mm	38	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

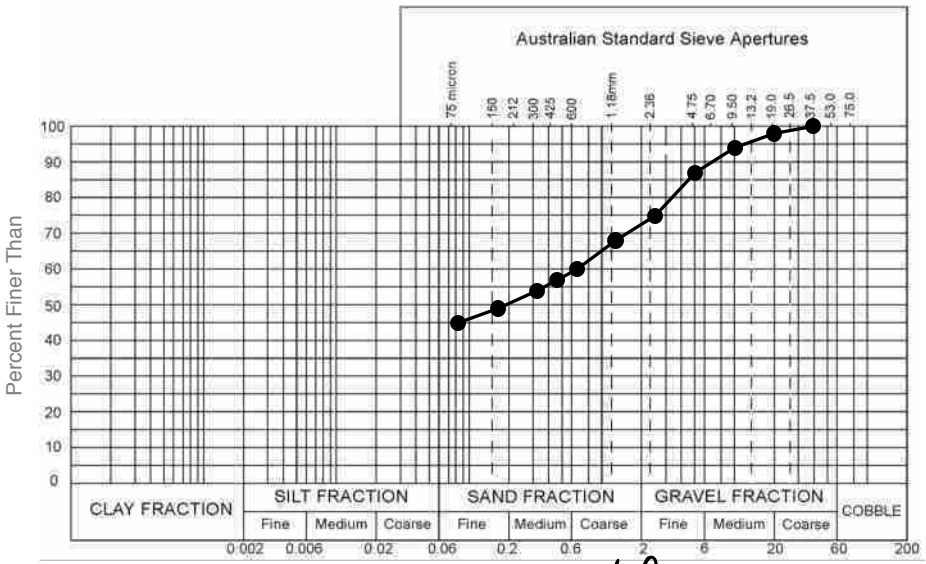
Sample Details

Laboratory Number	S865847-A-24	**Date tested**	20 Dec 2017		
Sample ID	TP11_0.2-2.8m			**Tested by**	JWS
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	AS 1726 - 2017 FINES with gravel, with sand			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	68	**Liquid Limit %**	
37.5 mm	100	0.6 mm	60	**Plastic Limit %**	
19 mm	98	0.425 mm	57	**Plasticity Index %**	
9.5 mm	94	0.3 mm	54	**Linear Shrinkage %**	
4.75 mm	87	0.15 mm	49	**Nature Of Shrinkage**	
2.36 mm	75	0.075 mm	45	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Particle Size Distribution & Atterberg Limits of a Soil

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Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

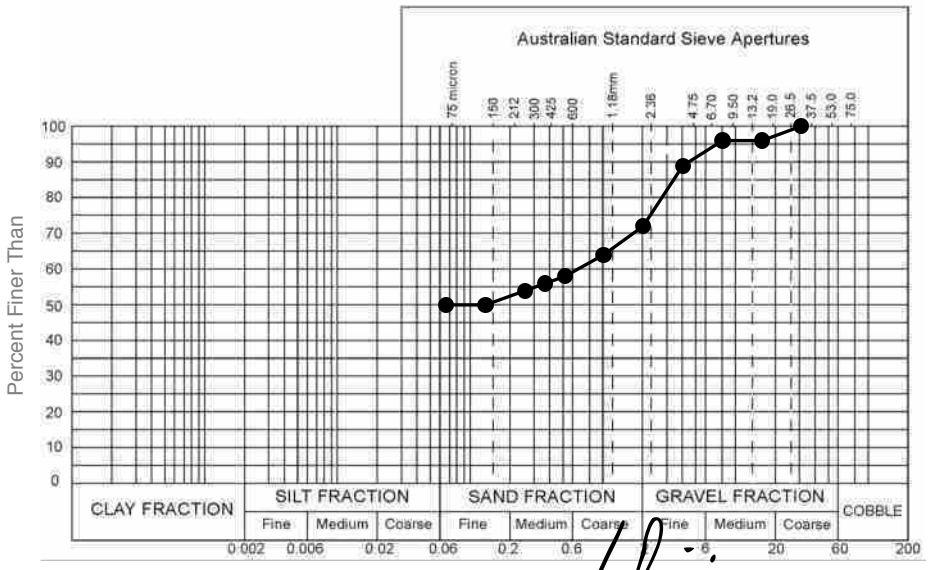
Sample Details

Laboratory Number	S865847-A-25	**Date tested**	20 Dec 2017
Sample ID	TP12_0.1-2.8m	**Tested by**	JWS
Proposed Use	Foundation	**Layer Thickness**	-
Material Description	AS 1726 - 2017 FINES with gravel, with sand	**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	64	**Liquid Limit %**	
37.5 mm	100	0.6 mm	58	**Plastic Limit %**	
19 mm	96	0.425 mm	56	**Plasticity Index %**	
9.5 mm	96	0.3 mm	54	**Linear Shrinkage %**	
4.75 mm	89	0.15 mm	50	**Nature Of Shrinkage**	
2.36 mm	72	0.075 mm	50	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Particle Size Distribution & Atterberg Limits of a Soil

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Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

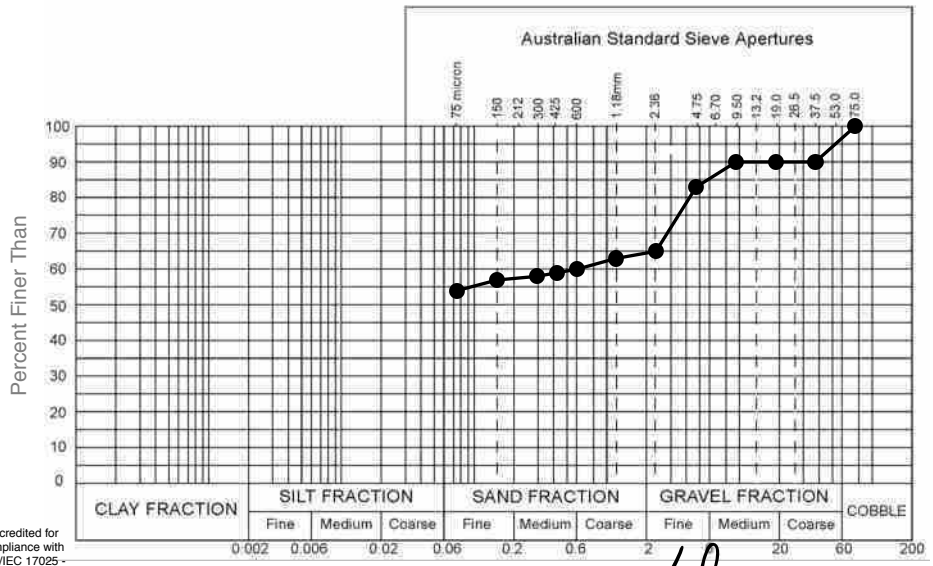
Sample Details

Laboratory Number	S865847-A-26	**Date tested**	20 Dec 2017		
Sample ID	TP13_0.1-0.7m			**Tested by**	JWS
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	AS 1726 - 2017 Gravelly FINES trace sand			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm	100	1.18 mm	63	**Liquid Limit %**	
37.5 mm	90	0.6 mm	60	**Plastic Limit %**	
19 mm	90	0.425 mm	59	**Plasticity Index %**	
9.5 mm	90	0.3 mm	58	**Linear Shrinkage %**	
4.75 mm	83	0.15 mm	57	**Nature Of Shrinkage**	
2.36 mm	65	0.075 mm	54	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
Issue 1

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Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

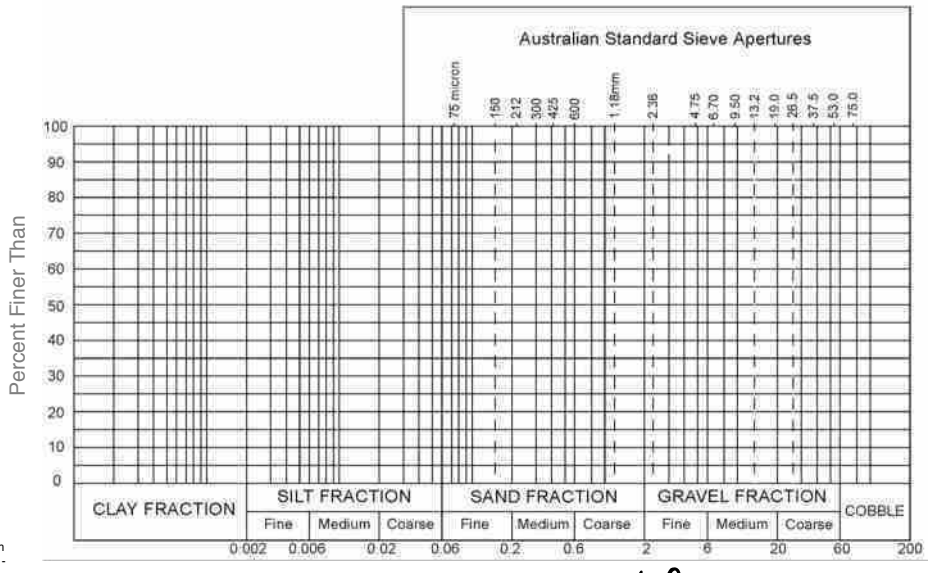
Sample Details

Laboratory Number	S865847-A-27	**Date tested**	11 December 2018		
Sample ID	TP13_0.7-2.8m			**Tested by**	CF
Proposed Use	Foundation		**Layer Thickness**		-
Material Description	Clayey Silt		**Test Depth**		
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm		**Liquid Limit %**	Not obtained
37.5 mm		0.6 mm		**Plastic Limit %**	Not obtained
19 mm		0.425 mm		**Plasticity Index %**	NP
9.5 mm		0.3 mm		**Linear Shrinkage %**	2.0
4.75 mm		0.15 mm		**Nature Of Shrinkage**	Normal
2.36 mm		0.075 mm		**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
Issue 1

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Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

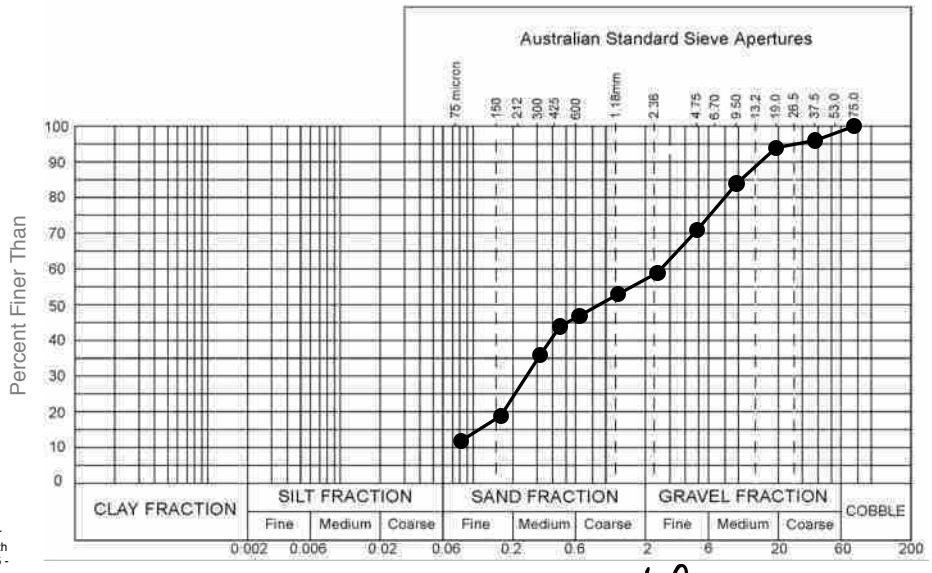
Sample Details

Laboratory Number	S865847-A-28	**Date tested**	20 Dec 2017
Sample ID	TP14_0.2-1.0m	**Tested by**	JWS
Proposed Use	Foundation	**Layer Thickness**	-
Material Description	AS 1726 - 2017 SM Silty or clayey, gravelly SAND	**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm	100	1.18 mm	53	**Liquid Limit %**	
37.5 mm	96	0.6 mm	47	**Plastic Limit %**	
19 mm	94	0.425 mm	44	**Plasticity Index %**	
9.5 mm	84	0.3 mm	36	**Linear Shrinkage %**	
4.75 mm	71	0.15 mm	19	**Nature Of Shrinkage**	
2.36 mm	59	0.075 mm	12	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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1 Erindale Rd Balcatta WA 6021

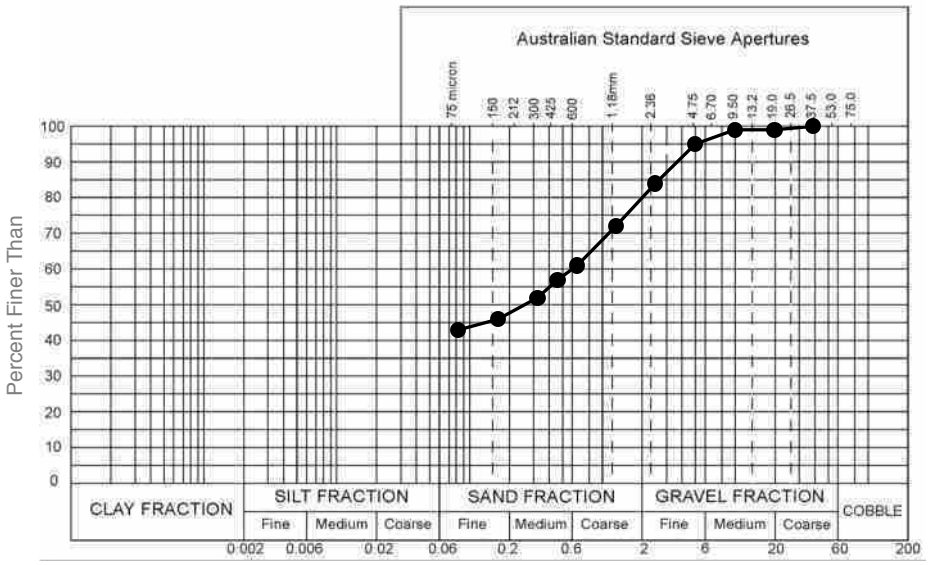
Sample Details

Laboratory Number	S865847-A-29	**Date tested**	20 Dec 2017		
Sample ID	TP15_0.2-2.7m			**Tested by**	JWS
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	AS 1726 - 2017 Sandy FINES with gravel			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	72	**Liquid Limit %**	
37.5 mm	100	0.6 mm	61	**Plastic Limit %**	
19 mm	99	0.425 mm	57	**Plasticity Index %**	
9.5 mm	99	0.3 mm	52	**Linear Shrinkage %**	
4.75 mm	95	0.15 mm	46	**Nature Of Shrinkage**	
2.36 mm	84	0.075 mm	43	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

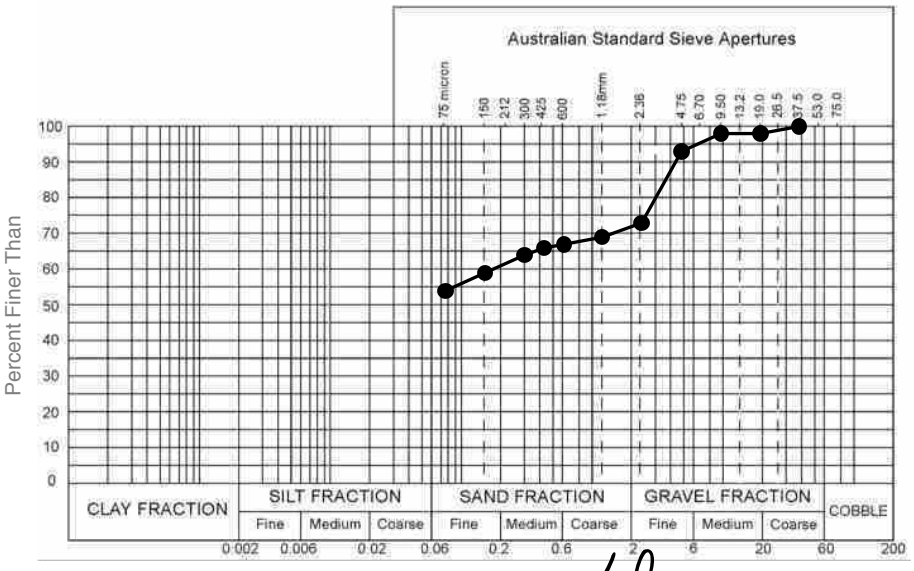
Sample Details

Laboratory Number	S865847-A-30	**Date tested**	20 Dec 2017
Sample ID	TP16_0.2-0.6m	**Tested by**	JWS
Proposed Use	Foundation	**Layer Thickness**	-
Material Description	AS 1726 - 2017 FINES with gravel, with sand	**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	69	**Liquid Limit %**	
37.5 mm	100	0.6 mm	67	**Plastic Limit %**	
19 mm	98	0.425 mm	66	**Plasticity Index %**	
9.5 mm	98	0.3 mm	64	**Linear Shrinkage %**	
4.75 mm	93	0.15 mm	59	**Nature Of Shrinkage**	
2.36 mm	73	0.075 mm	54	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Material Test Certificate

AS 1289.5.1.1 Determination of the dry density/moisture content relation of a soil using standard compactive effort

Report Number S865847-A Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

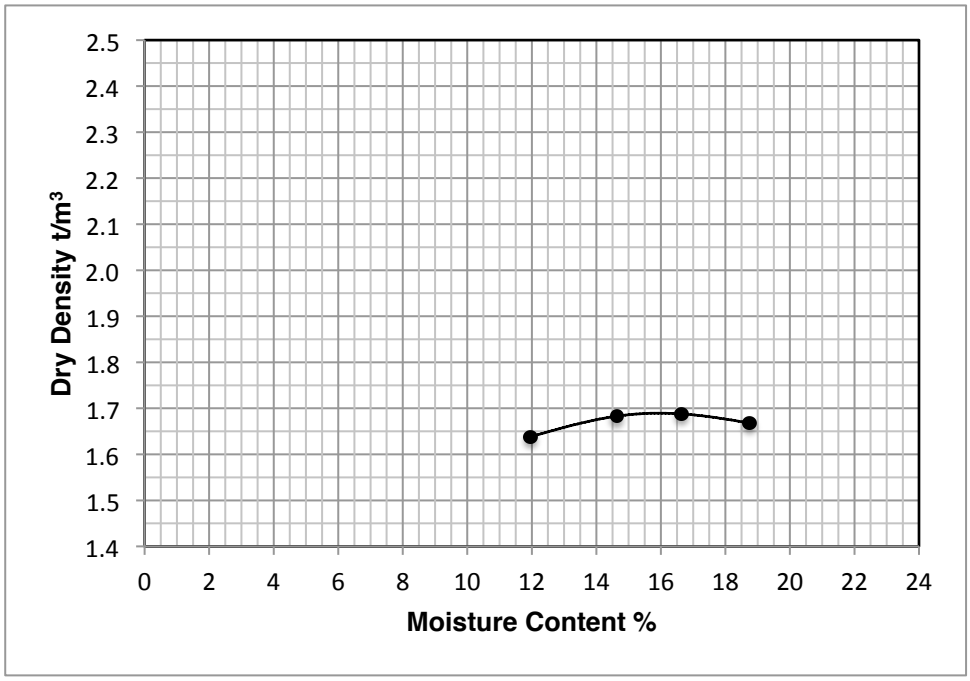
Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Laboratory Number	S865847-A-27	**Date tested**	13 Dec 2017
Sample ID	TP13_0.7-2.8m		
Proposed Use	Foundation		
Material Description	SILT with Clay		
Sampling Method	AS 1289.1.2.1	**Site Selection Method**	AS 1289.1.4.1

AS 1289.2.1.1 Determination of the moisture content of a soil - Oven drying method (standard method)

Maximum Dry Density t/m^3	1.69	**Optimum Moisture Content %**	16.0
% Retained 19mm Sieve	0	**% Retained 37.5mm Sieve**	0
Curing Time (hrs)	2	**Method used to determine LL**	Visual/Tactile



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Material Test Certificate

AS 1289.3.8.1 Determination of the Emerson class number of a soil

Report Number S865847-A Issue 1
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Project Ravensthorpe Gold Project - MURRAY ST PERTH
Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Lab No	S865847-A			**Date tested**	12 December 2017
Sample ID	-			**Time Tested**	-
Proposed Use	Foundation			**Layer Thickness mm**	-
Material Description	Various			**Test Depth mm**	-
Sampling Method	Client	**Site Selection Method**		Client	

Sample No.	Sample ID	Emerson Class No.
S865847-A-27	TP13_0.7-2.8m	2

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STRUCTERRE CONSULTING ENGINEERS
BALCATTA LABORATORY
ACCREDITATION NUMBER 18742

Date 16 January 2018

Authorised Signatory

Wayne Rozmianiec
Laboratory Manager

NDM Spec 201 Report

AS 1289.5.4.3 Rep2 Rev. 2.0 Feb-16

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Material Test Certificate

AS 1289.2.1.1 Determination of the moisture content of a soil - Oven drying method (standard method)

Report Number S865847-A Issue 1 **Client** MHA GEOTECHNICAL

Job Number S865847 **Project** Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Lab No	S865847-A			**Date tested**	1 December 2007
Sample ID	-			**Time Tested**	-
Proposed Use	Foundation			**Layer Thickness mm**	-
Material Description	Various			**Test Depth mm**	-
Sampling Method	Client	**Site Selection Method**	Client		

Sample No.	Sample ID	Moisture Content %
S865847-A-31	TP16_0.6-1.0m	11.1
S865847-A-32	TP16_1.0-2.8m	8.7
S865847-A-33	TP17_0.6-1.2m	9.1
S865847-A-34	TP17_1.2-2.7m	10.8
S865847-A-35	TP18_0.2-0.6m	6.1
S865847-A-36	TP18_0.6-1.2m	11.1
S865847-A-37	TP18_1.2-2.8m	9.9
S865847-A-38	TP19_0.2-0.6m	12.7
S865847-A-39	TP19_0.6-2.8m	14.6
S865847-A-40	TP20_0.2-0.4m	12.1

Remarks

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MATERIAL TEST CERTIFICATE

Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

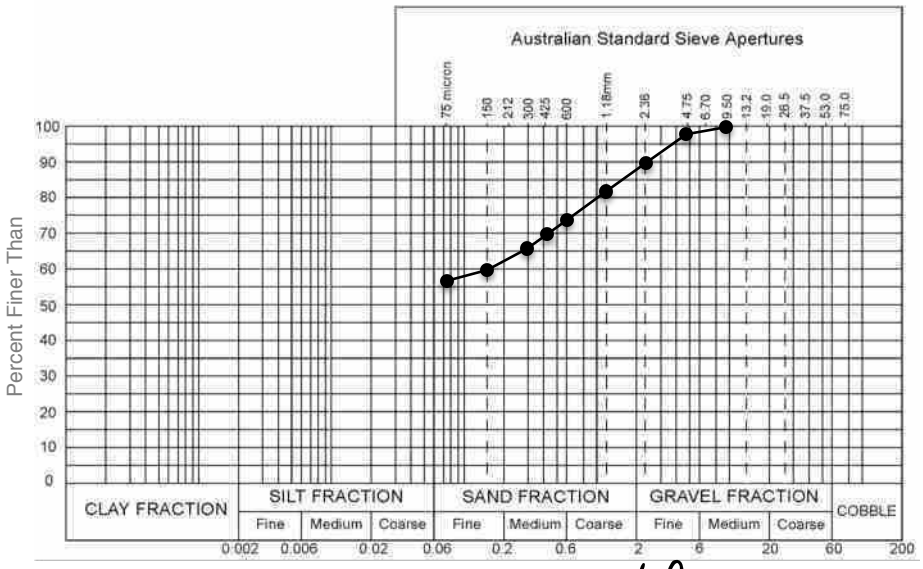
Sample Details

Laboratory Number	S865847-A-31	**Date tested**	20 Dec 2017
Sample ID	TP16_0.6-1.0m	**Tested by**	JWS
Proposed Use	Foundation	**Layer Thickness**	-
Material Description	AS 1726 - 2017 Sandy FINES trace gravel	**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	82	**Liquid Limit %**	
37.5 mm		0.6 mm	74	**Plastic Limit %**	
19 mm		0.425 mm	70	**Plasticity Index %**	
9.5 mm	100	0.3 mm	66	**Linear Shrinkage %**	
4.75 mm	98	0.15 mm	60	**Nature Of Shrinkage**	
2.36 mm	90	0.075 mm	57	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



Remarks

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Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

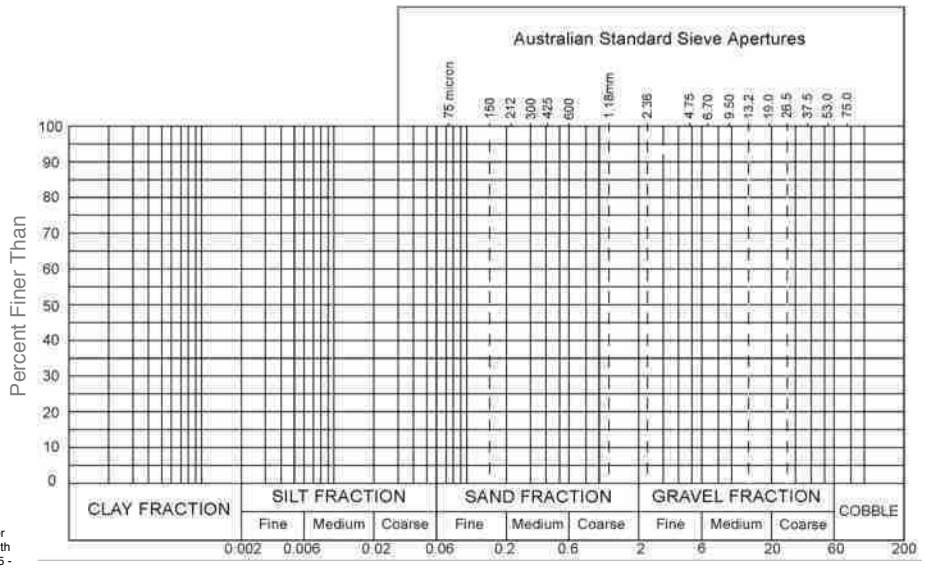
Sample Details

Laboratory Number	S865847-A-32	**Date tested**	11 December 2017		
Sample ID	TP16_1.0-2.8m			**Tested by**	CF
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	Clayey Silt			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm		**Liquid Limit %**	Not obtained
37.5 mm		0.6 mm		**Plastic Limit %**	Not obtained
19 mm		0.425 mm		**Plasticity Index %**	NP
9.5 mm		0.3 mm		**Linear Shrinkage %**	1.5
4.75 mm		0.15 mm		**Nature Of Shrinkage**	Normal
2.36 mm		0.075 mm		**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Particle Size Distribution & Atterberg Limits of a Soil

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Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

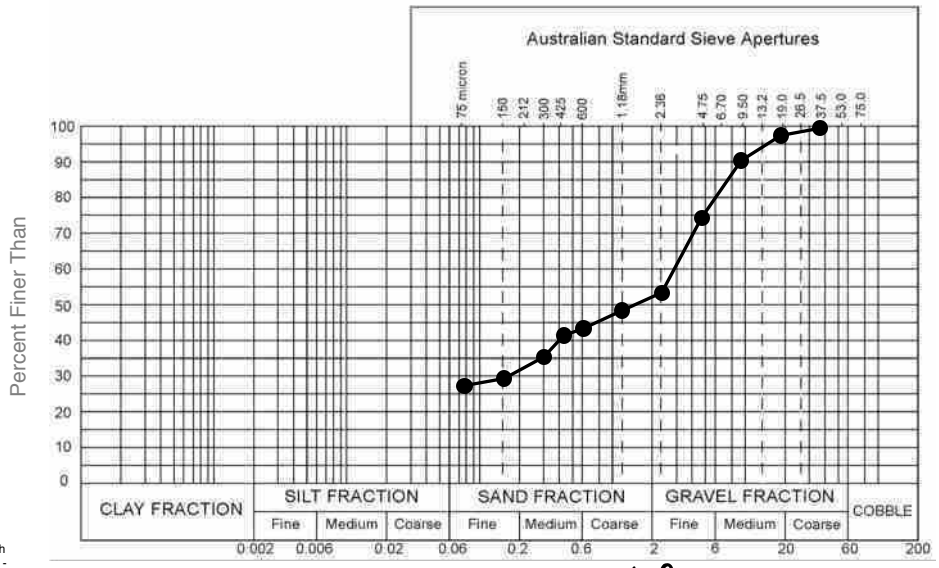
Sample Details

Laboratory Number	S865847-A-33	**Date tested**	20 Dec 2017		
Sample ID	TP17_0.6-1.2m			**Tested by**	JWS
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	AS 1726 - 2017 GM Silty or clayey GRAVEL with sand			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	49	**Liquid Limit %**	
37.5 mm	100	0.6 mm	44	**Plastic Limit %**	
19 mm	98	0.425 mm	42	**Plasticity Index %**	
9.5 mm	91	0.3 mm	36	**Linear Shrinkage %**	
4.75 mm	75	0.15 mm	30	**Nature Of Shrinkage**	
2.36 mm	54	0.075 mm	28	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
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Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

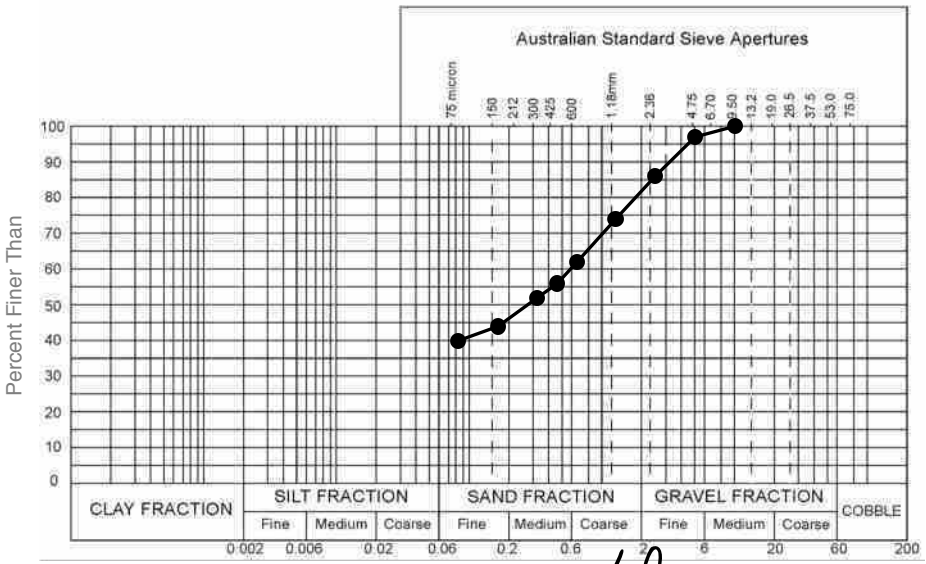
Sample Details

Laboratory Number	S865847-A-34	**Date tested**	20 Dec 2017		
Sample ID	TP17_1.2-2.7m			**Tested by**	JWS
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	AS 1726 - 2017 Sandy FINES trace gravel			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	74	**Liquid Limit %**	
37.5 mm		0.6 mm	62	**Plastic Limit %**	
19 mm		0.425 mm	56	**Plasticity Index %**	
9.5 mm	100	0.3 mm	52	**Linear Shrinkage %**	
4.75 mm	97	0.15 mm	44	**Nature Of Shrinkage**	
2.36 mm	86	0.075 mm	40	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Particle Size Distribution & Atterberg Limits of a Soil

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Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

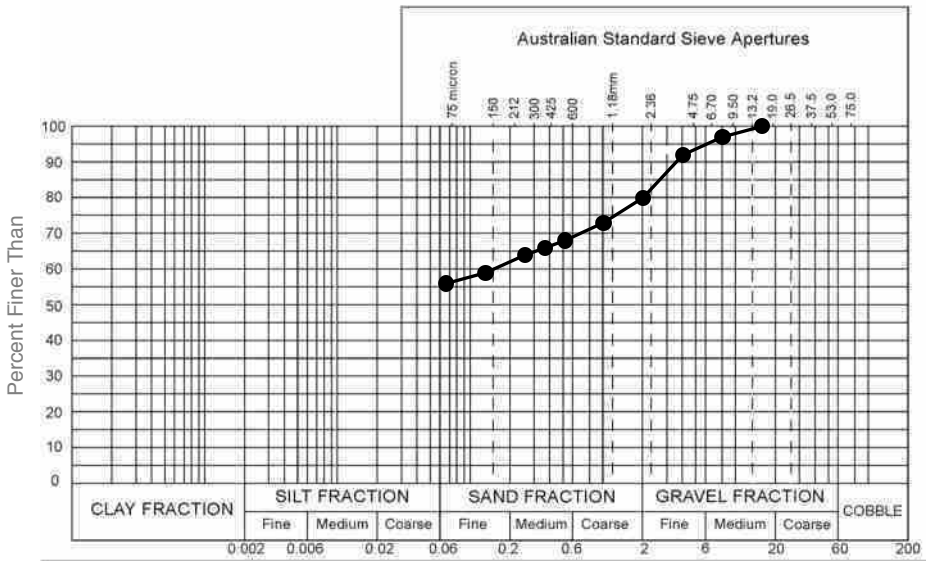
Sample Details

Laboratory Number	S865847-A-35	**Date tested**	20 Dec 2017
Sample ID	TP18_0.2-0.6m	**Tested by**	JWS
Proposed Use	Foundation	**Layer Thickness**	-
Material Description	AS 1726 - 2017 FINES with gravel, with sand	**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	73	**Liquid Limit %**	
37.5 mm		0.6 mm	68	**Plastic Limit %**	
19 mm	100	0.425 mm	66	**Plasticity Index %**	
9.5 mm	97	0.3 mm	64	**Linear Shrinkage %**	
4.75 mm	92	0.15 mm	59	**Nature Of Shrinkage**	
2.36 mm	80	0.075 mm	56	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
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Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

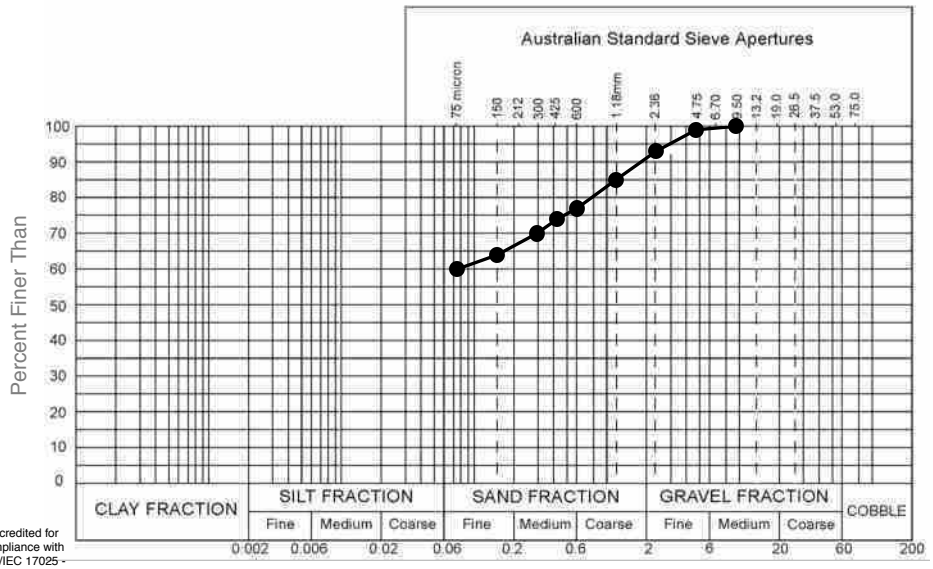
Sample Details

Laboratory Number	S865847-A-36	**Date tested**	20 Dec 2017
Sample ID	TP18_0.6-1.2m	**Tested by**	JWS
Proposed Use	Foundation	**Layer Thickness**	-
Material Description	AS 1726 - 2017 Sandy FINES trace gravel	**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	85	**Liquid Limit %**	
37.5 mm		0.6 mm	77	**Plastic Limit %**	
19 mm		0.425 mm	74	**Plasticity Index %**	
9.5 mm	100	0.3 mm	70	**Linear Shrinkage %**	
4.75 mm	99	0.15 mm	64	**Nature Of Shrinkage**	
2.36 mm	93	0.075 mm	60	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Particle Size Distribution & Atterberg Limits of a Soil

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Job Number S865847

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Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

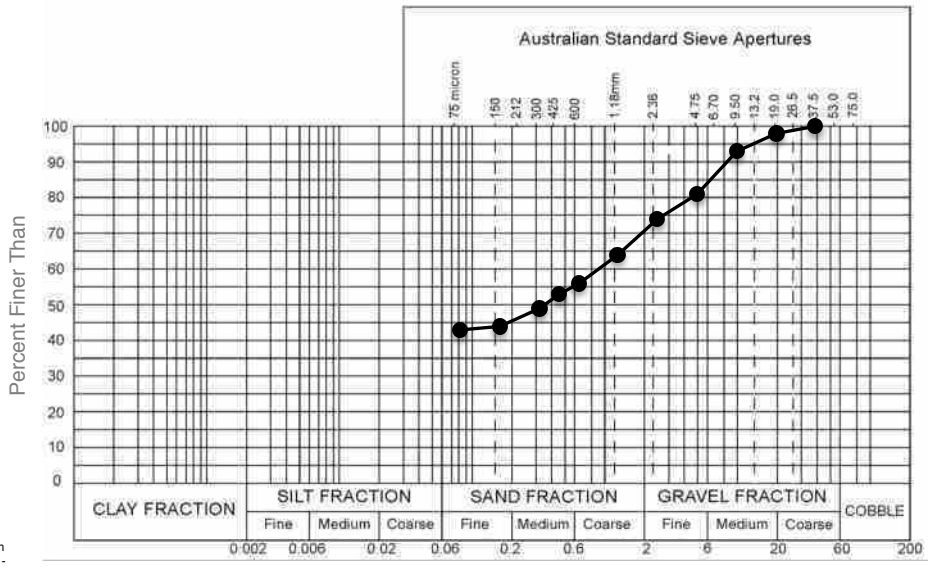
Sample Details

Laboratory Number	S865847-A-37	**Date tested**	20 Dec 2017
Sample ID	TP18_1.2-2.8m	**Tested by**	JWS
Proposed Use	Foundation	**Layer Thickness**	-
Material Description	AS 1726 - 2017 Sandy FINES with gravel	**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	64	**Liquid Limit %**	
37.5 mm	100	0.6 mm	56	**Plastic Limit %**	
19 mm	98	0.425 mm	53	**Plasticity Index %**	
9.5 mm	93	0.3 mm	49	**Linear Shrinkage %**	
4.75 mm	81	0.15 mm	44	**Nature Of Shrinkage**	
2.36 mm	74	0.075 mm	43	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

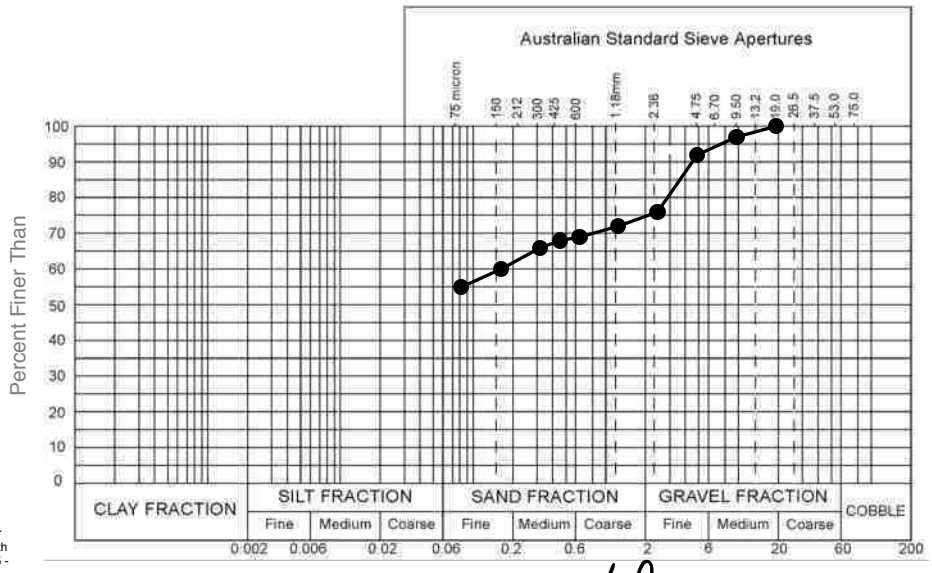
Sample Details

Laboratory Number	S865847-A-38	**Date tested**	20 Dec 2017
Sample ID	TP19_0.2-0.6m	**Tested by**	JWS
Proposed Use	Foundation	**Layer Thickness**	-
Material Description	AS 1726 - 2017 FINES with gravel, with sand	**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	72	**Liquid Limit %**	
37.5 mm		0.6 mm	69	**Plastic Limit %**	
19 mm	100	0.425 mm	68	**Plasticity Index %**	
9.5 mm	97	0.3 mm	66	**Linear Shrinkage %**	
4.75 mm	92	0.15 mm	60	**Nature Of Shrinkage**	
2.36 mm	76	0.075 mm	55	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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1 Erindale Rd Balcatta WA 6021

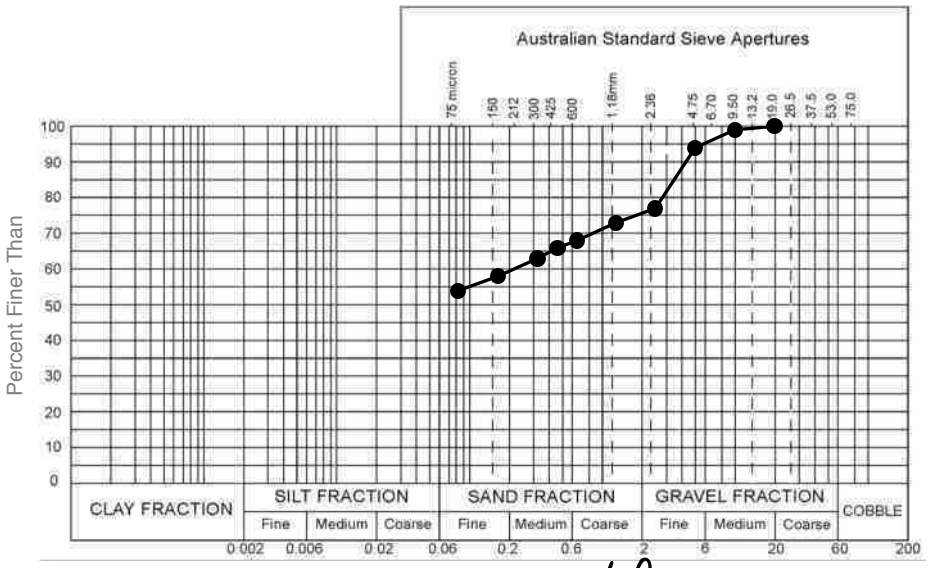
Sample Details

Laboratory Number	S865847-A-39	**Date tested**	20 Dec 2017		
Sample ID	TP19_0.6-2.8m			**Tested by**	JWS
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	AS 1726 - 2017 FINES with gravel, with sand			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	73	**Liquid Limit %**	
37.5 mm		0.6 mm	68	**Plastic Limit %**	
19 mm	100	0.425 mm	66	**Plasticity Index %**	
9.5 mm	99	0.3 mm	63	**Linear Shrinkage %**	
4.75 mm	94	0.15 mm	58	**Nature Of Shrinkage**	
2.36 mm	77	0.075 mm	54	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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BALCATTA LABORATORY
ACCREDITATION NUMBER 18742

Remarks

Date 16 January 2018

Authorised Signatory

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MATERIAL TEST CERTIFICATE

Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

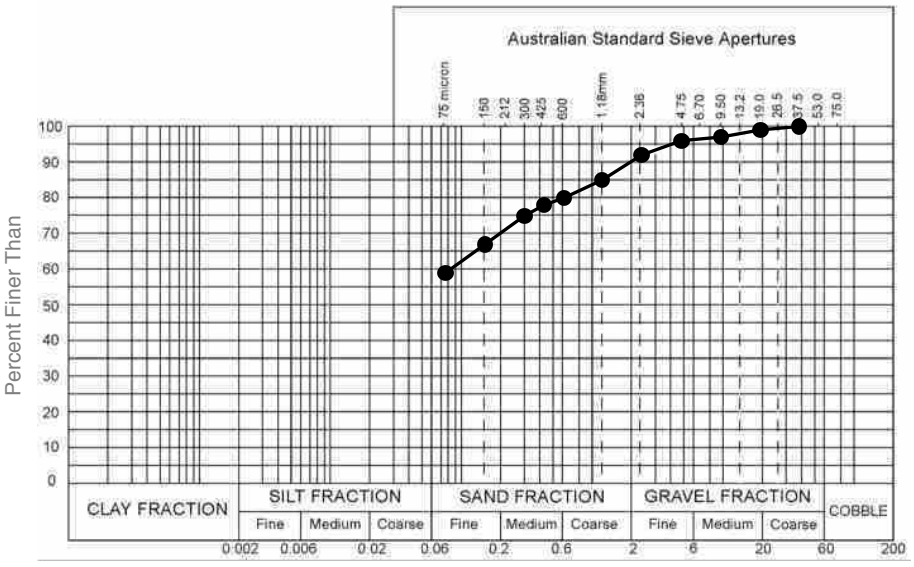
Sample Details

Laboratory Number	S865847-A-40	**Date tested**	20 Dec 2017		
Sample ID	TP20_0.2-0.4m			**Tested by**	JWS
Proposed Use	Foundation			**Layer Thickness**	-
Material Description	AS 1726 - 2017 Sandy FINES trace gravel			**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	85	**Liquid Limit %**	
37.5 mm	100	0.6 mm	80	**Plastic Limit %**	
19 mm	99	0.425 mm	78	**Plasticity Index %**	
9.5 mm	97	0.3 mm	75	**Linear Shrinkage %**	
4.75 mm	96	0.15 mm	67	**Nature Of Shrinkage**	
2.36 mm	92	0.075 mm	59	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Material Test Certificate

AS 1289.5.1.1 Determination of the dry density/moisture content relation of a soil using standard compactive effort

Report Number	S865847-A Issue 1	**Client**	MHA GEOTECHNICAL
Job Number	S865847	**Project**	Ravensthorpe Gold Project - MURRAY ST PERTH

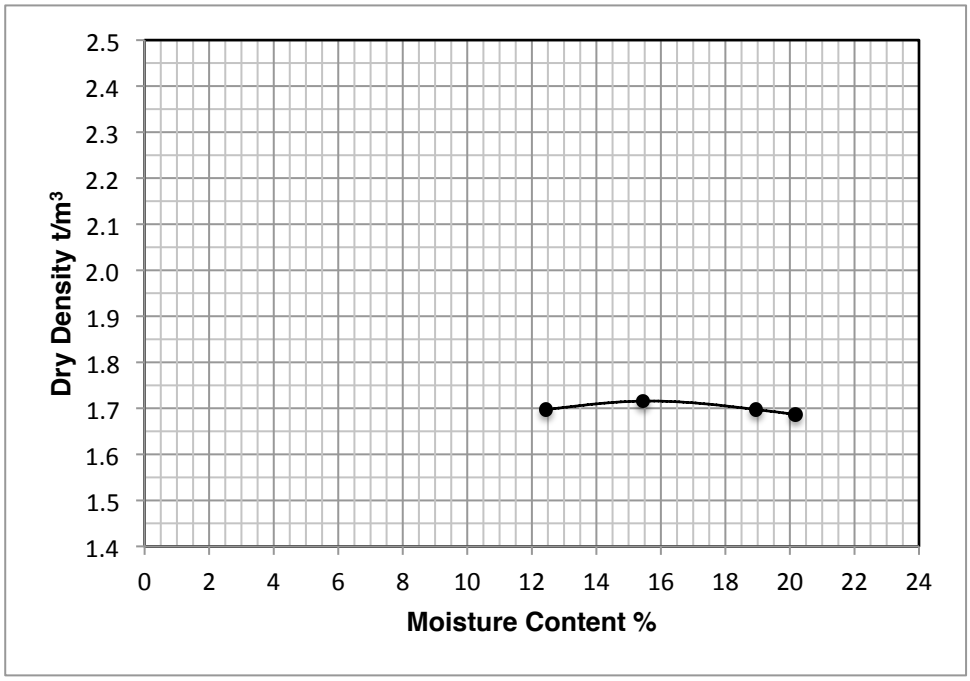
Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Laboratory Number	S865847-A-32	**Date tested**	13 Dec 2017
Sample ID	TP16_1.0-2.8m		
Proposed Use	Foundation		
Material Description	SILT		
Sampling Method	AS 1289.1.2.1	**Site Selection Method**	AS 1289.1.4.1

AS 1289.2.1.1 Determination of the moisture content of a soil - Oven drying method (standard method)

Maximum Dry Density t/m^3	1.72	**Optimum Moisture Content %**	15.5
% Retained 19mm Sieve	1	**% Retained 37.5mm Sieve**	0
Curing Time (hrs)	8	**Method used to determine LL**	Visual/Tactile



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Material Test Certificate

AS 1289.3.8.1 Determination of the Emerson class number of a soil

Report Number	S865847-A Issue 1	**Client**	MHA GEOTECHNICAL
Job Number	S865847	**Project**	Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Lab No	S865847-A			**Date tested**	12 December 2017
Sample ID	-			**Time Tested**	-
Proposed Use	Foundation			**Layer Thickness mm**	-
Material Description	Various			**Test Depth mm**	-
Sampling Method	Client	**Site Selection Method**		Client	

Sample No.	Sample ID	Emerson Class No.
S865847-A-32	TP16_1.0-2.8m	6

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ACCREDITATION NUMBER 18742

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NDM Spec 201 Report

AS 1289.5.4.3 Rep2 Rev. 2.0 Feb-16

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Material Test Certificate

AS 1289.2.1.1 Determination of the moisture content of a soil - Oven drying method (standard method)

Report Number	S865847-A Issue 1	**Client**	MHA GEOTECHNICAL
Job Number	S865847	**Project**	Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Lab No	S865847-A			**Date tested**	1 December 2007
Sample ID	-			**Time Tested**	-
Proposed Use	Foundation			**Layer Thickness mm**	-
Material Description	Various			**Test Depth mm**	-
Sampling Method	Client	**Site Selection Method**	Client		

Sample No.	Sample ID	Moisture Content %
S865847-A-41	TP20_0.4-1.0m	7

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MATERIAL TEST CERTIFICATE

Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-A
Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

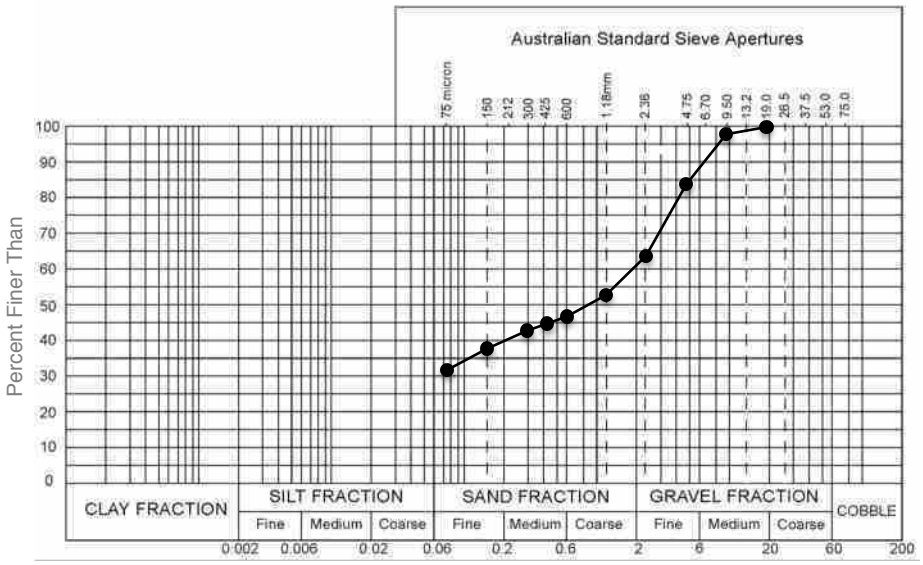
Sample Details

Laboratory Number	S865847-A-41	**Date tested**	20 Dec 2017
Sample ID	TP20_0.4-1.3m	**Tested by**	JWS
Proposed Use	Foundation	**Layer Thickness**	-
Material Description	AS 1726 - 2017 GM Silty or clayey, sandy GRAVEL	**Test Depth**	-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm	53	**Liquid Limit %**	
37.5 mm		0.6 mm	47	**Plastic Limit %**	
19 mm	100	0.425 mm	45	**Plasticity Index %**	
9.5 mm	98	0.3 mm	43	**Linear Shrinkage %**	
4.75 mm	84	0.15 mm	38	**Nature Of Shrinkage**	
2.36 mm	64	0.075 mm	32	**Sample History**	Dried at 50 °C

Particle Size Distribution Graph



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Material Test Certificate

AS 1289.2.1.1 Determination of the moisture content of a soil - Oven drying method (standard method)

Report Number	S865847-B Issue 1	**Client**	MHA GEOTECHNICAL
Job Number	S865847	**Project**	Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Lab No	S865847-B			**Date tested**	1 December 2007
Sample ID	-			**Time Tested**	-
Proposed Use	Borrow			**Layer Thickness mm**	-
Material Description	Various			**Test Depth mm**	-
Sampling Method	Client	**Site Selection Method**	Client		

Sample No.	Sample ID	Moisture Content %
S865847-B-1	Borrow 1	6.3
S865847-B-2	Borrow 2	3.8
S865847-B-3	Borrow 3	7.2

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MATERIAL TEST CERTIFICATE

Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-B
Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

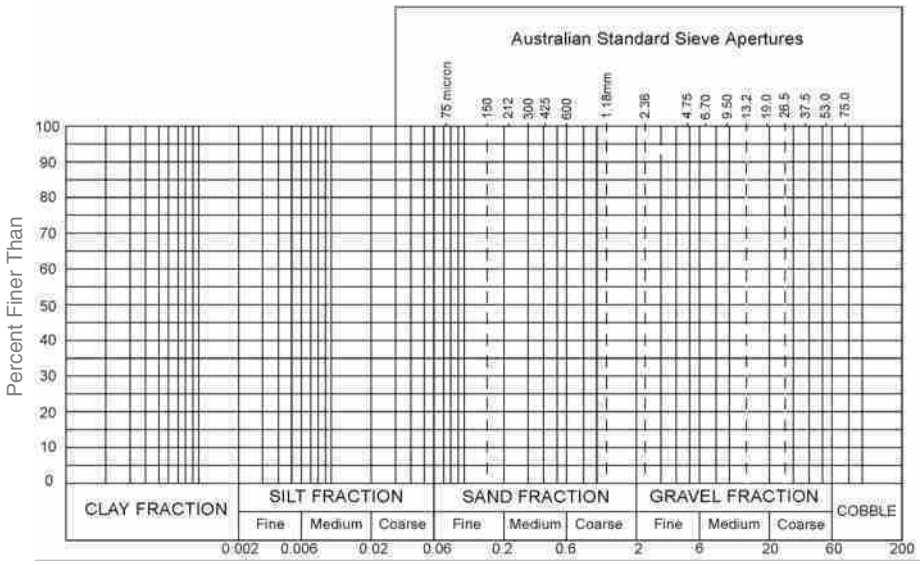
Sample Details

Laboratory Number	S865847-B-1	**Date tested**	11 December 2017		
Sample ID	Borrow 1			**Tested by**	CF
Proposed Use	Borrow		**Layer Thickness**		-
Material Description	Clayey Silt		**Test Depth**		-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm		**Liquid Limit %**	Not obtained
37.5 mm		0.6 mm		**Plastic Limit %**	Not obtained
19 mm		0.425 mm		**Plasticity Index %**	NP
9.5 mm		0.3 mm		**Linear Shrinkage %**	2.0
4.75 mm		0.15 mm		**Nature Of Shrinkage**	Normal
2.36 mm		0.075 mm		**Sample History**	Dried at 50 °C
				Moisture Content % of LL specimen	31.8

Particle Size Distribution Graph



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MATERIAL TEST CERTIFICATE

Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-B
Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

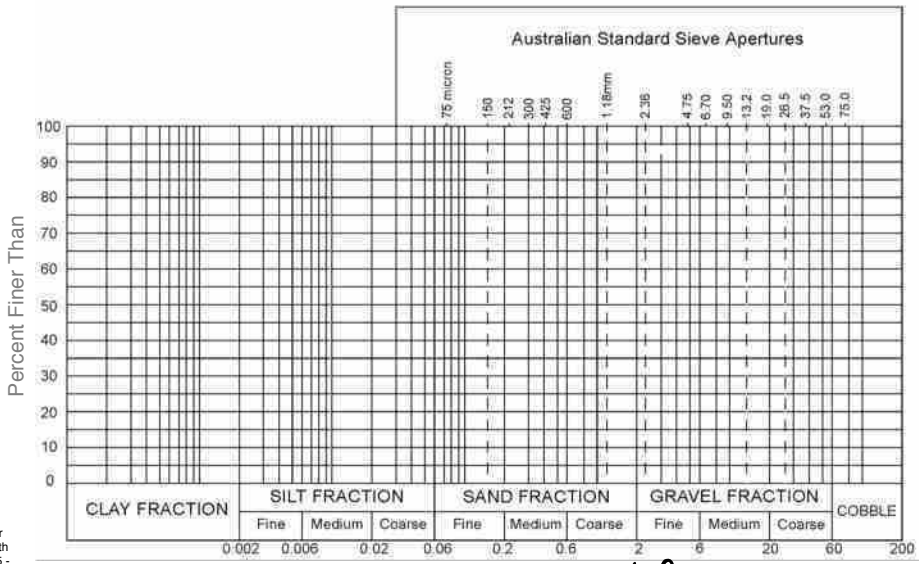
Sample Details

Laboratory Number	S865847-B-2	**Date tested**	11 December 2017		
Sample ID	Borrow 2			**Tested by**	CF
Proposed Use	Borrow		**Layer Thickness**		-
Material Description	Clayey Silt		**Test Depth**		-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm		**Liquid Limit %**	Not obtained
37.5 mm		0.6 mm		**Plastic Limit %**	Not obtained
19 mm		0.425 mm		**Plasticity Index %**	NP
9.5 mm		0.3 mm		**Linear Shrinkage %**	1.5
4.75 mm		0.15 mm		**Nature Of Shrinkage**	Normal
2.36 mm		0.075 mm		**Sample History**	Dried at 50 °C
				Moisture Content % of LL specimen	36.7

Particle Size Distribution Graph



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MATERIAL TEST CERTIFICATE

Particle Size Distribution & Atterberg Limits of a Soil

Report Number S865847-B
Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

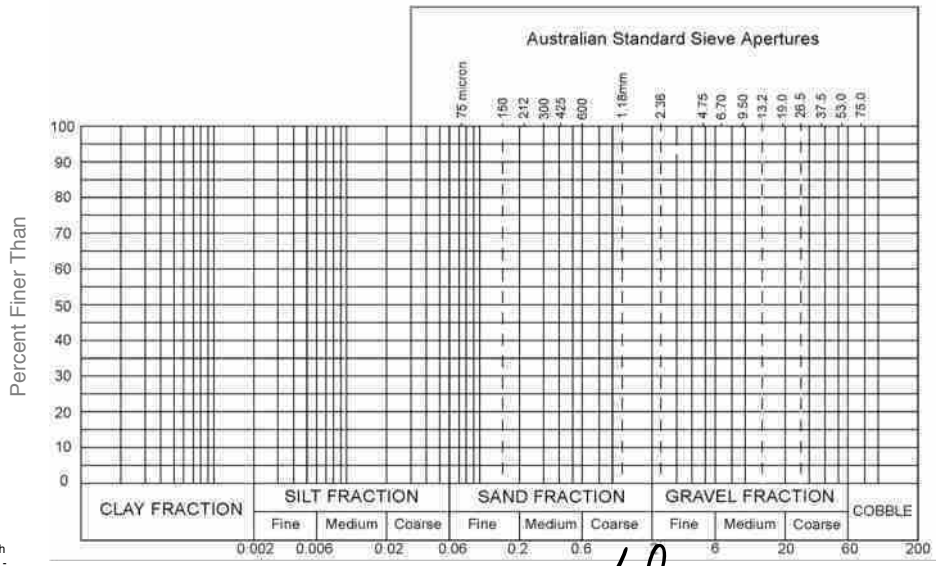
Sample Details

Laboratory Number	S865847-B-3	**Date tested**	11 December 2017		
Sample ID	Borrow 3			**Tested by**	CF
Proposed Use	Borrow		**Layer Thickness**		-
Material Description	Clayey Silt		**Test Depth**		-
Sampling Method	AS 1289.1.4.1	**Drying Method**	Dried to constant mass		

Particle Size Distribution & Atterberg Limits of a Soil

Particle Size Distribution AS 1289.3.6.1				Atterberg Limits (AS 1289.3.1.2,AS 1289.3.2.1,AS 1289.3.3.1,AS 1289.3.4.1)	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**		
75 mm		1.18 mm		**Liquid Limit %**	Not obtained
37.5 mm		0.6 mm		**Plastic Limit %**	Not obtained
19 mm		0.425 mm		**Plasticity Index %**	NP
9.5 mm		0.3 mm		**Linear Shrinkage %**	1.5
4.75 mm		0.15 mm		**Nature Of Shrinkage**	Normal
2.36 mm		0.075 mm		**Sample History**	Dried at 50 °C
				Moisture Content % of LL specimen	31.6

Particle Size Distribution Graph



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Material Test Certificate

AS 1289.5.1.1 Determination of the dry density/moisture content relation of a soil using standard compactive effort

Report Number	S865847-B Issue 1	**Client**	MHA GEOTECHNICAL
Job Number	S865847	**Project**	Ravensthorpe Gold Project - MURRAY ST PERTH

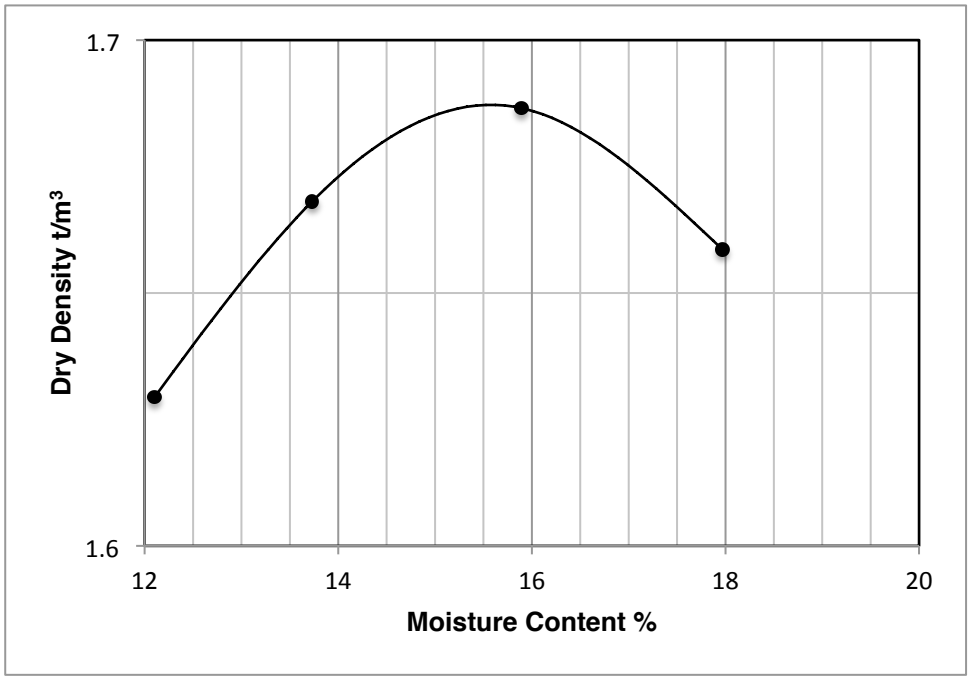
Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Laboratory Number	S865847-B-1	**Date tested**	Monday, 11 December 2017
Sample ID	Borrow Pit 1		
Proposed Use	Embankment Construction		
Material Description	Clay		
Sampling Method	AS 1289.1.2.1	**Site Selection Method**	AS 1289.1.4.1

AS 1289.2.1.1 Determination of the moisture content of a soil - Oven drying method (standard method)

Maximum Dry Density t/m^3	1.69	**Optimum Moisture Content %**	15.5
% Retained 19mm Sieve	2	**% Retained 37.5mm Sieve**	0
Curing Time (hrs)	2	**Method used to determine LL**	Visual/Tactile



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Material Test Certificate

AS 1289.5.1.1 Determination of the dry density/moisture content relation of a soil using standard compactive effort

Report Number	S865847-B Issue 1	**Client**	MHA GEOTECHNICAL
Job Number	S865847	**Project**	Ravensthorpe Gold Project - MURRAY ST PERTH

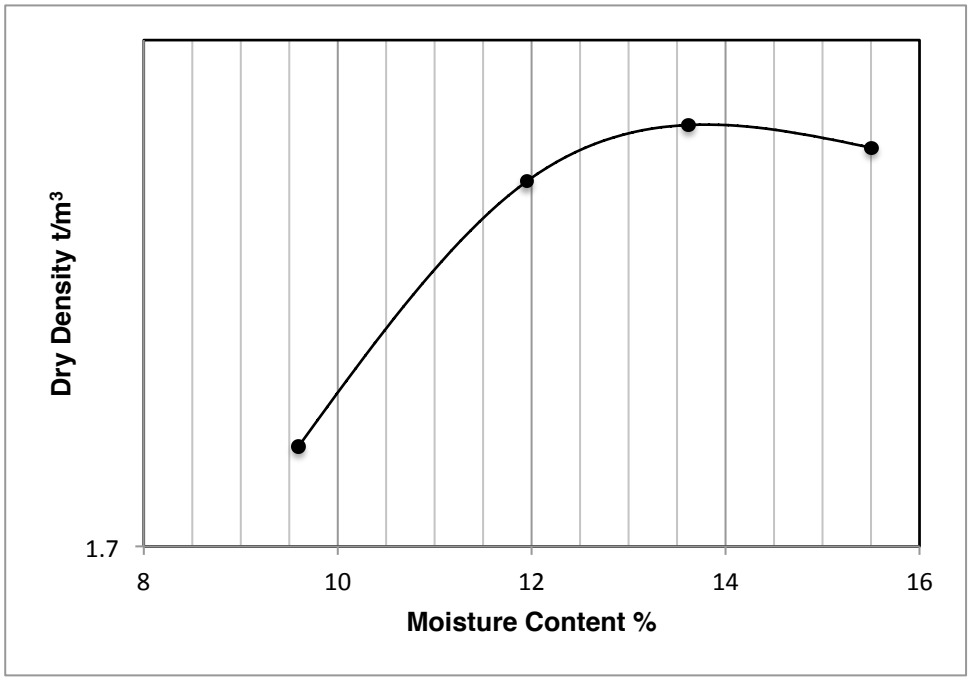
Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Laboratory Number	S865847-B-2	**Date tested**	Monday, 11 December 2017
Sample ID	Borrow Pit 2		
Proposed Use	Embankment Construction		
Material Description	Clay		
Sampling Method	AS 1289.1.2.1	**Site Selection Method**	AS 1289.1.4.1

AS 1289.2.1.1 Determination of the moisture content of a soil - Oven drying method (standard method)

Maximum Dry Density t/m^3	1.74	**Optimum Moisture Content %**	14.0
% Retained 19mm Sieve	0	**% Retained 37.5mm Sieve**	0
Curing Time (hrs)	2	**Method used to determine LL**	Visual/Tactile



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Material Test Certificate

AS 1289.5.1.1 Determination of the dry density/moisture content relation of a soil using standard compactive effort

Report Number S865847-B Issue 1 **Client** MHA GEOTECHNICAL

Job Number S865847 **Project** Ravensthorpe Gold Project - MURRAY ST PERTH

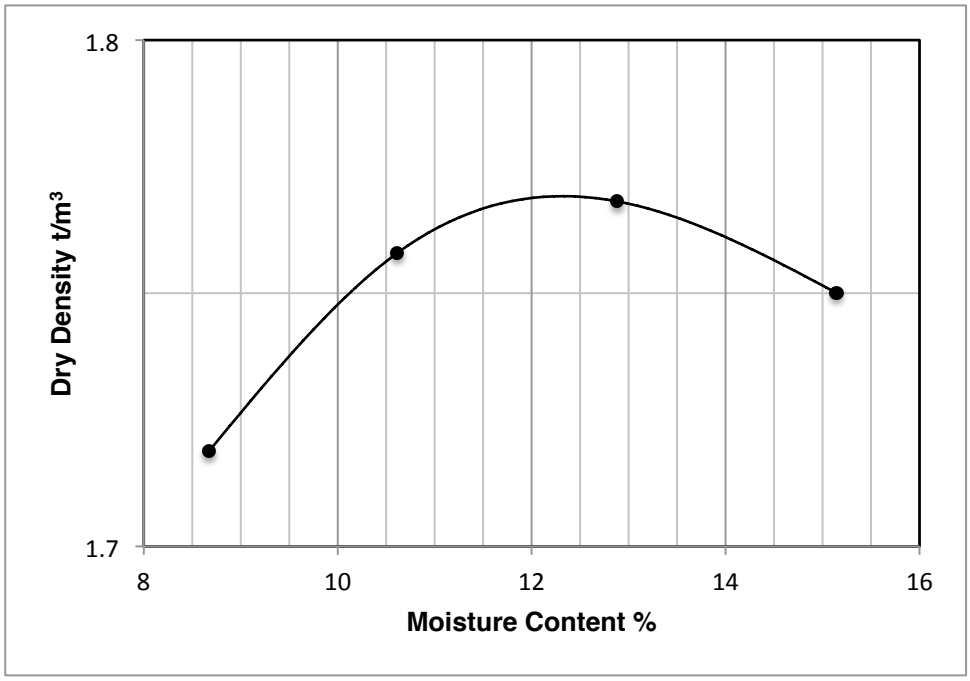
Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Laboratory Number	S865847-B-3	**Date tested**	Monday, 11 December 2017
Sample ID	Borrow Pit 3		
Proposed Use	Embankment Construction		
Material Description	Clay		
Sampling Method	AS 1289.1.2.1	**Site Selection Method**	AS 1289.1.4.1

AS 1289.2.1.1 Determination of the moisture content of a soil - Oven drying method (standard method)

Maximum Dry Density t/m³	1.77	**Optimum Moisture Content %**	12.5
% Retained 19mm Sieve	0	**% Retained 37.5mm Sieve**	0
Curing Time (hrs)	2	**Method used to determine LL**	Visual/Tactile



Remarks

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STRUCTERRE CONSULTING ENGINEERS
BALCATTA LABORATORY
ACCREDITATION NUMBER 18742

Date 16 January 2018

Authorised Signatory

Wayne Rozmianiec
Laboratory Manager

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ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

Material Test Certificate

AS 1289.5.2.1 Determination of the dry density/moisture content relation of a soil using modified compactive effort

Report Number	S865847-B Issue 1	**Client**	MHA GEOTECHNICAL
Job Number	S865847	**Project**	Ravensthorpe Gold Project - MURRAY ST PERTH

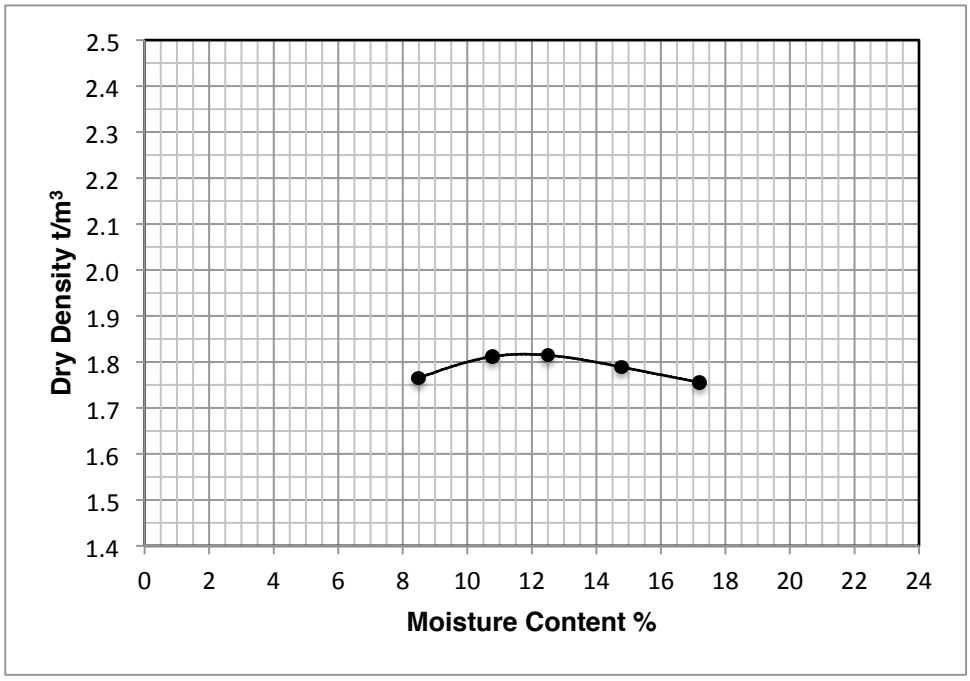
Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Laboratory Number	S865847-B-1	**Date tested**	13 Dec 2017
Sample ID	Borrow 1		
Proposed Use	Borrow		
Material Description	Clayey Silt		
Sampling Method	AS 1289.1.2.1	**Site Selection Method**	AS 1289.1.4.1

AS 1289.2.1.1 Determination of the moisture content of a soil - Oven drying method (standard method)

Maximum Dry Density t/m^3	1.82	**Optimum Moisture Content %**	12.0
% Retained 19mm Sieve	1	**% Retained 37.5mm Sieve**	4
Curing Time (hrs)	2	**Method used to determine LL**	Visual/Tactile



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Material Test Certificate

AS 1289.5.2.1 Determination of the dry density/moisture content relation of a soil using modified compactive effort

Report Number	S865847-B Issue 1	**Client**	MHA GEOTECHNICAL
Job Number	S865847	**Project**	Ravensthorpe Gold Project - MURRAY ST PERTH

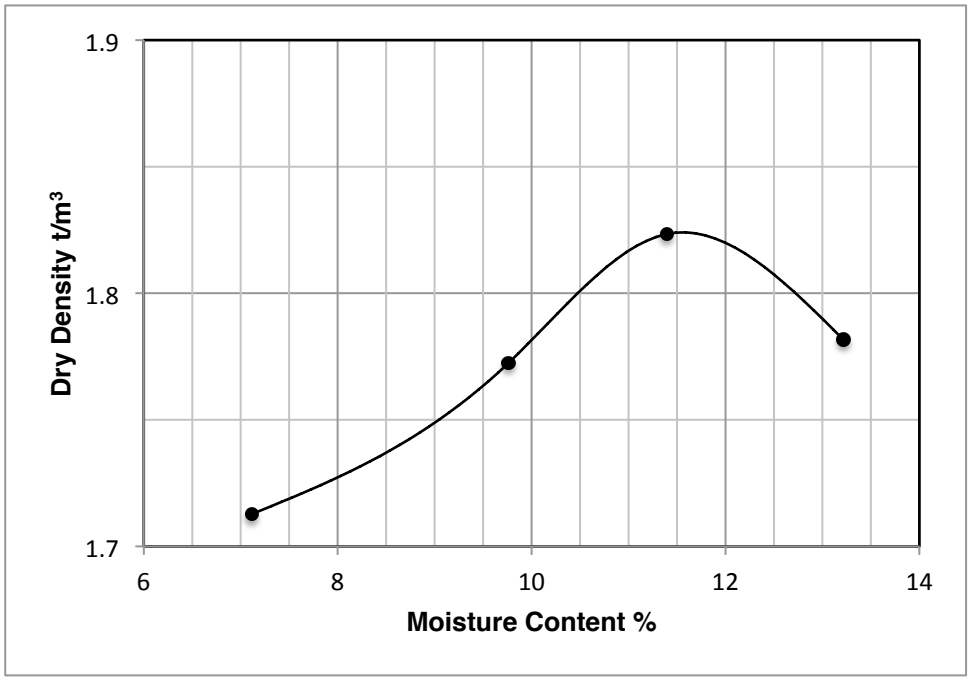
Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Laboratory Number	S865847-B-2	**Date tested**	Monday, 11 December 2017
Sample ID	Borrow Pit 2		
Proposed Use	Borrow		
Material Description	Clayey Silt		
Sampling Method	AS 1289.1.2.1	**Site Selection Method**	AS 1289.1.4.1

AS 1289.2.1.1 Determination of the moisture content of a soil - Oven drying method (standard method)

Maximum Dry Density t/m^3	1.82	**Optimum Moisture Content %**	11.5
% Retained 19mm Sieve	0	**% Retained 37.5mm Sieve**	0
Curing Time (hrs)	2	**Method used to determine LL**	Visual/Tactile



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Material Test Certificate

AS 1289.5.2.1 Determination of the dry density/moisture content relation of a soil using modified compactive effort

Report Number S865847-B Issue 1

Client MHA GEOTECHNICAL

Job Number S865847

Project Ravensthorpe Gold Project - MURRAY ST PERTH

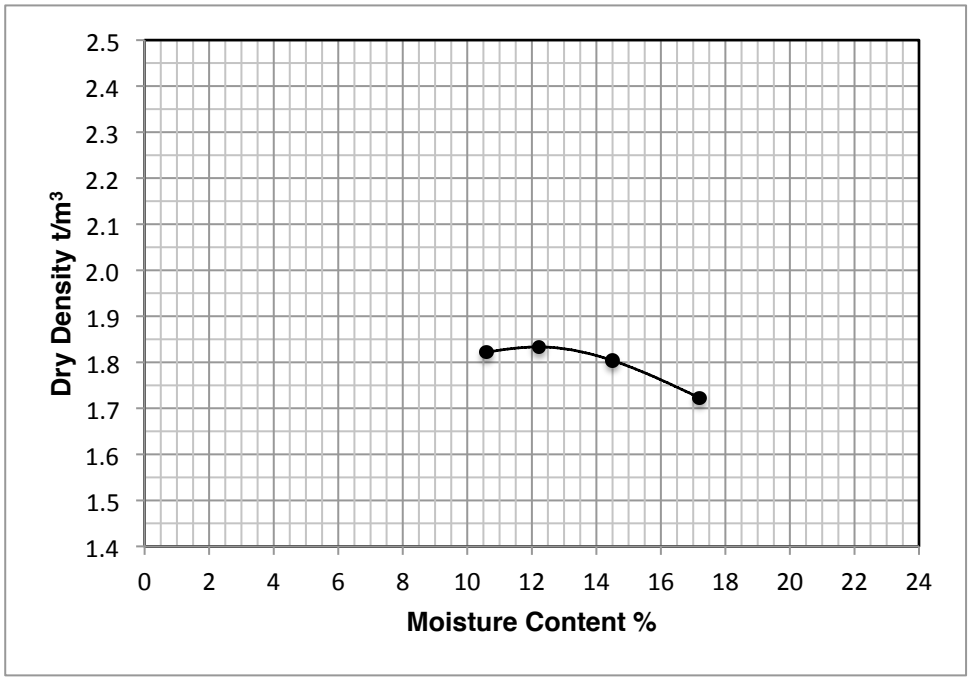
Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Laboratory Number	S865847-B-3	**Date tested**	13 Dec 2017
Sample ID	Borrow 3		
Proposed Use	Borrow		
Material Description	Clayey Silt		
Sampling Method	AS 1289.1.2.1	**Site Selection Method**	AS 1289.1.4.1

AS 1289.2.1.1 Determination of the moisture content of a soil - Oven drying method (standard method)

Maximum Dry Density t/m³	1.83	**Optimum Moisture Content %**	12.0
% Retained 19mm Sieve	0	**% Retained 37.5mm Sieve**	0
Curing Time (hrs)	2	**Method used to determine LL**	Visual/Tactile



Remarks

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BALCATTA LABORATORY
ACCREDITATION NUMBER 18742

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Material Test Certificate

AS 1289.3.8.1 Determination of the Emerson class number of a soil

Report Number S865847-B Issue 1
Client MHA GEOTECHNICAL

Job Number S865847
Project Ravensthorpe Gold Project - MURRAY ST PERTH
Tests carried out at Balcatta Laboratory
1 Erindale Rd Balcatta WA 6021

Sample Details

Lab No	S865847-B			**Date tested**	20 December 2017
Sample ID	Borrow			**Time Tested**	-
Proposed Use	Borrow			**Layer Thickness mm**	-
Material Description	Various			**Test Depth mm**	-
Sampling Method	AS 1289.1.2.1	**Site Selection Method**	AS 1289.1.4.1		

Sample No.	Sample ID	Emerson Class No.
S865847-B-1	Borrow 1	5
S865847-B-2	Borrow 2	6
S865847-B-3	Borrow 3	6

Authorised Signatory

Date 16 January 2018

Wayne Rozmianiec
Laboratory Manager

NDM Spec 201 Report

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WA 6107
Ph: +61 8 9258 8323

TRIAXIAL TEST REPORT

Test Method: ASTM D7181-11

Client:	Structerre Consulting Engineers	**Report No.:**	18010243 - CD
		Workorder No.	0003674
Address	PO Box 792 BALCATTA WA 6914	**Test Date:**	14/01/2018
		Report Date:	22/01/2018
Project:	Ravensthorpe Gold Project		
Client Id.:	A5 TP02	**Depth (m):**	0.50-1.10
Description:	GRAVELLY SILTY CLAY- red brown		

SAMPLE & TEST DETAILS

Sample 1

Initial Height:	199.8	mm
Initial Diameter:	100.2	mm
L/D Ratio:	2.0 : 1	
Initial Moisture Content:	9.4	%
Final Moisture Content:	13.3	%
Wet Density:	2.14	t/m^3
Dry Density:	1.96	t/m^3
Rate of Strain:	0.002	%/min
B Response:	98	%

Failure Criteria: Maximum Deviator Stress

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		
292 kPa	800 kPa	508 kPa	508 kPa	507 kPa	770 kPa	293 kPa	2.629	477 kPa	7.36 %

Sample Type: Single Individual Specimen remoulded to a target density of 95% of Standard Maximum Dry Density at Optimum Moisture Content (-19.0mm material tested)

Sample/s supplied by the client — Note: Graph not to scale — **Page 1 of 6**

REP16401

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Tested at Trilab Brisbane Laboratory.

Authorised Signatory
C. Channon

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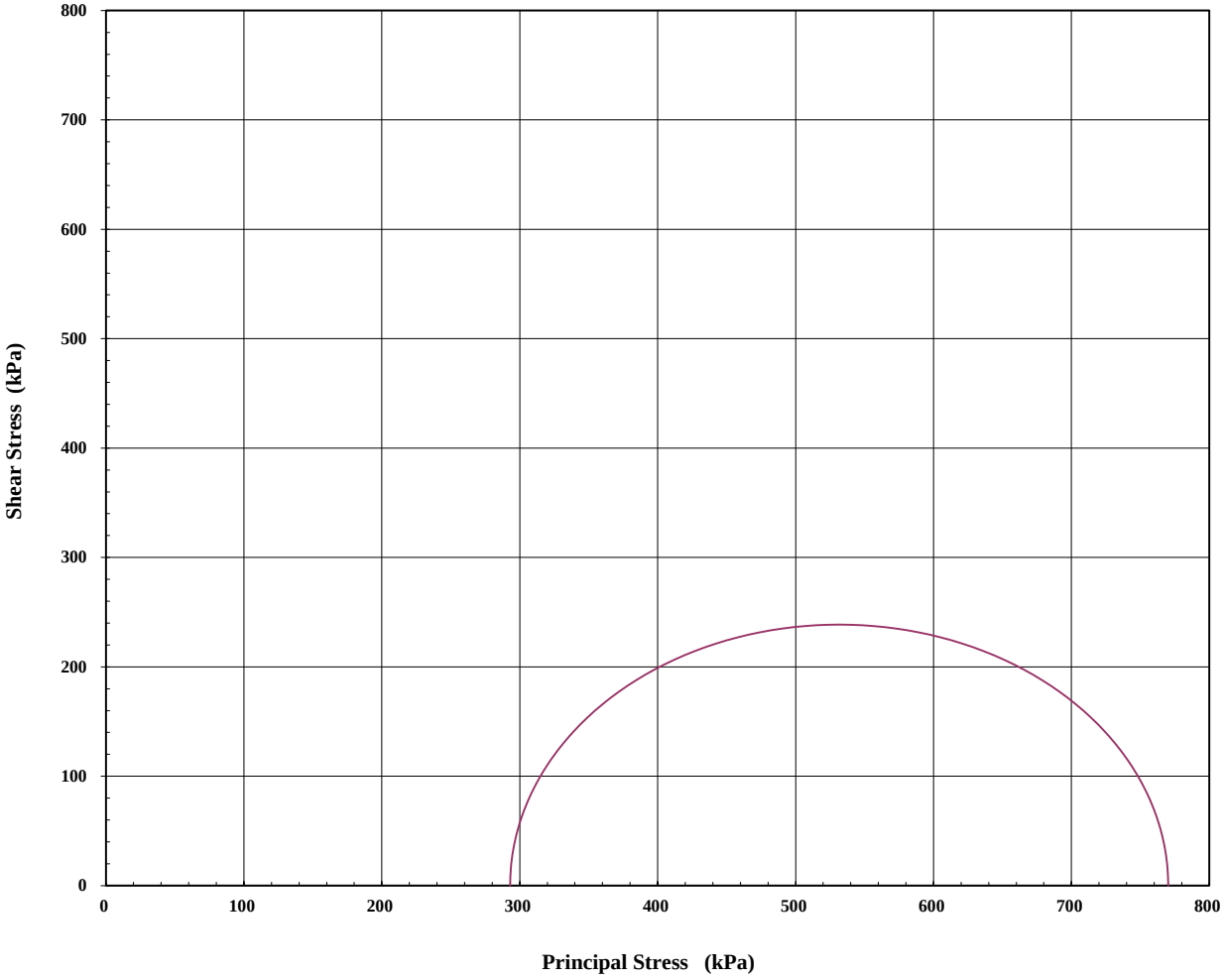
TRIAXIAL TEST REPORT

Test Method: ASTM D7181-11

Client: Structerre Consulting Engineers

Report No.: 18010243 - CD

Mohr Circle Diagram



Interpretation between stages :

Cohesion C' (kPa) :

Angle of Shear Resistance Φ' (Degrees) :

Sample Type: Single Individual Specimen remoulded to a target density of 95% of Standard Maximum Dry Density at Optimum Moisture Content (-19.0mm material tested)

Sample/s supplied by the client — Note: Graph not to scale — **Page 2 of 6**

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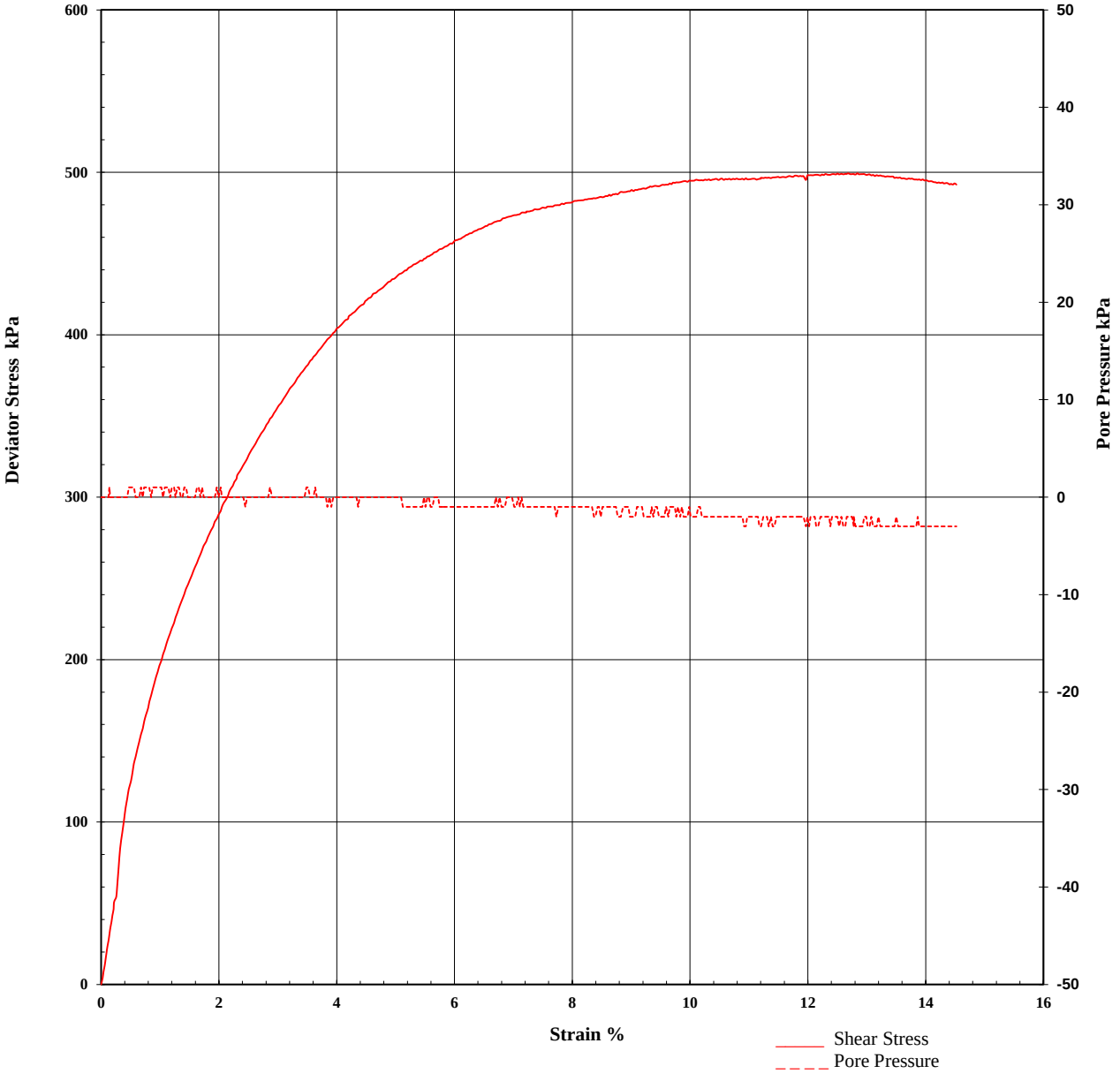
TRIAXIAL TEST REPORT

Test Method: ASTM D7181-11

Client: Structerre Consulting Engineers

Report No.: 18010243 - CD

Stress/Strain & Pore Pressure/Strain Diagram



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Sample/s supplied by the client — Note: Graph not to scale — **Page 3 of 6**

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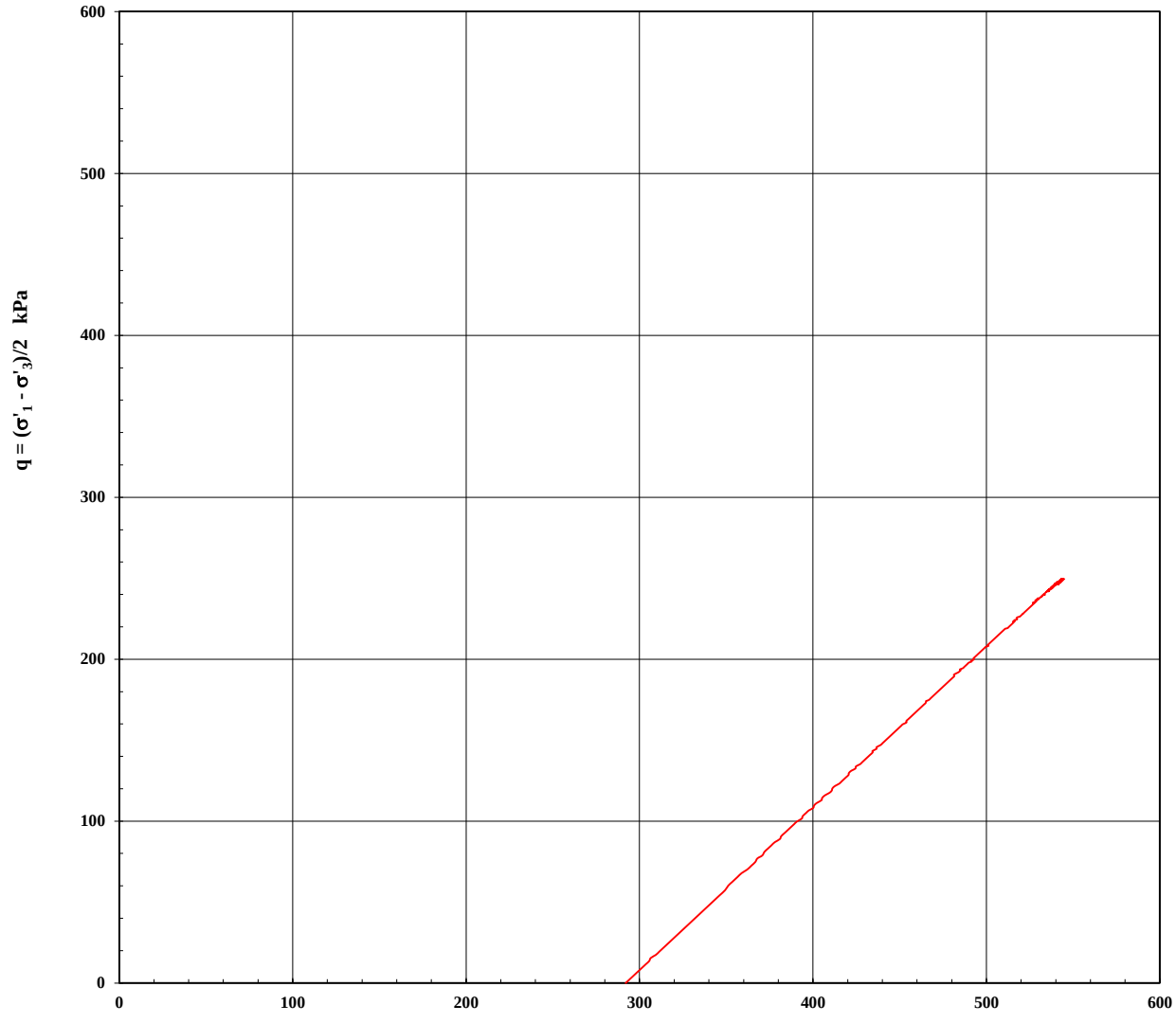
TRIAXIAL TEST REPORT

Test Method: ASTM D7181-11

Client: Structerre Consulting Engineers

Report No.: 18010243 - CD

p' - q Diagram



Sample Type: Single Individual Specimen remoulded to a target density of 95% of Standard Maximum Dry Density at Optimum Moisture Content (-19.0mm material tested)

Sample/s supplied by the client

Note: Graph not to scale

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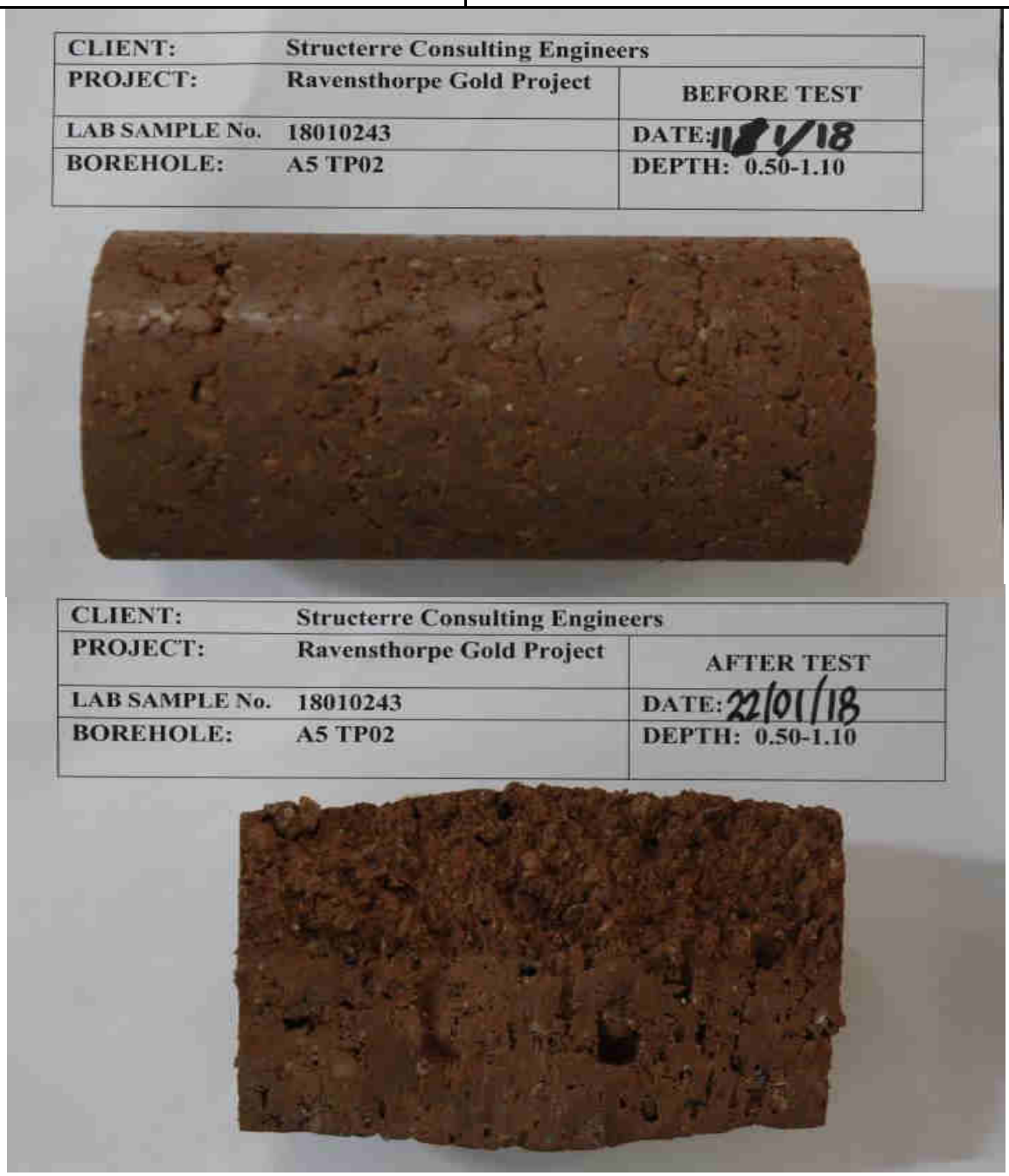
TRIAXIAL TEST REPORT

Test Method: ASTM D7181-11

Client: Structerre Consulting Engineers

Report No.: 18010243 - CD



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Sample/s supplied by the client

Note: Graph not to scale

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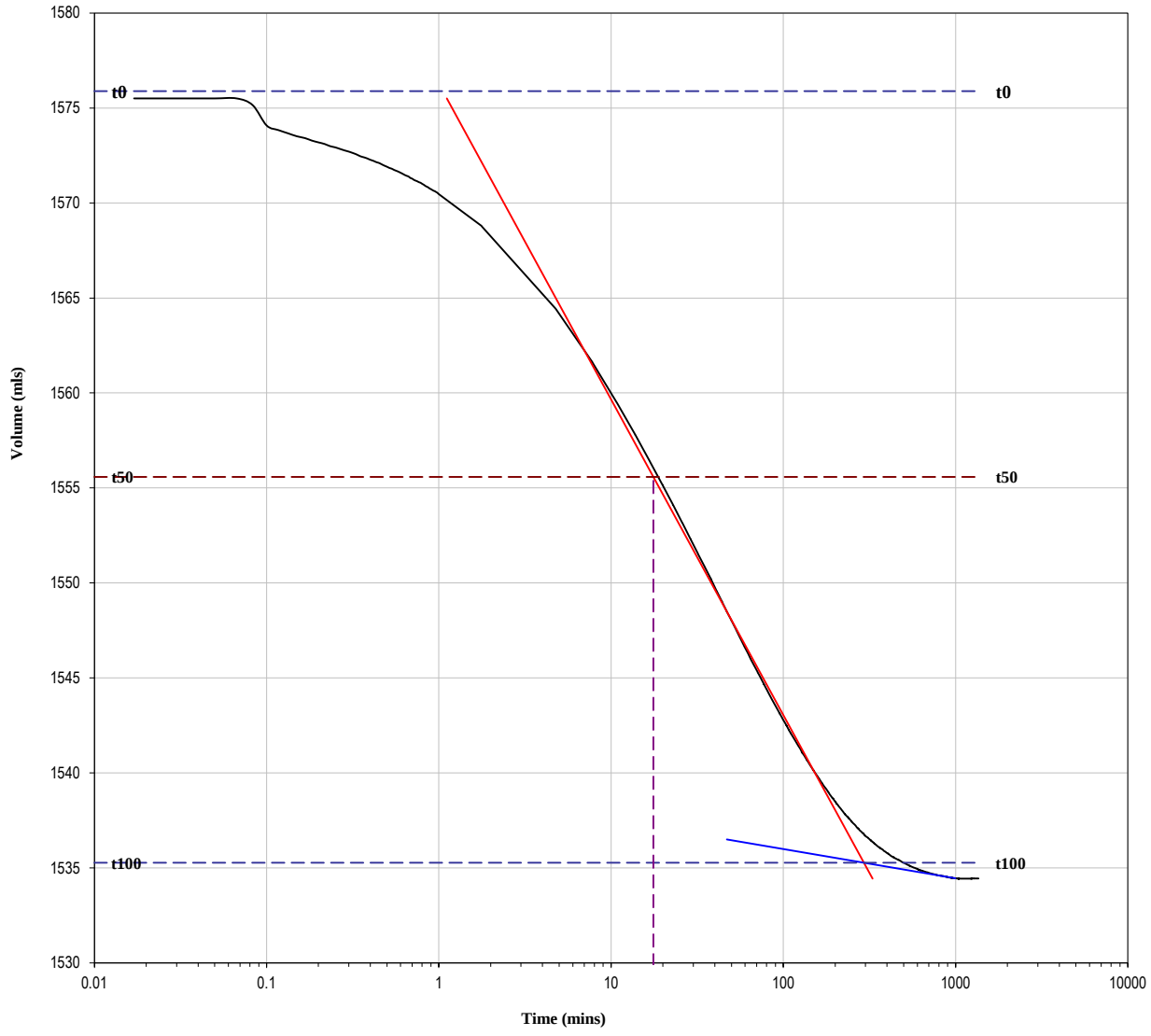
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

Client: Structerre Consulting Engineers

Report No.: 18010243 - CD

Volume v's Time (Log Scale)



t_{50} = 17.6 mins

Sample Type:	Single Individual Specimen remoulded to a target density of 95% of Standard Maximum Dry Density at Optimum Moisture Content (-19.0mm material tested)	
Sample/s supplied by the client	Note: Graph not to scale	**Page 6 of 6**

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TRIAXIAL TEST REPORT

Test Method: ASTM D7181-11

Client:	Structerre Consulting Engineers	**Report No.:**	18010244 - CD
		Workorder No.	0003674
Address	PO Box 792 BALCATTA WA 6914	**Test Date:**	11/01/2018
		Report Date:	22/01/2018
Project:	Ravensthorpe Gold Project		
Client Id.:	A27 TP13	**Depth (m):**	0.70-2.80
Description:	CLAYEY SILT- pale brown		

SAMPLE & TEST DETAILS

Sample 1

Initial Height:	199.9	mm
Initial Diameter:	100.2	mm
L/D Ratio:	2.0 : 1	
Initial Moisture Content:	16.2	%
Final Moisture Content:	22.0	%
Wet Density:	1.88	t/m^3
Dry Density:	1.62	t/m^3
Rate of Strain:	0.002	%/min
B Response:	98	%

Failure Criteria: Maximum Deviator Stress

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		
296 kPa	801 kPa	505 kPa	505 kPa	507 kPa	779 kPa	294 kPa	2.646	484 kPa	7.67 %

Sample Type: Single Individual Specimen remoulded to a target density of 95% of Standard Maximum Dry Density at Optimum Moisture Content (-19.0mm material tested)

Sample/s supplied by the client — Note: Graph not to scale — **Page 1 of 6**

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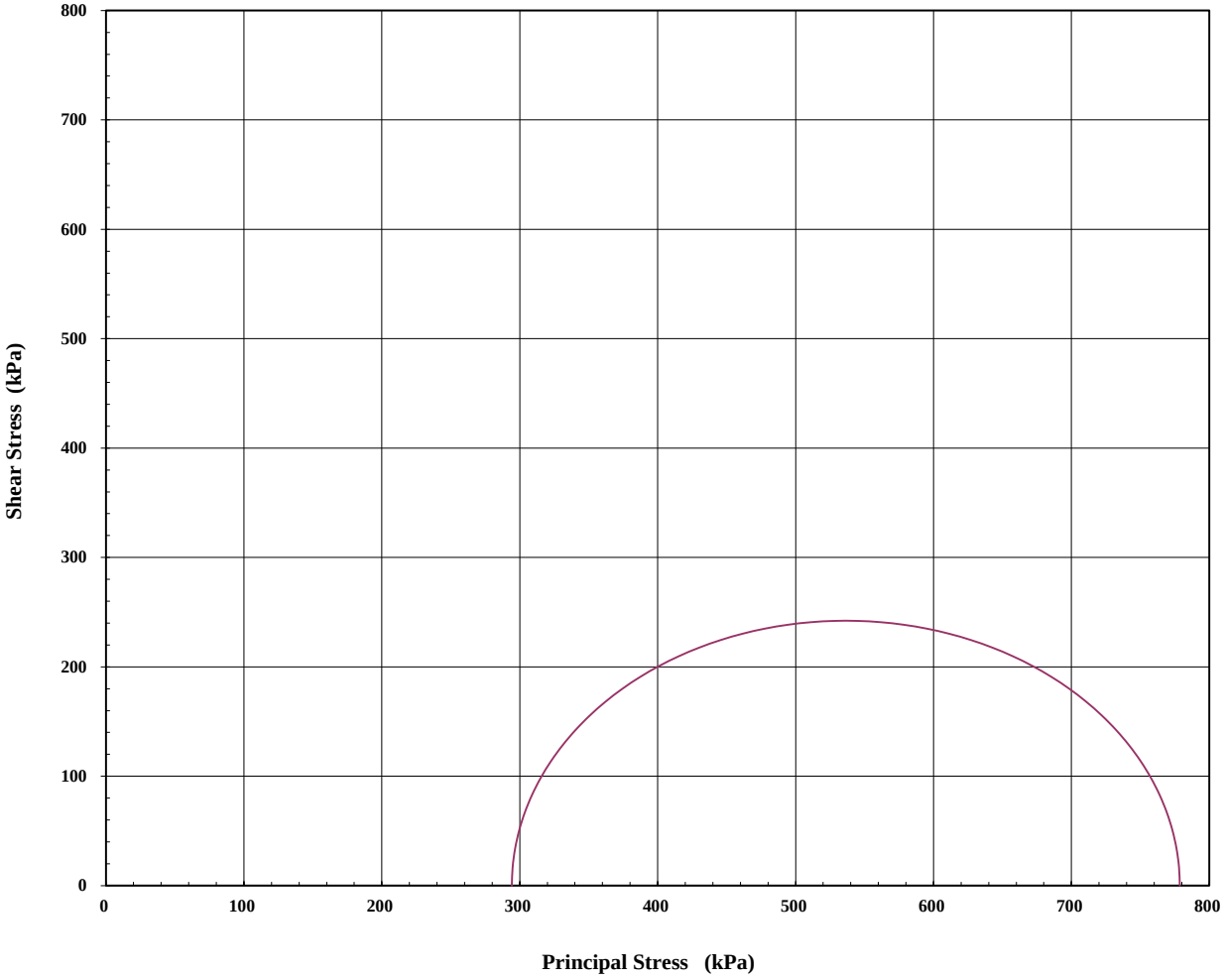
TRIAXIAL TEST REPORT

Test Method: ASTM D7181-11

Client: Structerre Consulting Engineers

Report No.: 18010244 - CD

Mohr Circle Diagram



Interpretation between stages :

Cohesion C' (kPa) :

Angle of Shear Resistance Φ' (Degrees) :

Sample Type: Single Individual Specimen remoulded to a target density of 95% of Standard Maximum Dry Density at Optimum Moisture Content (-19.0mm material tested)

Sample/s supplied by the client — Note: Graph not to scale

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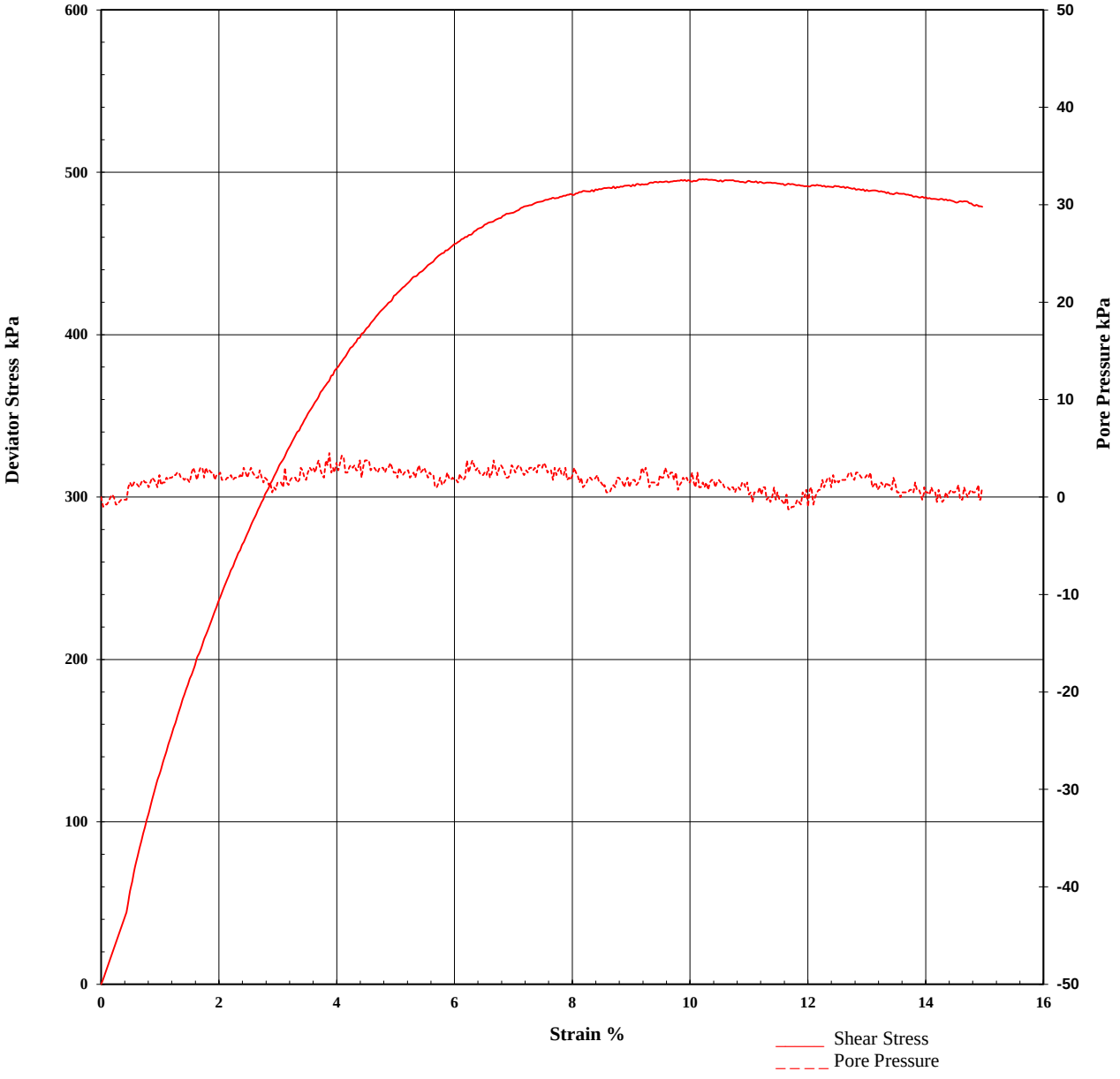
TRIAXIAL TEST REPORT

Test Method: ASTM D7181-11

Client: Structerre Consulting Engineers

Report No.: 18010244 - CD

Stress/Strain & Pore Pressure/Strain Diagram



Sample Type: Single Individual Specimen remoulded to a target density of 95% of Standard Maximum Dry Density at Optimum Moisture Content (-19.0mm material tested)

Sample/s supplied by the client — Note: Graph not to scale — **Page 3 of 6**

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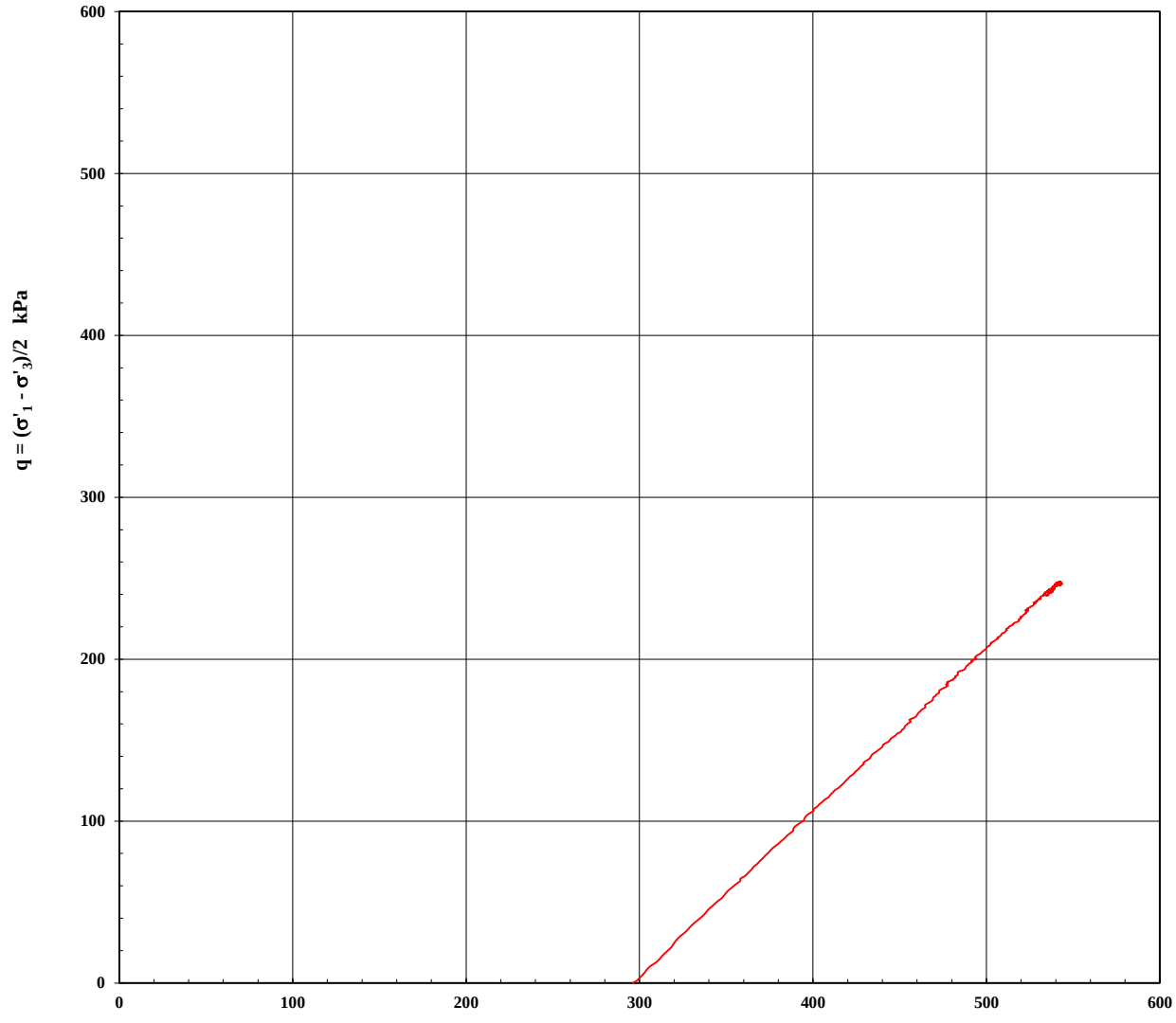
TRIAXIAL TEST REPORT

Test Method: ASTM D7181-11

Client: Structerre Consulting Engineers

Report No.: 18010244 - CD

p' - q Diagram



Sample Type:	Single Individual Specimen remoulded to a target density of 95% of Standard Maximum Dry Density at Optimum Moisture Content (-19.0mm material tested)	
Sample/s supplied by the client	Note: Graph not to scale	**Page 4 of 6**

REP16401

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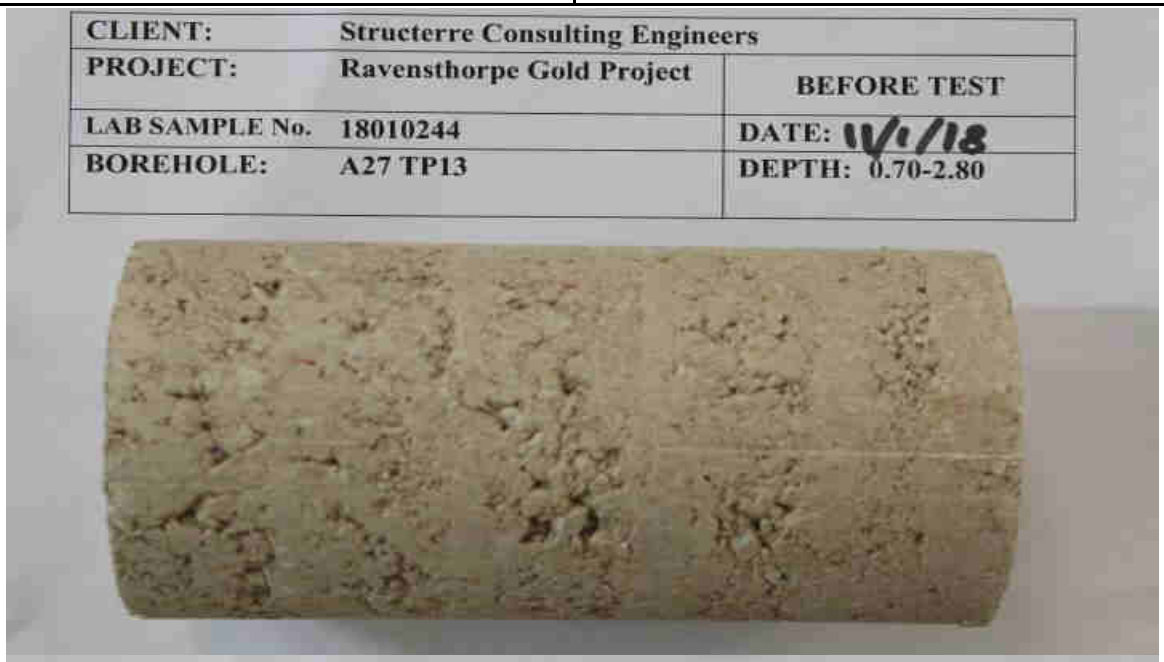
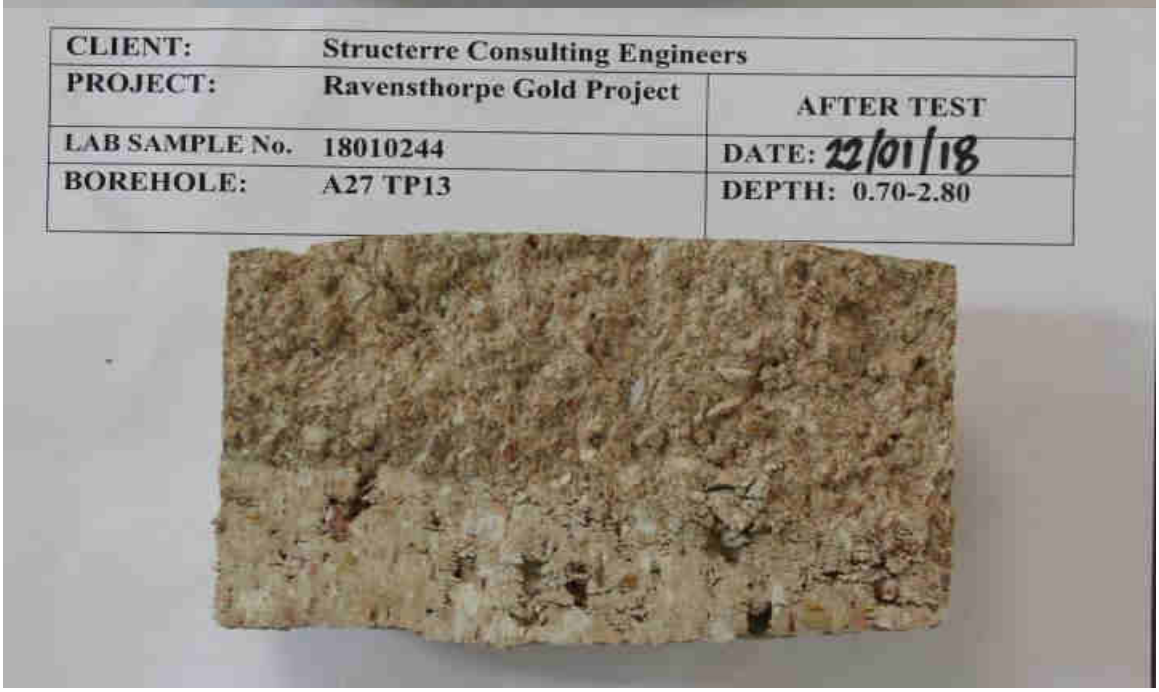
TRIAXIAL TEST REPORT

Test Method: ASTM D7181-11

Client: Structerre Consulting Engineers

Report No.: 18010244 - CD





Sample Type: Single Individual Specimen remoulded to a target density of 95% of Standard Maximum Dry Density at Optimum Moisture Content (-19.0mm material tested)

Sample/s supplied by the client — Note: Graph not to scale

REP16401

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Tested at Trilab Brisbane Laboratory.

Authorised Signatory

C. Channon

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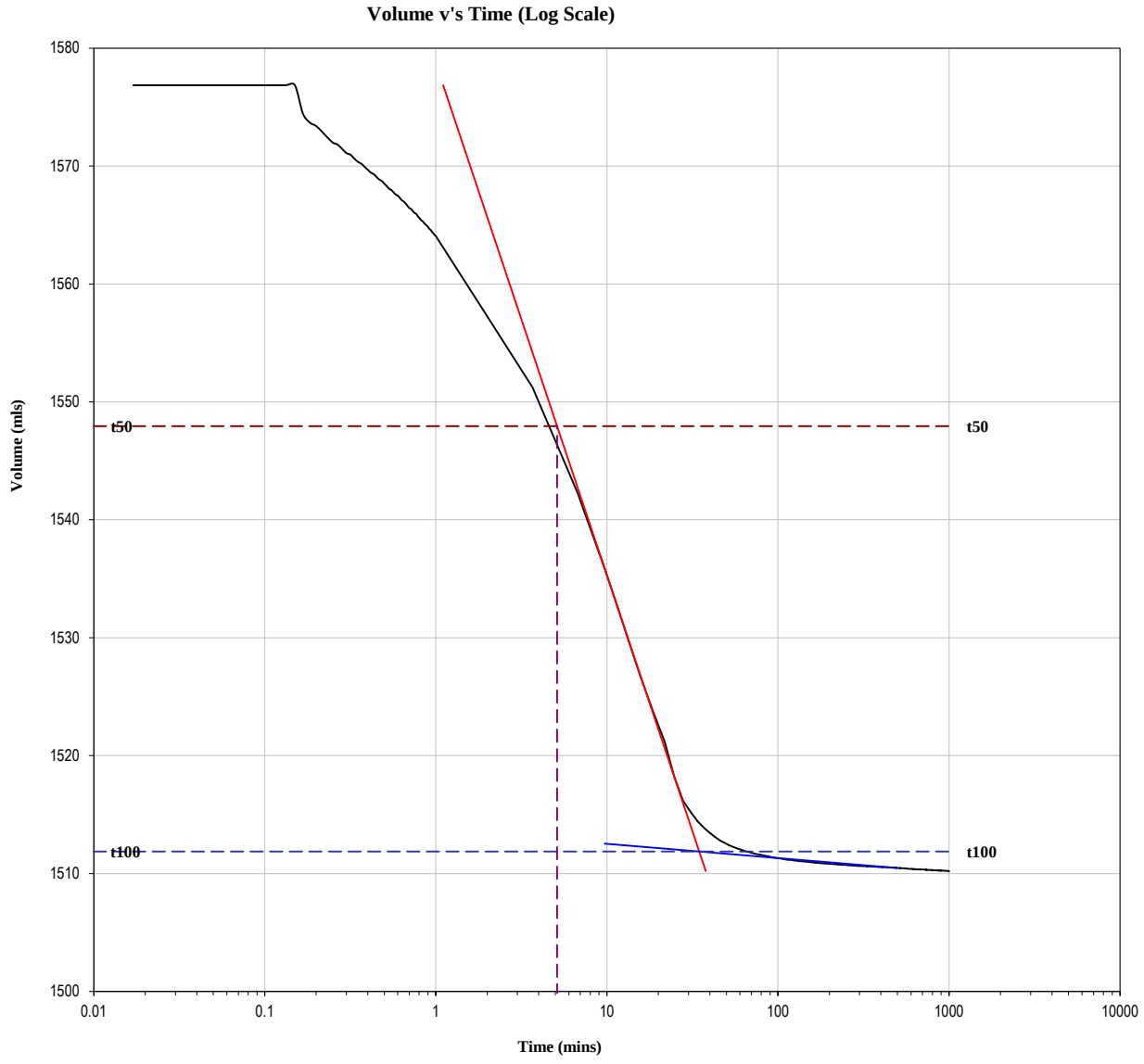
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

Client: Structerre Consulting Engineers

Report No.: 18010244 - CD



t_{50} = 5.1 mins

Sample Type: Single Individual Specimen remoulded to a target density of 95% of Standard Maximum Dry Density at Optimum Moisture Content (-19.0mm material tested)

Sample/s supplied by the client — Note: Graph not to scale — **Page 6 of 6**

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TRIAXIAL TEST REPORT

Test Method: ASTM D4767-04

Client:	Structerre Consulting Engineers	**Report No.:**	18010245 - CU
		Workorder No.	0003674
Address	PO Box 792 BALCATTA WA 6914	**Test Date:**	11/01/2018
		Report Date:	22/01/2018
Project:	Ravensthorpe Gold Project		
Client Id.:	B1	**Depth (m):**	Not Supplied
Description:	SANDY CLAYEY SILT- pale brown		

SAMPLE & TEST DETAILS

Sample 1

Initial Height:	199.8	mm
Initial Diameter:	100.2	mm
L/D Ratio:	2.0 : 1	
Initial Moisture Content:	15.6	%
Final Moisture Content:	20.8	%
Wet Density:	1.86	t/m^3
Dry Density:	1.61	t/m^3
Rate of Strain:	0.002	%/min
B Response:	98	%

Failure Criteria: Maximum Deviator Stress

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		
304 kPa	800 kPa	496 kPa	496 kPa	499 kPa	880 kPa	302 kPa	2.916	578 kPa	10.46 %

Sample Type: Single Individual Specimen remoulded to a target density of 98% of Standard Maximum Dry Density at Optimum Moisture Content (-19.0mm material tested)

Sample/s supplied by the client — Note: Graph not to scale

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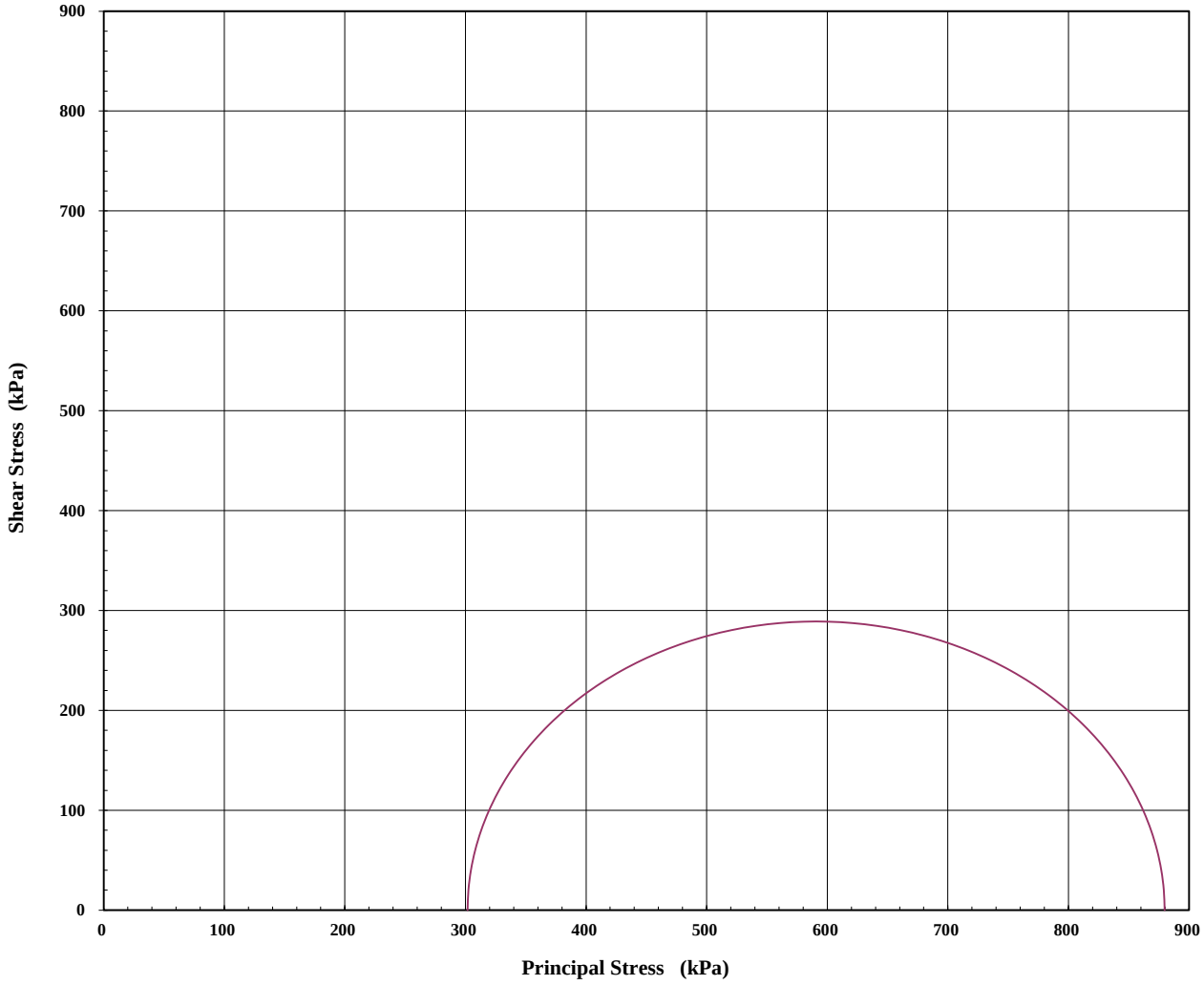
TRIAXIAL TEST REPORT

Test Method: ASTM D4767-04

Client: Structerre Consulting Engineers

Report No.: 18010245 - CU

Mohr Circle Diagram



Interpretation between stages :

Cohesion C' (kPa) :

Angle of Shear Resistance Φ' (Degrees) :

Sample Type: Single Individual Specimen remoulded to a target density of 98% of Standard Maximum Dry Density at Optimum Moisture Content (-19.0mm material tested)

Sample/s supplied by the client

Note: Graph not to scale

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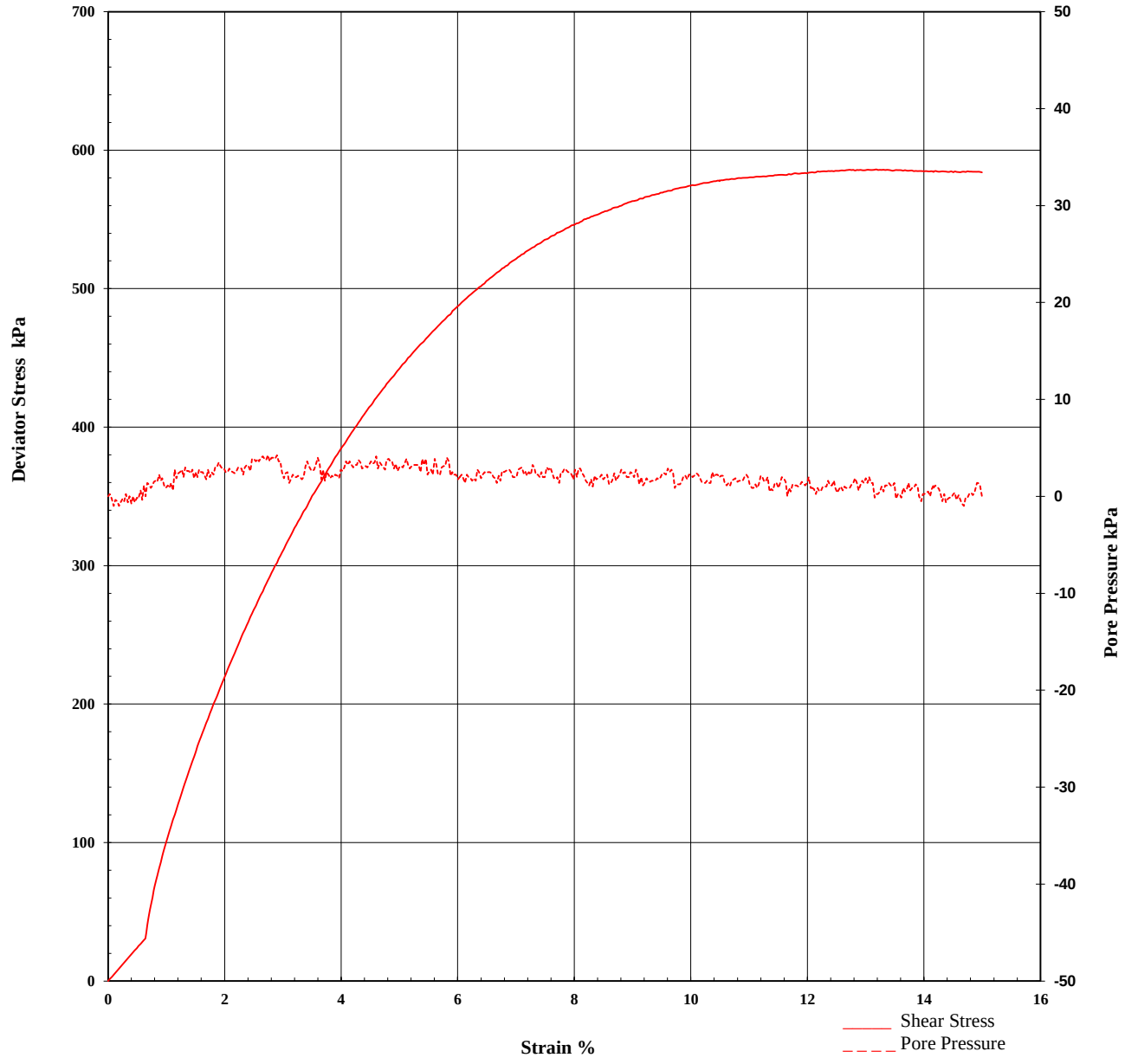
TRIAXIAL TEST REPORT

Test Method: ASTM D4767-04

Client: Structerre Consulting Engineers

Report No.: 18010245 - CU

Stress/Strain & Pore Pressure/Strain Diagram



Sample Type: Single Individual Specimen remoulded to a target density of 98% of Standard Maximum Dry Density at Optimum Moisture Content (-19.0mm material tested)

Sample/s supplied by the client — Note: Graph not to scale

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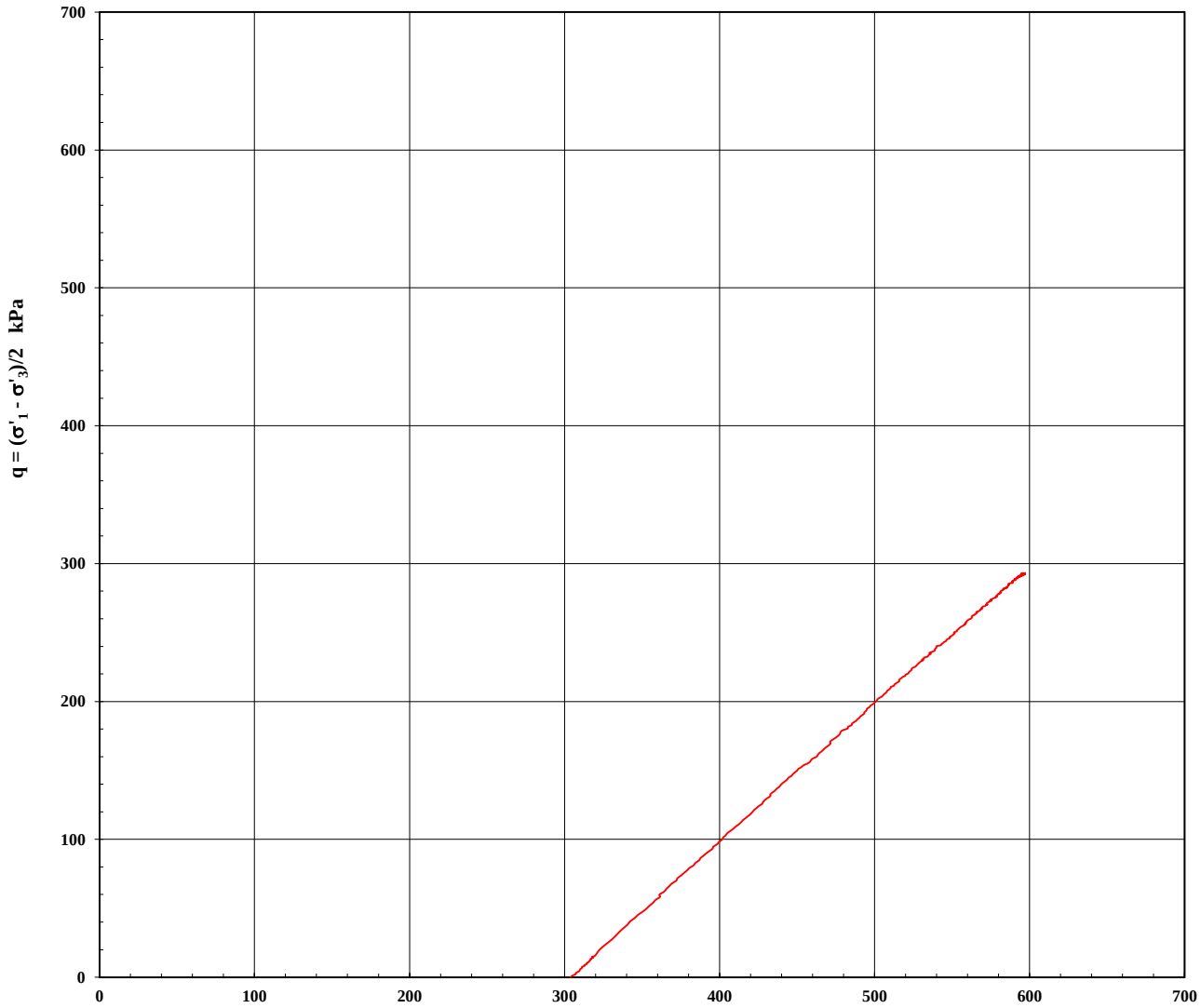
TRIAXIAL TEST REPORT

Test Method: ASTM D4767-04

Client: Structerre Consulting Engineers

Report No.: 18010245 - CU

p' - q Diagram



Sample Type: Single Individual Specimen remoulded to a target density of 98% of Standard Maximum Dry Density at Optimum Moisture Content (-19.0mm material tested)

Sample/s supplied by the client

Note: Graph not to scale

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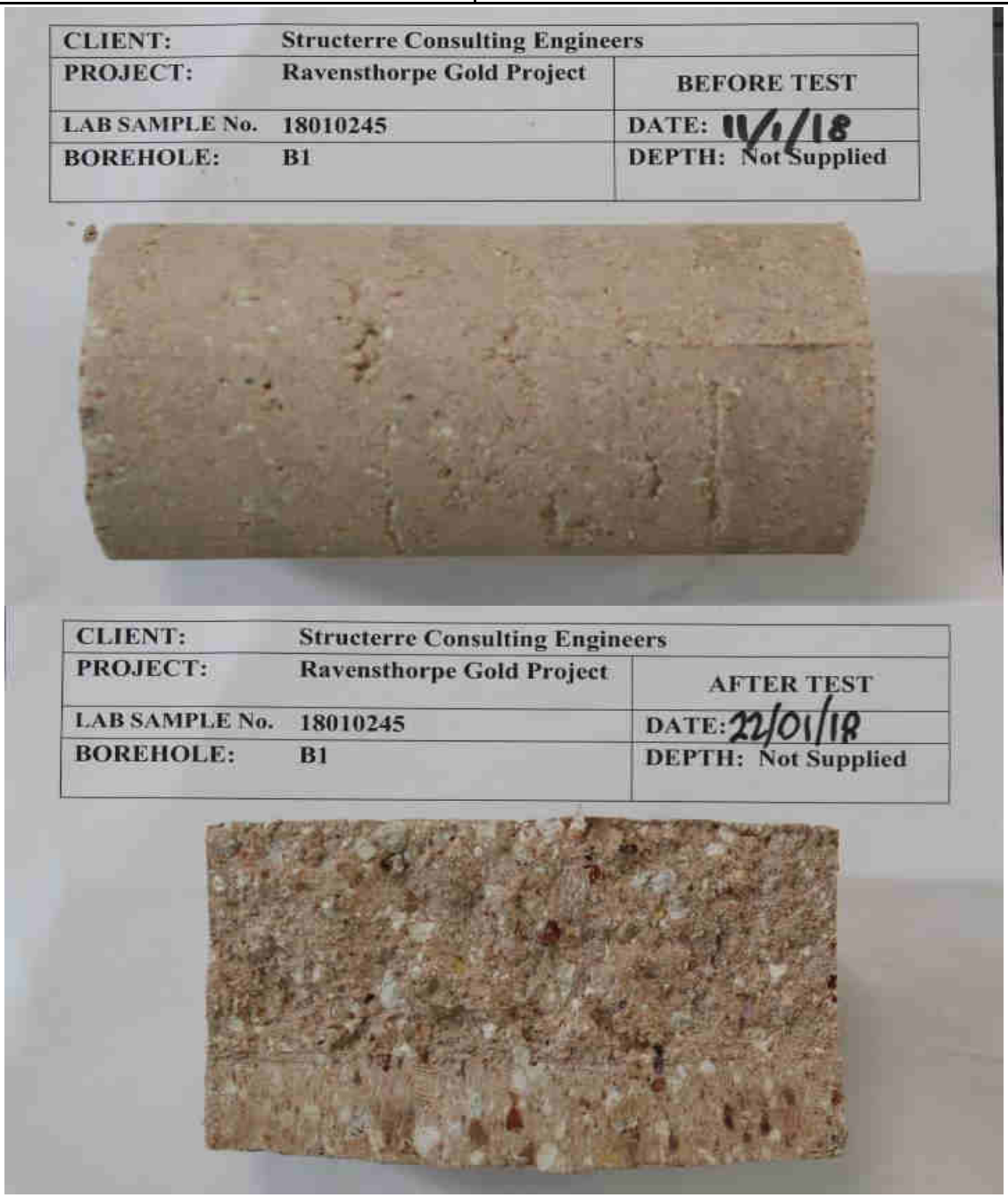
TRIAXIAL TEST REPORT

Test Method: ASTM D4767-04

Client: Structerre Consulting Engineers

Report No.: 18010245 - CU



Sample Type: Single Individual Specimen remoulded to a target density of 98% of Standard Maximum Dry Density at Optimum Moisture Content (-19.0mm material tested)

Sample/s supplied by the client

Note: Graph not to scale

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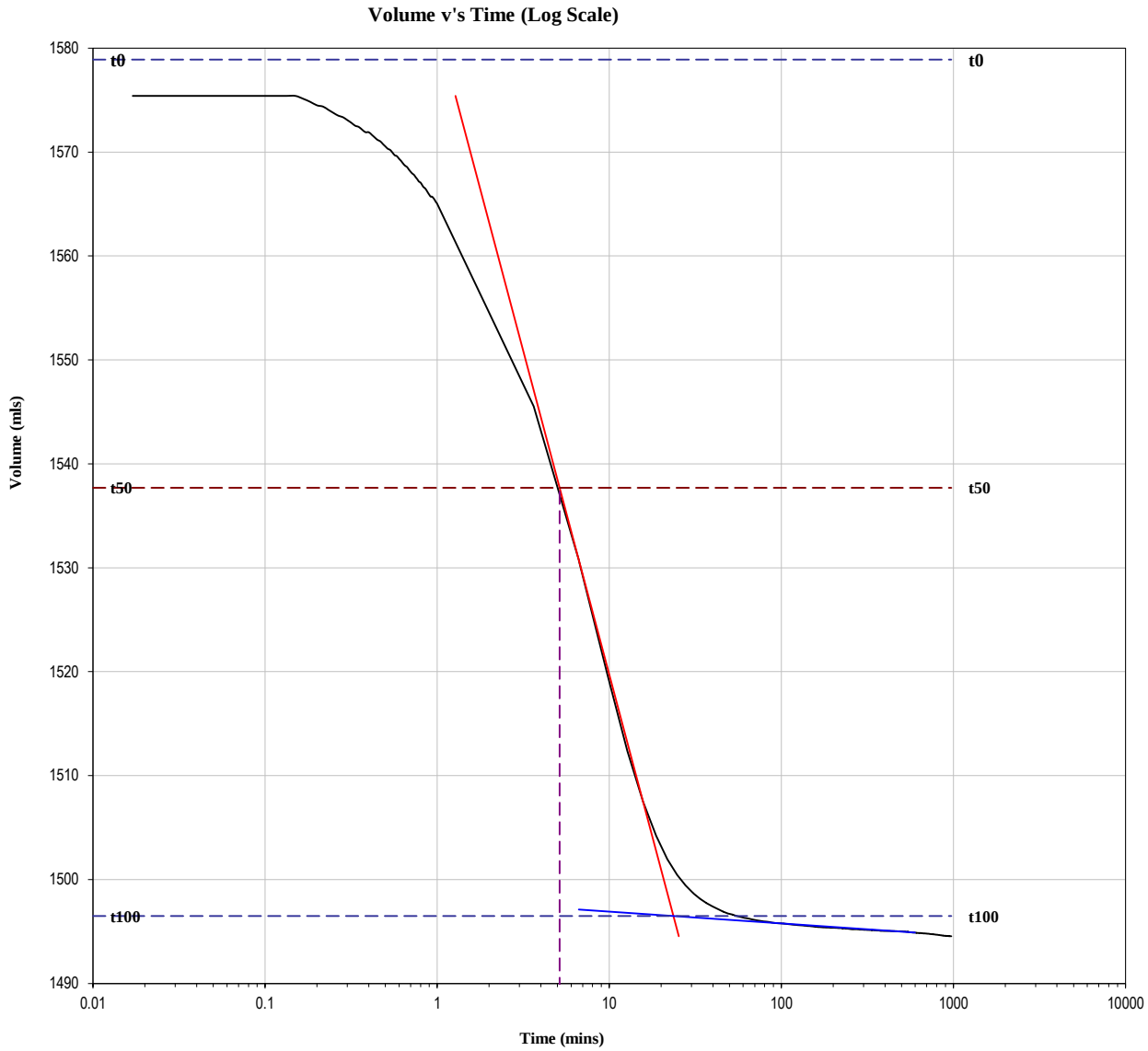
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

Client: Structerre Consulting Engineers

Report No.: 18010245 - CU



t_{50} = 5.1 mins

Sample Type: Single Individual Specimen remoulded to a target density of 98% of Standard Maximum Dry Density at Optimum Moisture Content (-19.0mm material tested)

Sample/s supplied by the client

Note: Graph not to scale

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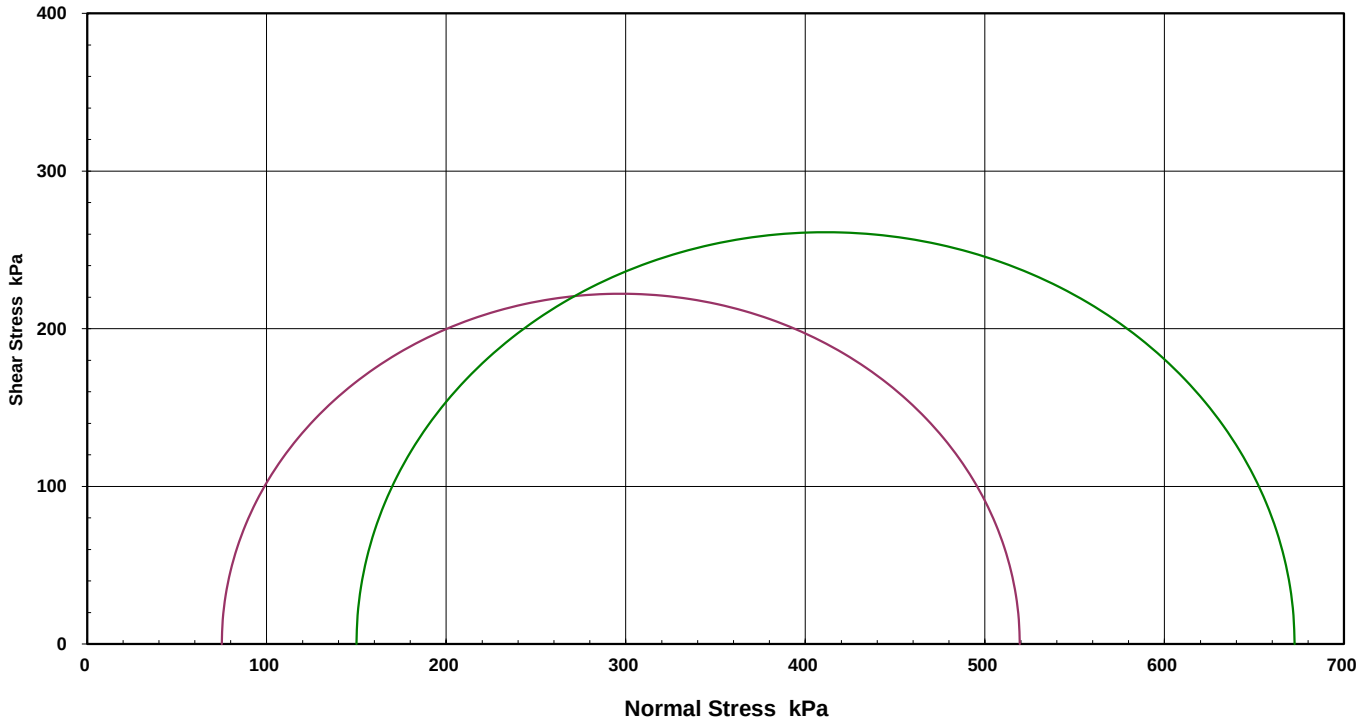
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.1

Client	Structerre Consulting Engineers	**Report No.**	18010243- UU
		Workorder No.	0003674
Address	PO Box 792 BALCATTA WA 6914	**Test Date**	10/01/2018
		Report Date	16/01/2018
Project	Ravensthorpe Gold Project		
Client ID	A5 TP02	**Depth (m)**	0.50-1.10
Description	GRAVELLY SILTY CLAY- red brown	**Sample Type**	Single Individual Specimen remoulded to a target density of 95% of Standard Maximum Dry Density at Optimum Moisture Content (-19.0mm material tested)

Mohr Circle Diagram



Interpretation between stages	**1 to 2**
Cohesion C (kPa)	**128.2**
Angle of Shear Resistance Φ (^{0})	**20.0**

MOISTURE CONTENTS **Initial** 9.4 % **Final** 9.4 %

Failure Criteria Maimum Deviator Stress

SAMPLE & TEST DETAILS

Sample Details			Confining Pressure
Initial Height	200.2	mm	
Initial Diameter	100.4	mm	
Wet Density	2.13	t/m^3	75 kPa
Dry Density	1.94	t/m^3	150 kPa
Rate of Strain	0.500	% / min	

FAILURE DETAILS

Principal Stresses σ_1	Principal Stresses σ_3	Deviator Stress	Strain
519 kPa	75 kPa	444 kPa	11.51 %
672 kPa	150 kPa	522 kPa	19.28 %

Notes/Remarks: Test completed on Stage 2 as 20% strain has been reached as per AS1289 6.4.1.

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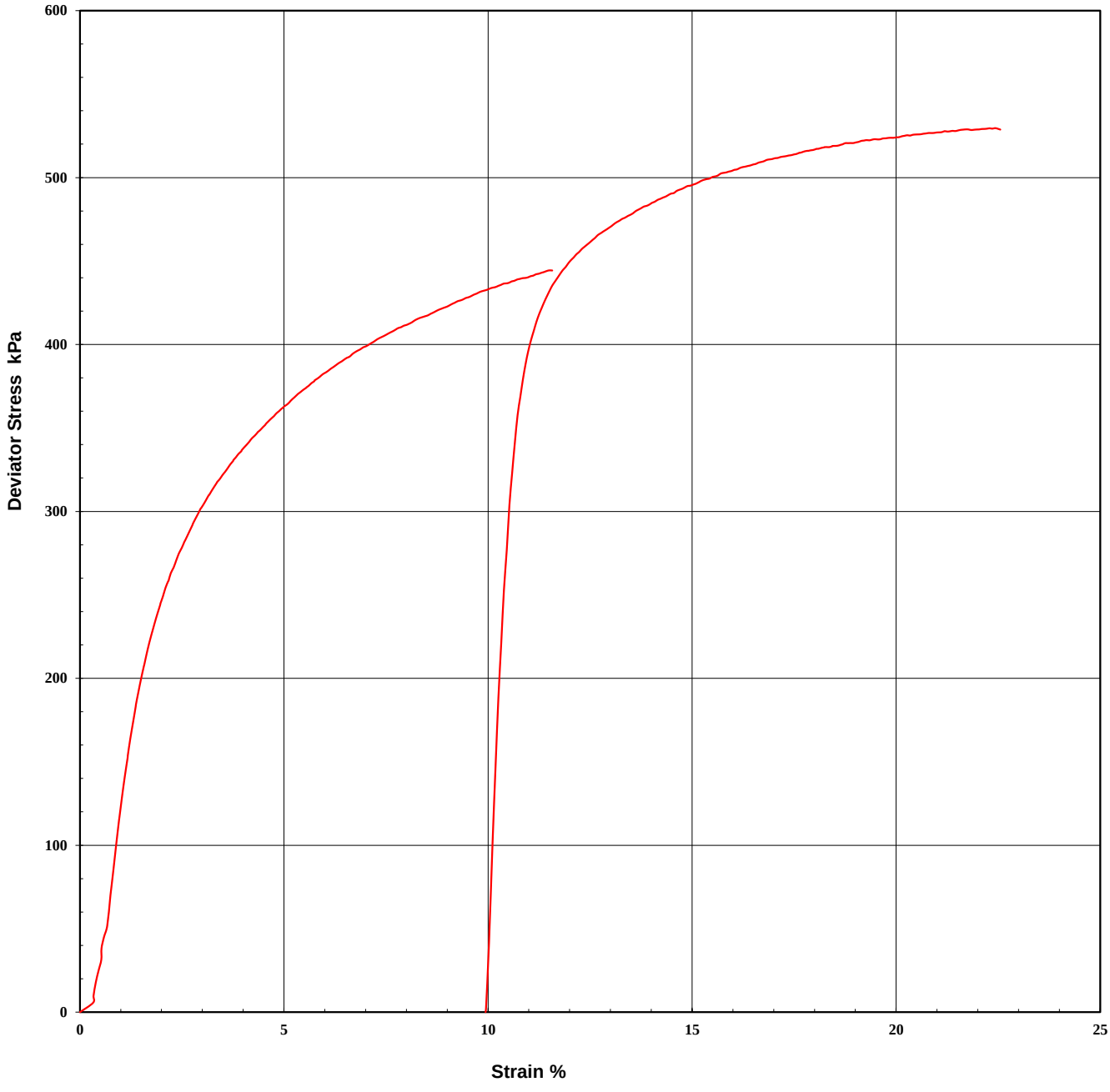
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.1

Client Structerre Consulting Engineers

Report No. 18010243- UU

Stress/Strain Diagram



Notes/Remarks: Test completed on Stage 2 as 20% strain has been reached as per AS1289 6.4.1.

Graph not to scale

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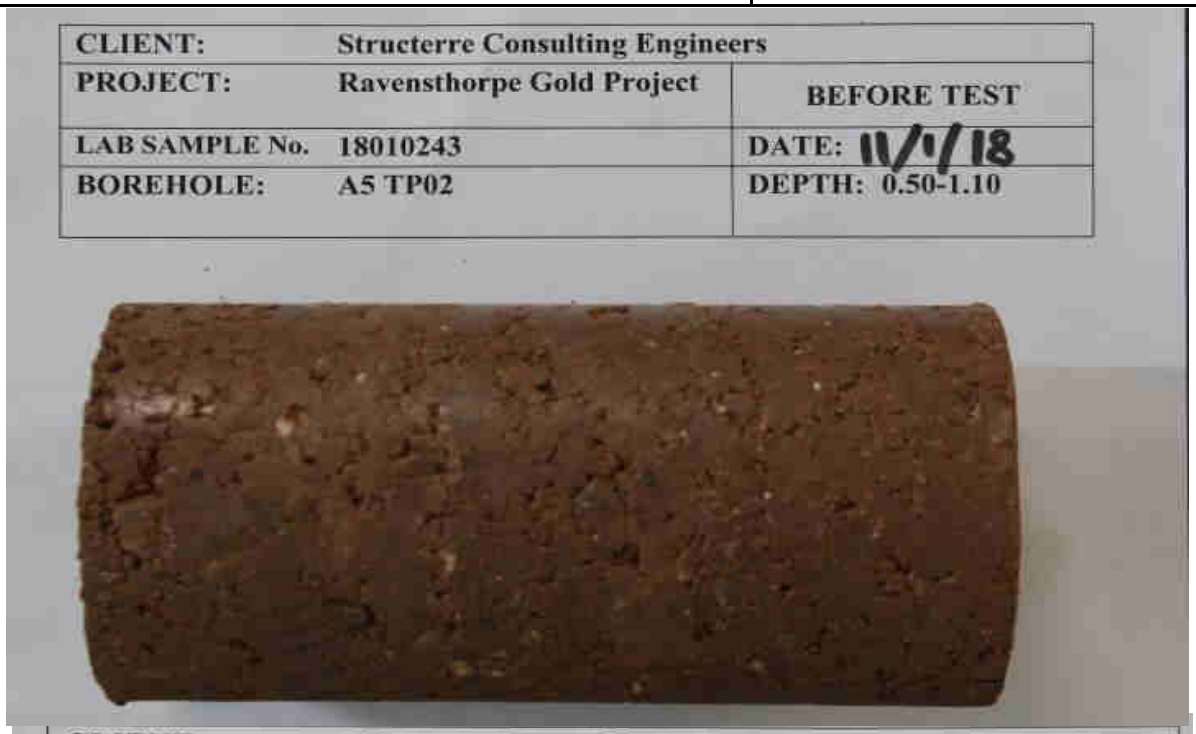
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.1

Client	Structerre Consulting Engineers	**Report No.**	18010243- UU



Notes/Remarks:
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Photo not to scale

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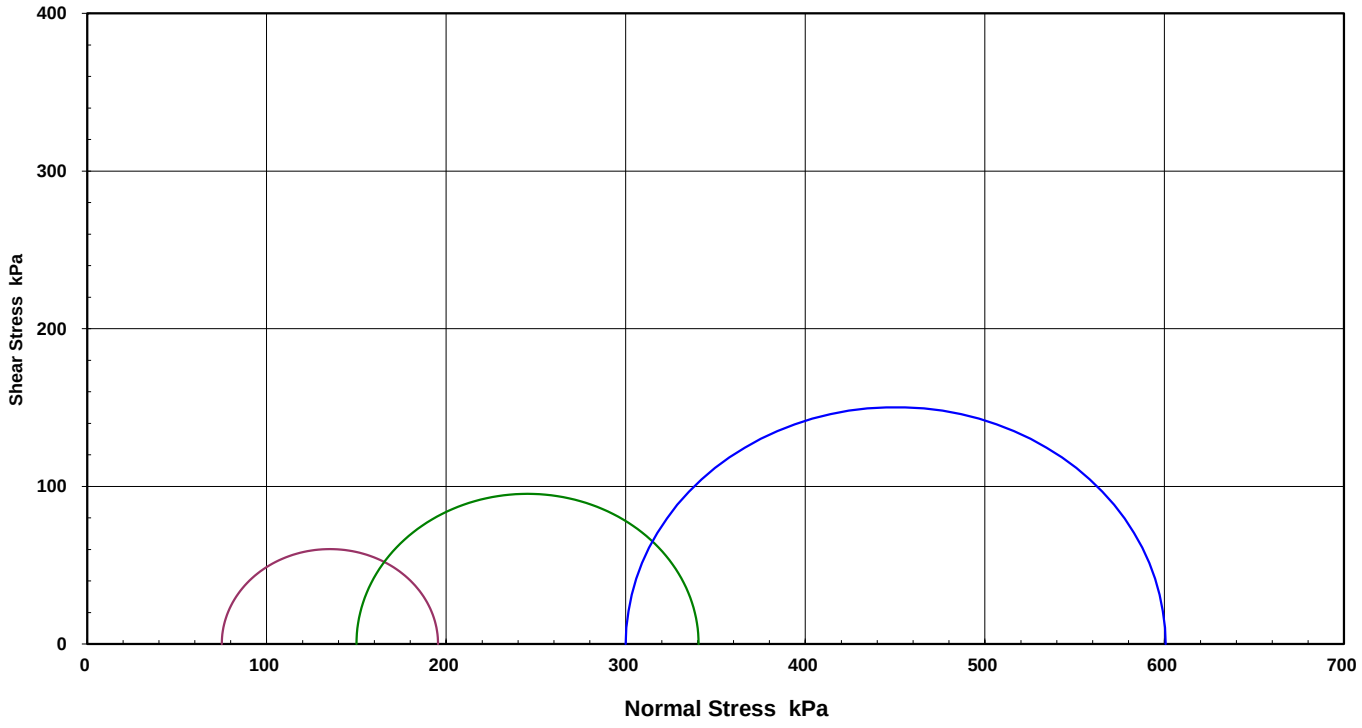
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.1

Client	Structerre Consulting Engineers	**Report No.**	18010244- UU
		Workorder No.	0003674
Address	PO Box 792 BALCATTA WA 6914	**Test Date**	12/01/2018
		Report Date	16/01/2018
Project	Ravensthorpe Gold Project		
Client ID	A27 TP13	**Depth (m)**	0.70-2.80
Description	CLAYEY SILT- yellow/brown	**Sample Type**	Single Individual Specimen remoulded to a target density of 95% of Standard Maximum Dry Density at Optimum Moisture Content (-19.0mm material tested)

Mohr Circle Diagram



Interpretation between stages	1 to 2	2 to 3	1 to 3
Cohesion C (kPa)	18.1	30.6	24.4
Angle of Shear Resistance Φ (^{0})	18.6	15.6	16.5

MOISTURE CONTENTS **Initial** 16.2 % **Final** 16.2 %

Failure Criteria Maximum Deviator Stress

SAMPLE & TEST DETAILS

Sample Details		
Initial Height	200.0	mm
Initial Diameter	100.1	mm
Wet Density	1.88	t/m^3
Dry Density	1.62	t/m^3
Rate of Strain	0.250	% / min

FAILURE DETAILS

Confining Pressure	Principal Stresses σ_1	Principal Stresses σ_3	Deviator Stress	Strain
75 kPa	195 kPa	75 kPa	120 kPa	5.41 %
150 kPa	341 kPa	150 kPa	191 kPa	9.78 %
300 kPa	601 kPa	300 kPa	301 kPa	15.09 %

Notes/Remarks:
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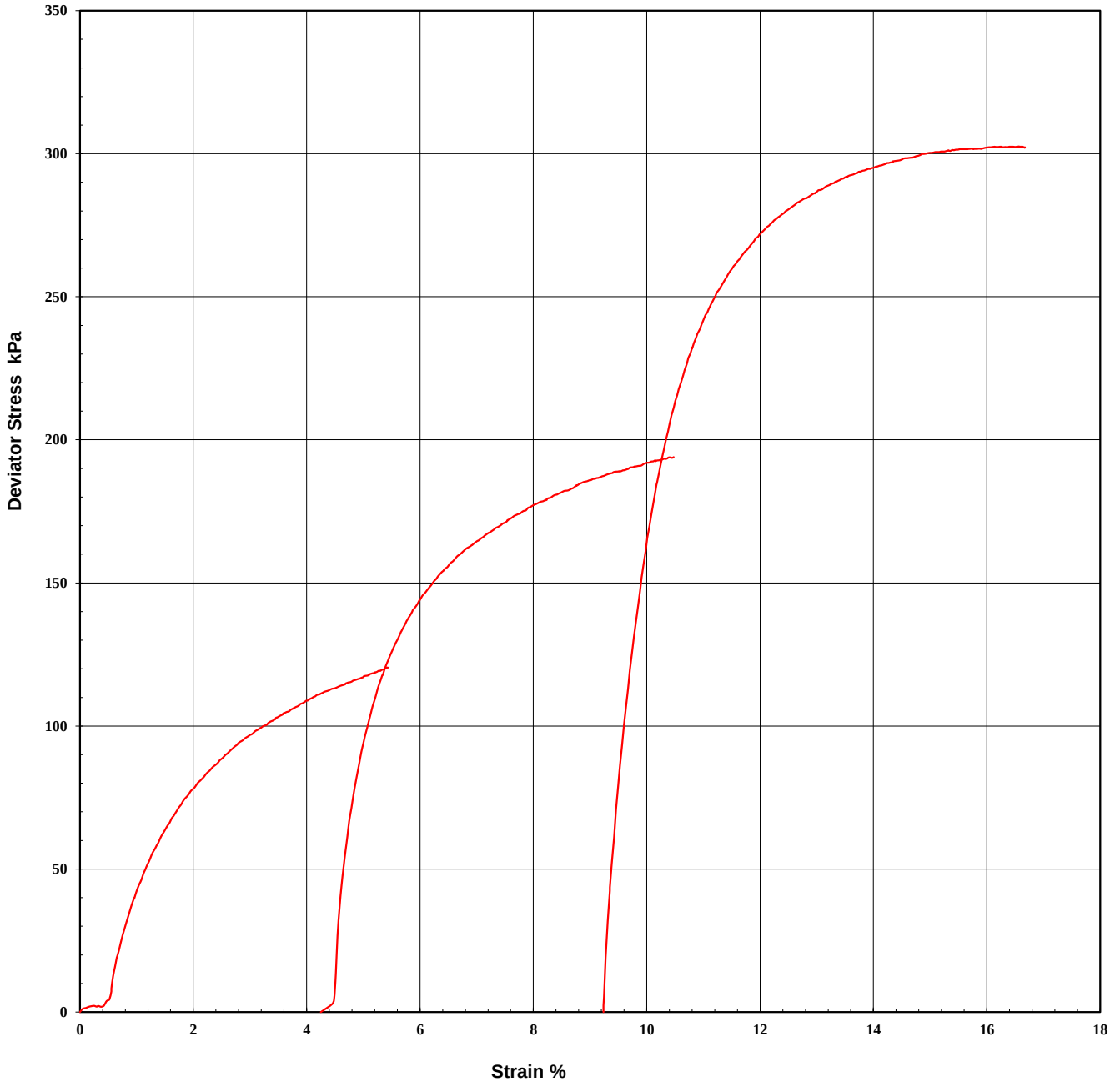
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.1

Client	Structerre Consulting Engineers	**Report No.**	18010244- UU

Stress/Strain Diagram



Notes/Remarks:
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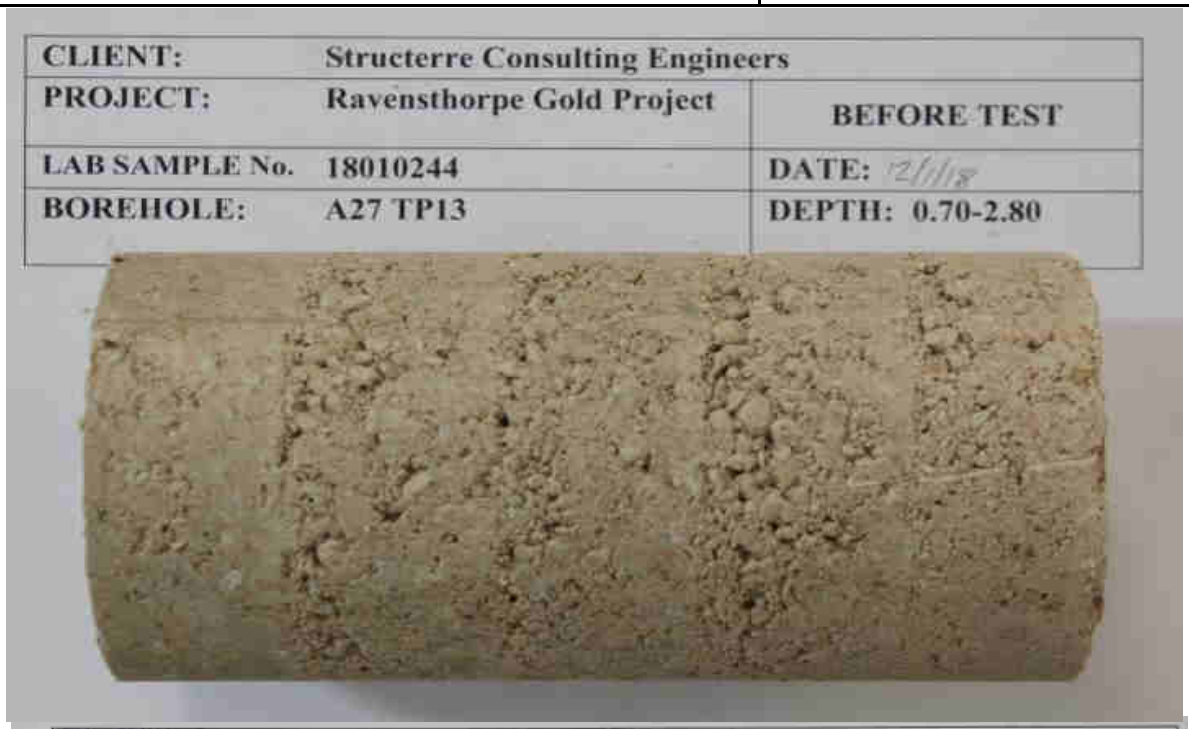
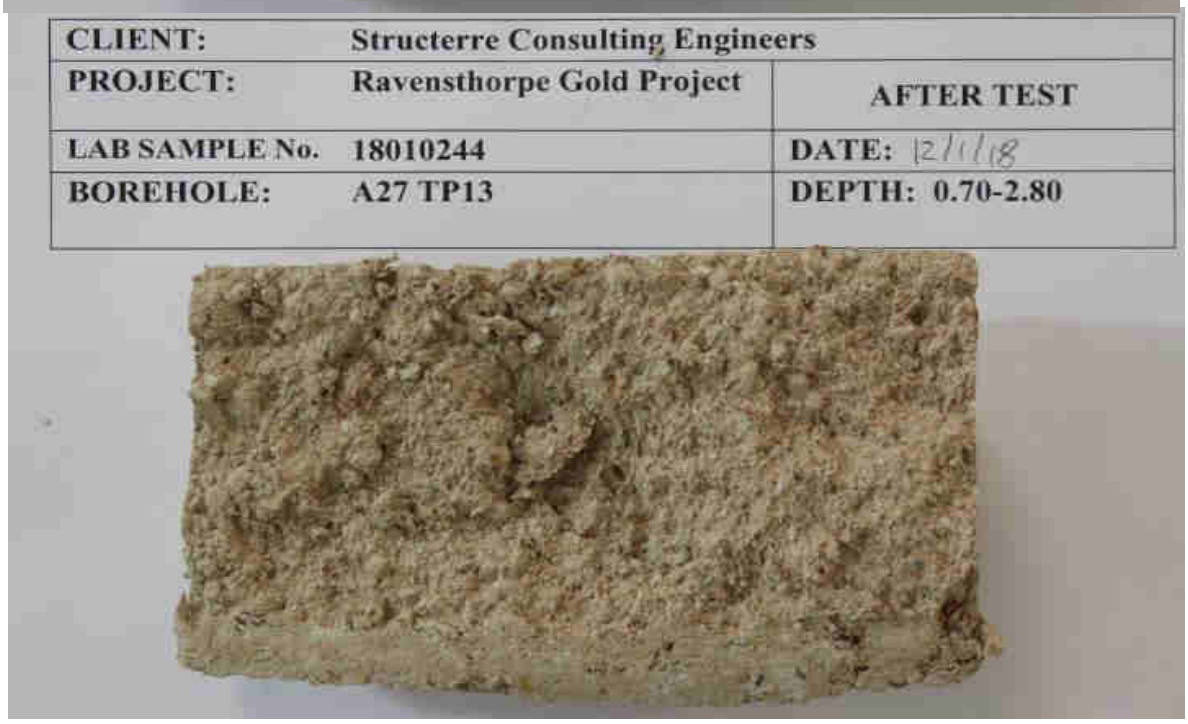
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.1

Client	Structerre Consulting Engineers	**Report No.**	18010244- UU





Notes/Remarks:
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Photo not to scale

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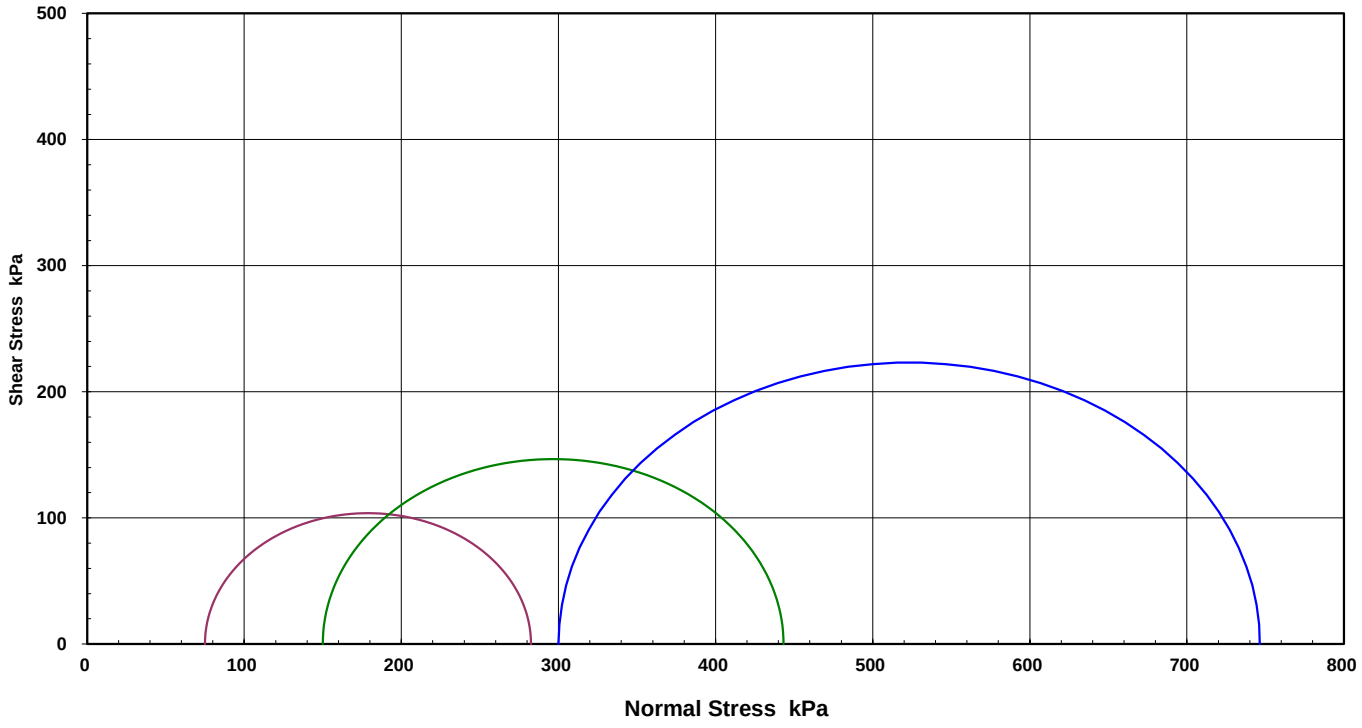
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.1

Client	Structerre Consulting Engineers	**Report No.**	18010245- UU
		Workorder No.	0003674
Address	PO Box 792 BALCATTA WA 6914	**Test Date**	13/01/2018
		Report Date	16/01/2018
Project	Ravensthorpe Gold Project		
Client ID	B1	**Depth (m)**	Not Supplied
Description	SANDY CLAYEY SILT- pale brown	**Sample Type**	Single Individual Specimen remoulded to a target density of 95% of Standard Maximum Dry Density at Optimum Moisture Content (-19.0mm material tested)

Mohr Circle Diagram



Interpretation between stages	1 to 2	2 to 3	1 to 3
Cohesion C (kPa)	41.6	49.3	45.6
Angle of Shear Resistance Φ (^{0})	21.3	19.8	20.2

MOISTURE CONTENTS **Initial** 15.6 % **Final** 15.6 %

Failure Criteria Maximum Deviator Stress

SAMPLE & TEST DETAILS

Sample Details		
Initial Height	199.6	mm
Initial Diameter	100.1	mm
Wet Density	1.86	t/m^3
Dry Density	1.61	t/m^3
Rate of Strain	0.501	% / min

FAILURE DETAILS

Confining Pressure	Principal Stresses σ_1	Principal Stresses σ_3	Deviator Stress	Strain
75 kPa	283 kPa	75 kPa	208 kPa	5.82 %
150 kPa	443 kPa	150 kPa	293 kPa	10.17 %
300 kPa	746 kPa	300 kPa	446 kPa	15.22 %

Notes/Remarks:
Graph not to scale

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Tested at Trilab Brisbane Laboratory.

Authorised Signatory
C. Channon

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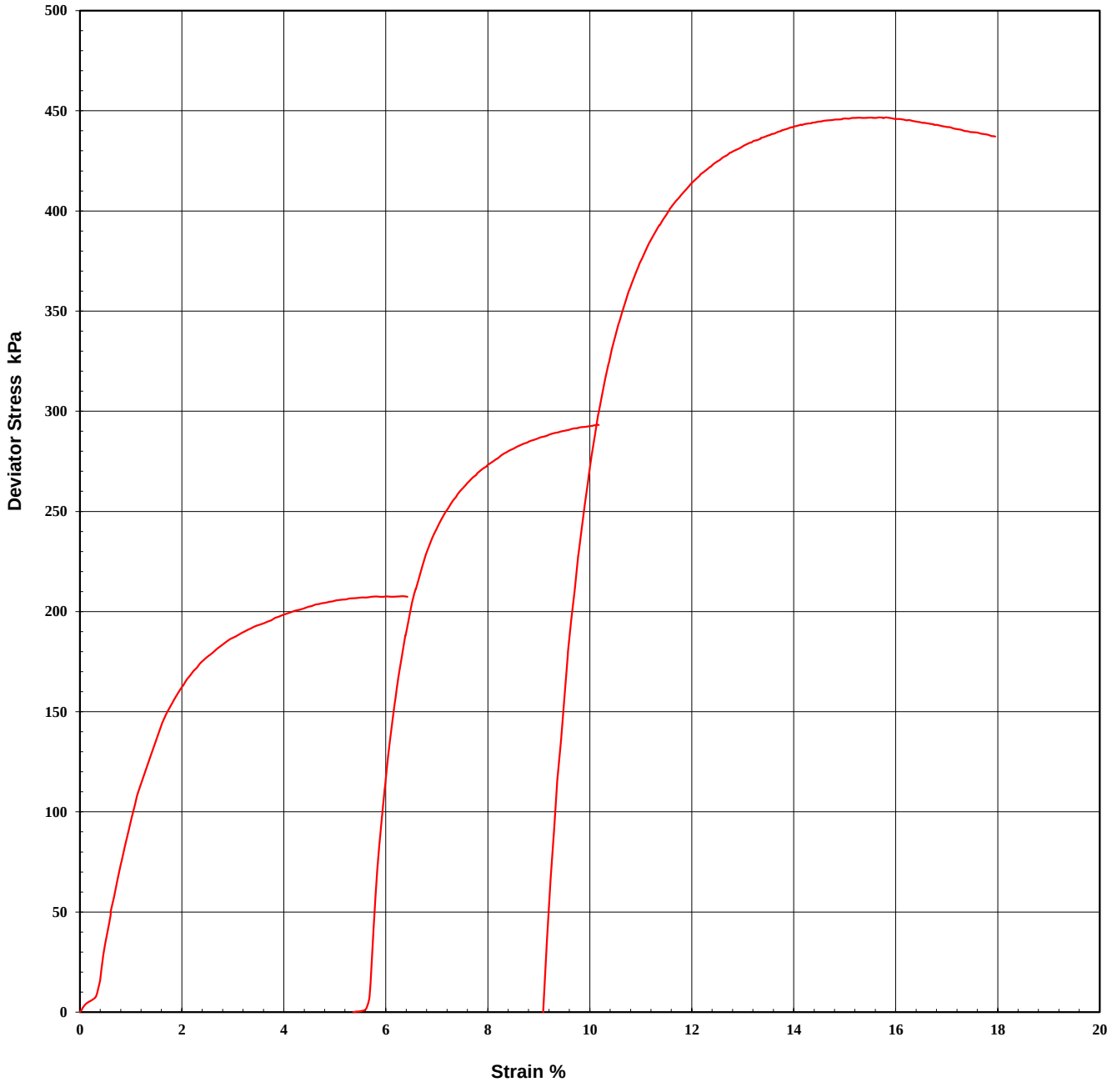
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.1

Client	Structerre Consulting Engineers	**Report No.**	18010245- UU

Stress/Strain Diagram



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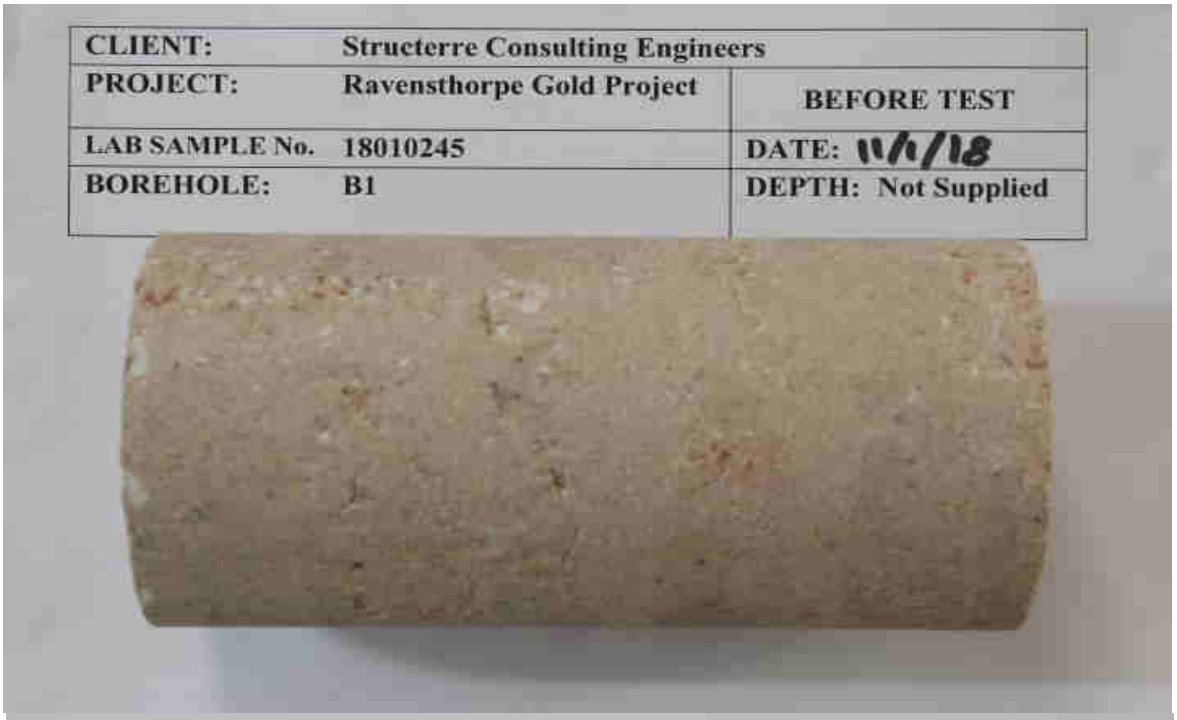
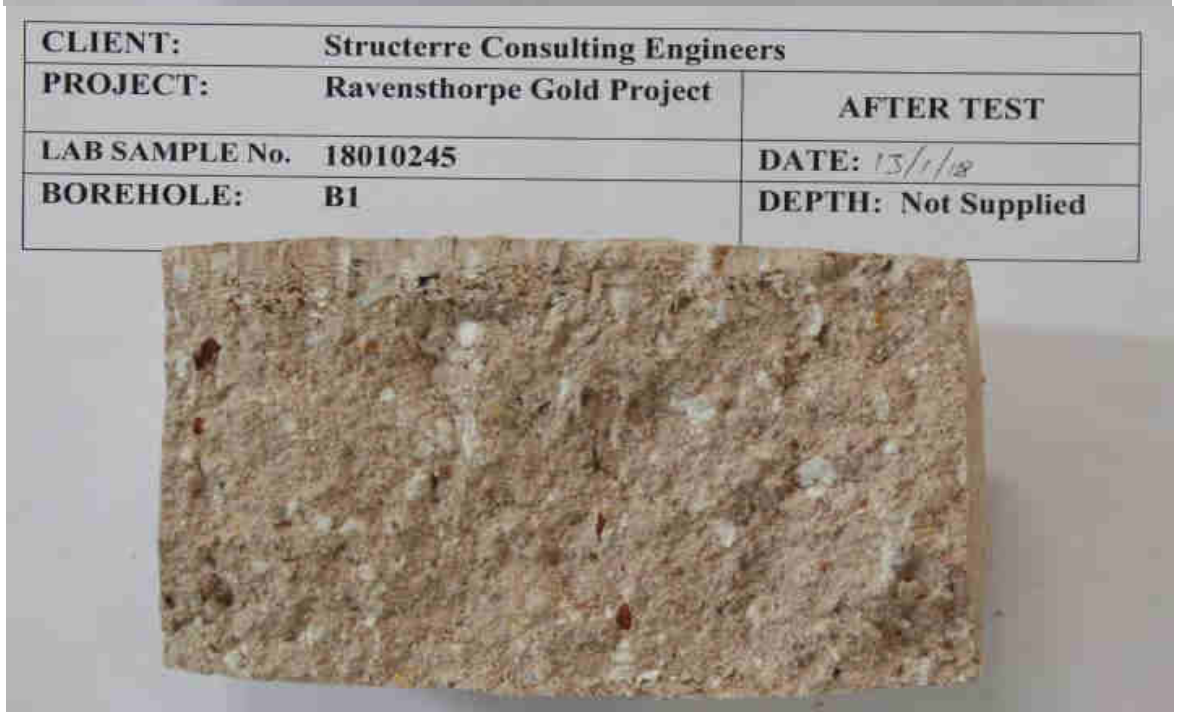
TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.1

Client	Structerre Consulting Engineers	**Report No.**	18010245- UU





Notes/Remarks:
Graph not to scale

Photo not to scale

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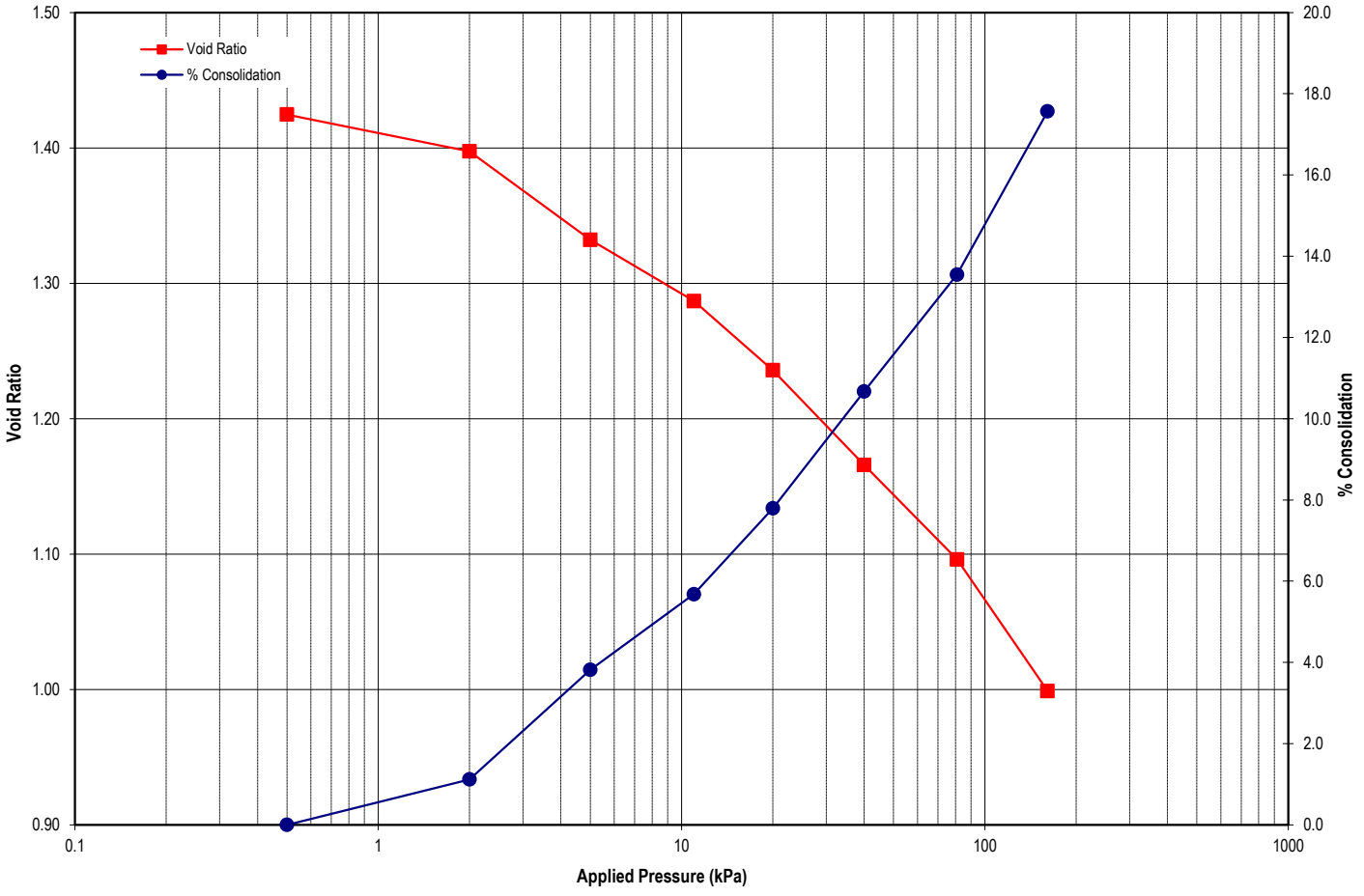
OEDOMETER TEST REPORT

Test Method: AS1289.6.6.1, 3.5.1

Client:	Structerre Consulting Engineers	**Report No.:**	18090289-CHP
		Workorder No.	4845
Address	PO Box 792 BALCATTA WA 6914	**Test Date:**	21/09/2018
		Report Date:	15/10/2018
Project:	S893890 - Ravensthorpe Gold Project		
Client Id.:	S893890-A - Oxide Tailing Sample	**Depth (m):**	Not Supplied
Description:	SILT - pale brown, Tailings		



Wet Density (t/m^3):	2.91	Initial Moisture (%):	163.2		
Particle Density (t/m^3):	2.68	Initial Voids Ratio:	1.425	Initial Degree of Saturation (%):	100.0
Slurry sample supplied by client		Remarks:	Mixed to a target of 40% Solids		Page 1 of 2

REP03102

Authorised Signatory

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OEDOMETER TEST REPORT

Test Method: AS1289.6.6.1, 3.5.1

Client:	Structerre Consulting Engineers	**Report No.:**	18090289-CHP
		Workorder No.	4845
Address	PO Box 792 BALCATTA WA 6914	**Test Date:**	21/09/2018
		Report Date:	15/10/2018
Project:	S893890 - Ravensthorpe Gold Project		
Client Id.:	S893890-A - Oxide Tailing Sample	**Depth (m):**	Not Supplied
Description:	SILT - pale brown, Tailings		

TEST RESULTS

Stage	Load (kPa)	Cc	Cv (m^2/yr) t_{50}	Cv (m^2/yr) t_{90}	Mv ($kPa^{-1}x10^{-3}$)	C_a x 10^{-3}	% Consolidation
1	0.5-2	0.045	74.39	61.35	7.473	0.00	1.1
2	2-5	0.164	53.62	59.46	9.095	2.02	3.8
3	5-11	0.132	113.89	85.89	3.228	2.87	5.7
4	11-20	0.197	264.59	228.43	2.486	2.95	7.8
5	20-40	0.232	376.48	346.75	1.561	2.66	10.7
6	40-81	0.228	599.35	453.37	0.786	2.23	13.5
7	81-161	0.326	1294.13	1202.88	0.581	2.24	17.6

Remarks: Mixed to a target of 40% Solids

REP03102

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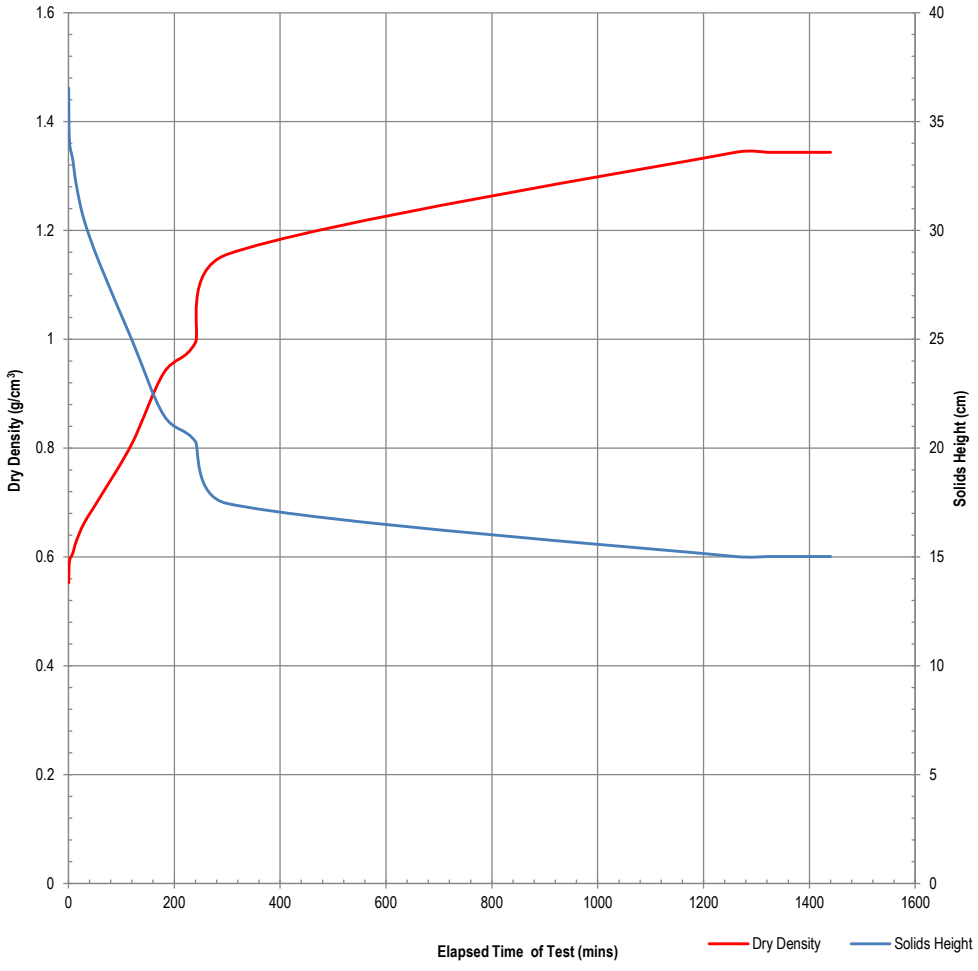
SETTLING TEST REPORT

Settling Test Procedure - as Supplied by Client

Client	Structerre Consulting Engineers	**Report No.**	18080058-SETL
Address	PO Box 792 BALCATTA WA 6914	**Test Date**	28/08/2018
		Report Date	3/09/2018
Project	S893890 - Ravensthorpe Gold Project		
Client ID	Oxide Tailing Sample (S893890-A)	**Depth (m)**	Not Supplied
Description	SILT - brown	**Sample Type**	Drained

RESULTS OF TESTING

Initial Mass of Slurry (g):	2434.3	**Volume of water in Cylinder (ml)**		2000.0
Settling Test Type:	Drained	**Mass of dry waste material (g)**		994.2



Elapsed Time (min)	Solids Height (cm)	Dry Density (g/cm³)
0.5	36.54	0.552
1	34.91	0.578
2	34.10	0.592
4	33.70	0.599
8	33.29	0.606
15	32.07	0.629
30	30.45	0.663
60	28.42	0.710
120	24.97	0.808
180	21.52	0.938
240	20.30	0.994
300	17.46	1.156
1260	15.02	1.344
1320	15.02	1.344
1380	15.02	1.344
1440	15.02	1.344

Remarks:

Sample/s supplied by client

Authorised Signatory

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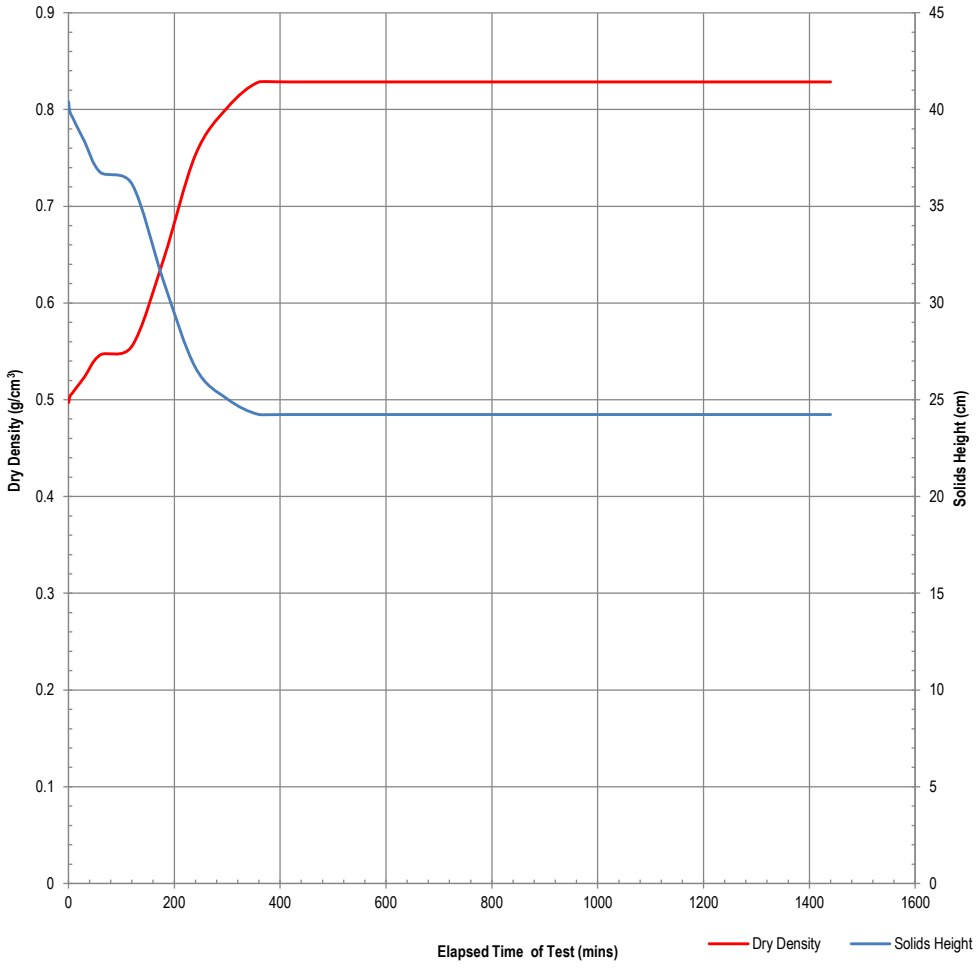
SETTLING TEST REPORT

Settling Test Procedure - as Supplied by Client

Client	Structerre Consulting Engineers	**Report No.**	18080058-SETL
Address	PO Box 792 BALCATTA WA 6914	**Test Date**	3/09/2018
		Report Date	28/08/2018
Project	S893890 - Ravensthorpe Gold Project		
Client ID	Oxide Tailing Sample (S893890-A)	**Depth (m)**	Not Supplied
Description	TAILINGS - brown	**Sample Type**	Undrained

RESULTS OF TESTING

Initial Mass of Slurry (g):	2434.3	**Volume of water in Cylinder (ml)**		2000.0
Settling Test Type:	Undrained	**Mass of dry waste material (g)**		994.2



Elapsed Time (min)	Solids Height (cm)	Dry Density (g/cm³)
0.5	40.39	0.497
1	40.19	0.500
2	39.99	0.502
4	39.79	0.505
8	39.58	0.507
15	39.18	0.512
30	38.37	0.523
60	36.76	0.546
120	36.15	0.555
180	31.10	0.646
240	26.66	0.753
300	25.04	0.802
360	24.24	0.829
420	24.24	0.829
1320	24.24	0.829
1380	24.24	0.829
1440	24.24	0.829

Remarks:

Sample/s supplied by client

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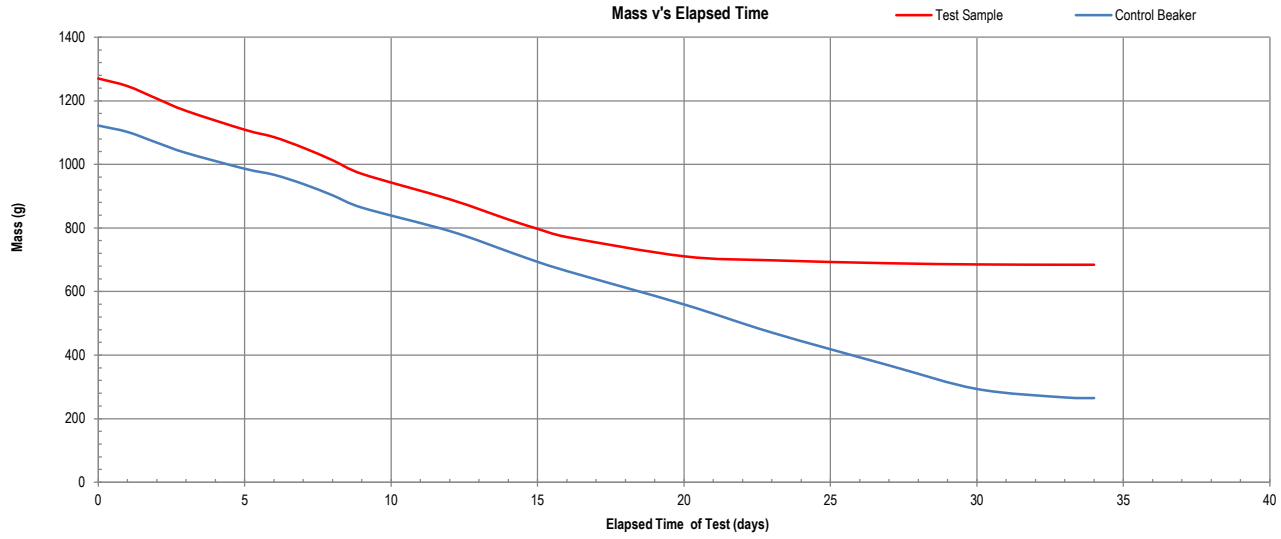
AIR DRYING TEST REPORT

Air Drying Test Procedure - as Supplied by Client

Client	Structerre Consulting Engineers	**Report No.**	P18080058-AD
Address	PO Box 792 BALCATTA WA 6914	**Test Date**	29/08/2018-2/10/2018
		Report Date	2/10/2018
Project	S893890 - Ravensthorpe Gold Project		
Client ID	Oxide Tailing Sample (S893890-A)	**Depth (m)**	Not Supplied
		Sample Type	Tailings at 40% solids

RESULTS OF TESTING

Date	Control Beaker			Test Sample		Decant	
	Temperature (° C)	Mass (g)	Evaporation (g)	Mass (g)	Evaporation (g)	Mass (g)	Decantation (g)
29/08/2018 Start Date	19.1	1122.1	-	1270.2	-	0.0	-
30/08/2018	18.6	1101.9	20.2	1246.1	24.1	0.0	1246.1
31/08/2018	27.8	1068.4	53.7	1206.7	63.5	0.0	1206.7
1/09/2018	21.3	1036.0	86.1	1168.3	101.9	0.0	1168.3
3/09/2018	22.0	986.3	135.8	1109.0	161.2	0.0	1109.0
4/09/2018	21.2	967.3	154.8	1085.7	184.5	0.0	1085.7
5/09/2018	29.0	938.2	183.9	1052.3	217.9	0.0	1052.3
6/09/2018	29.2	902.7	219.4	1013.1	257.1	0.0	1013.1
7/09/2018	30.9	863.9	258.2	970.2	300.0	0.0	970.2
10/09/2018	22.6	790.3	331.8	890.2	380.0	0.0	890.2
12/09/2018	29.3	725.8	396.3	826.7	443.5	0.0	826.7
13/09/2018	27.9	693.3	428.8	797.3	472.9	0.0	797.3
14/09/2018	28.1	664.4	457.7	771.4	498.8	0.0	771.4
18/09/2018	29.0	559.4	562.7	710.8	559.4	0.0	710.8
21/09/2018	20.4	470.9	651.2	698.2	572.0	0.0	698.2
25/09/2018	21.7	367.6	754.5	689.0	581.2	0.0	689.0
28/09/2018	19.3	293.5	828.6	685.3	584.9	0.0	685.3
1/10/2018	22.3	266.9	855.2	684.3	585.9	0.0	684.3
2/10/2018	21.9	264.9	857.2	684.3	585.9	0.0	684.3



Remarks:

Sample/s supplied by client

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ATTERBERG LIMITS TEST REPORT

Test Method: AS 1289 2.1.1, 3.1.1, 3.1.2, 3.2.1, 3.3.1, 3.4.1

Client	Structerre Consulting Engineers	**Report No.**	P 18080058-AL
Address	PO Box 792 BALCATTA WA 6914		
Project	S893890 - Ravensthorpe Gold Project	**Test Date**	03/09/2018
		Report Date	04/09/2018

Sample No.	18080058	-	-	-	-	-
Client ID	Oxide Tailing Sample (S893890-A)	-	-	-	-	-
Depth (m)	Not Supplied	-	-	-	-	-
Liquid Limit (%)	33	-	-	-	-	-
Plastic Limit (%)	28	-	-	-	-	-
Plasticity Index (%)	5	-	-	-	-	-
Linear Shrinkage (%)	2.0	-	-	-	-	-
Moisture Content (%)	143.6	-	-	-	-	-

Sample No.	-	-	-	-	-	-
Client ID	-	-	-	-	-	-
Depth (m)	-	-	-	-	-	-
Liquid Limit (%)	-	-	-	-	-	-
Plastic Limit (%)	-	-	-	-	-	-
Plasticity Index (%)	-	-	-	-	-	-
Linear Shrinkage (%)	-	-	-	-	-	-
Moisture Content (%)	-	-	-	-	-	-

NOTES/REMARKS: The samples were tested oven dried, dry sieved and in a 125-250mm mould.

Sample/s supplied by the client * Cracking occurred + Curling occurred

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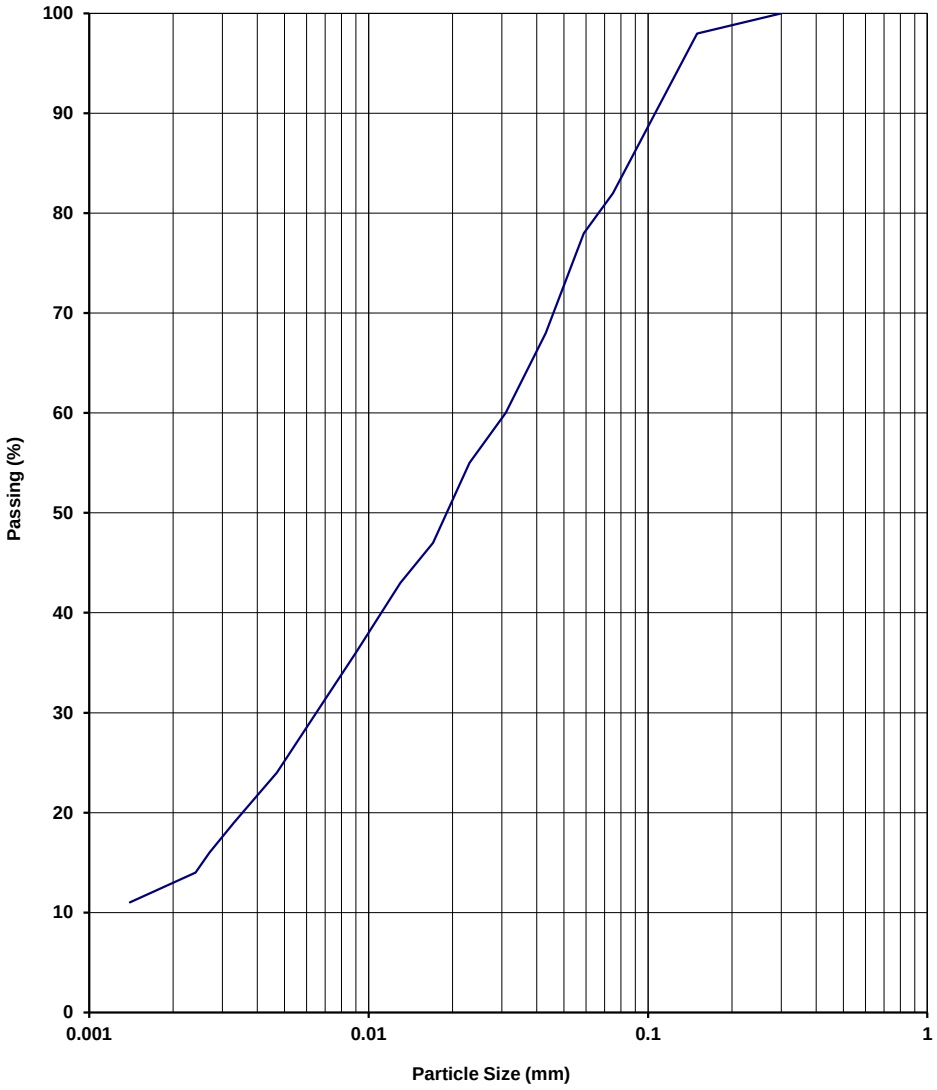
PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1

Client	Structerre Consulting Engineers	**Report No.**	P 18080058-G
Address	PO Box 792 BALCATTA WA 6914		
Project	S893890 - Ravensthorpe Gold Project	**Test Date**	28/08/2018-4/09/2018
		Report Date	4/09/2018
Client ID	Oxide Tailing Sample (S893890-A)	**Depth (m)**	Not Supplied

Sieve Size (mm)	Passing %
150.0	
75.0	
53.0	
37.5	
26.5	
19.0	
9.5	
4.75	
2.36	
1.18	
0.600	
0.425	
0.300	100
0.150	98
0.075	82
0.059	78
0.043	68
0.031	60
0.023	55
0.017	47
0.013	43
0.009	36
0.007	30
0.005	24
0.004	21
0.003	19
0.003	16
0.002	14
0.001	11



NOTES/REMARKS:

Moisture Content 143.6%

-2.36mm Soil Particle Density(t/m^3) 2.82

Sample/s supplied by the client

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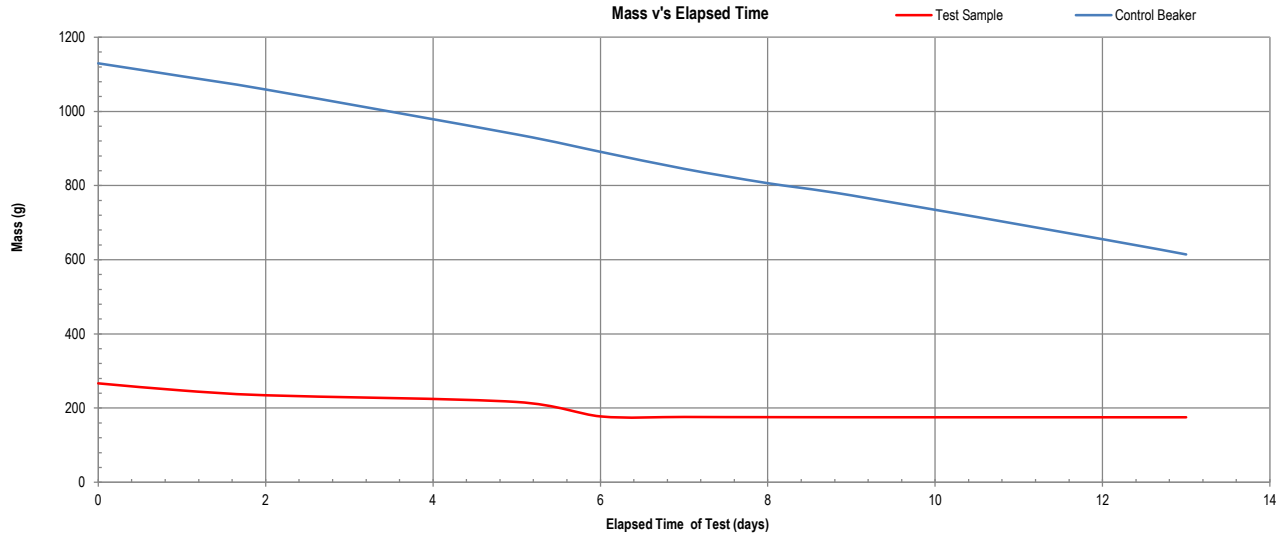
AIR DRYING TEST REPORT

Air Drying Test Procedure - as Supplied by Client

Client	Structerre Consulting Engineers	**Report No.**	P18120017-AD
Address	PO Box 792 BALCATTA WA 6914	**Test Date**	2/01/2019-15/01/2019
		Report Date	16/01/2019
Project	S906559		
Client ID	Tailing Sample (S906559-A)	**Depth (m)**	Not Supplied
		Sample Type	Tailings at 48% solids

RESULTS OF TESTING

Date	Control Beaker			Test Sample		Decant	
	Temperature (° C)	Mass (g)	Evaporation (g)	Mass (g)	Evaporation (g)	Mass (g)	Decantation (g)
2/01/2019 Start Date	22.6	1129.6	-	266.7	-	-	-
3/01/2019	20.4	1094.7	34.9	247.5	19.2	-	-
4/01/2019	21.4	1059.0	70.6	234.6	32.1	-	-
7/01/2019	20.3	937.9	191.7	216.5	50.2	-	-
8/01/2019	23.4	891.1	238.5	177.6	89.1	-	-
9/01/2019	21.4	845.2	284.4	176.1	90.6	-	-
10/01/2019	20.7	806.4	323.2	175.6	91.1	-	-
11/01/2019	22.2	773.5	356.1	175.3	91.4	-	-
14/01/2019	21.0	655.4	474.2	175.2	91.5	-	-
15/01/2019	22.1	614.3	515.3	175.2	91.5	-	-



Remarks:

Sample/s supplied by client

Authorised Signatory

G. Creely

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Reference should be made to Trilab's "Standard Terms and Conditions of Business" for further details.
Trilab Pty Ltd ABN 25 065 630 506

ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

Trilab
Soil Rock Calibration

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

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

ATTERBERG LIMITS TEST REPORT

Test Method: AS 1289 2.1.1, 3.1.1, 3.1.2, 3.2.1, 3.3.1, 3.4.1

Client	Structerre Consulting Engineers	**Report No.**	P 18120017-AL
Address	PO Box 792 BALCATTA WA 6914		
Project	S906559	**Test Date**	18/12/2018-19/12/2018
		Report Date	20/12/2018

Sample No.	18120017	-	-	-	-	-
Client ID	Tailing Sample (S906559-A)	-	-	-	-	-
Depth (m)	Not Supplied	-	-	-	-	-
Liquid Limit (%)	Not Obtainable	-	-	-	-	-
Plastic Limit (%)	Not Obtainable	-	-	-	-	-
Plasticity Index (%)	Non-plastic	-	-	-	-	-
Linear Shrinkage (%)	Not Obtainable	-	-	-	-	-
Moisture Content (%)	59.6	-	-	-	-	-

Sample No.	-	-	-	-	-	-
Client ID	-	-	-	-	-	-
Depth (m)	-	-	-	-	-	-
Liquid Limit (%)	-	-	-	-	-	-
Plastic Limit (%)	-	-	-	-	-	-
Plasticity Index (%)	-	-	-	-	-	-
Linear Shrinkage (%)	-	-	-	-	-	-
Moisture Content (%)	-	-	-	-	-	-

NOTES/REMARKS: The samples were tested oven dried, dry sieved and in a 125-250mm mould.

Sample/s supplied by the client * Cracking occurred + Curling occurred

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 Perth Laboratory.

Authorised Signatory

G. Creely

NATA ACCREDITED FOR TECHNICAL COMPETENCE

Laboratory No. 9926

The results of calibrations and tests performed apply only to the specific instrument or sample at the time of test unless otherwise clearly stated.
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Trilab Pty Ltd ABN 25 065 630 506

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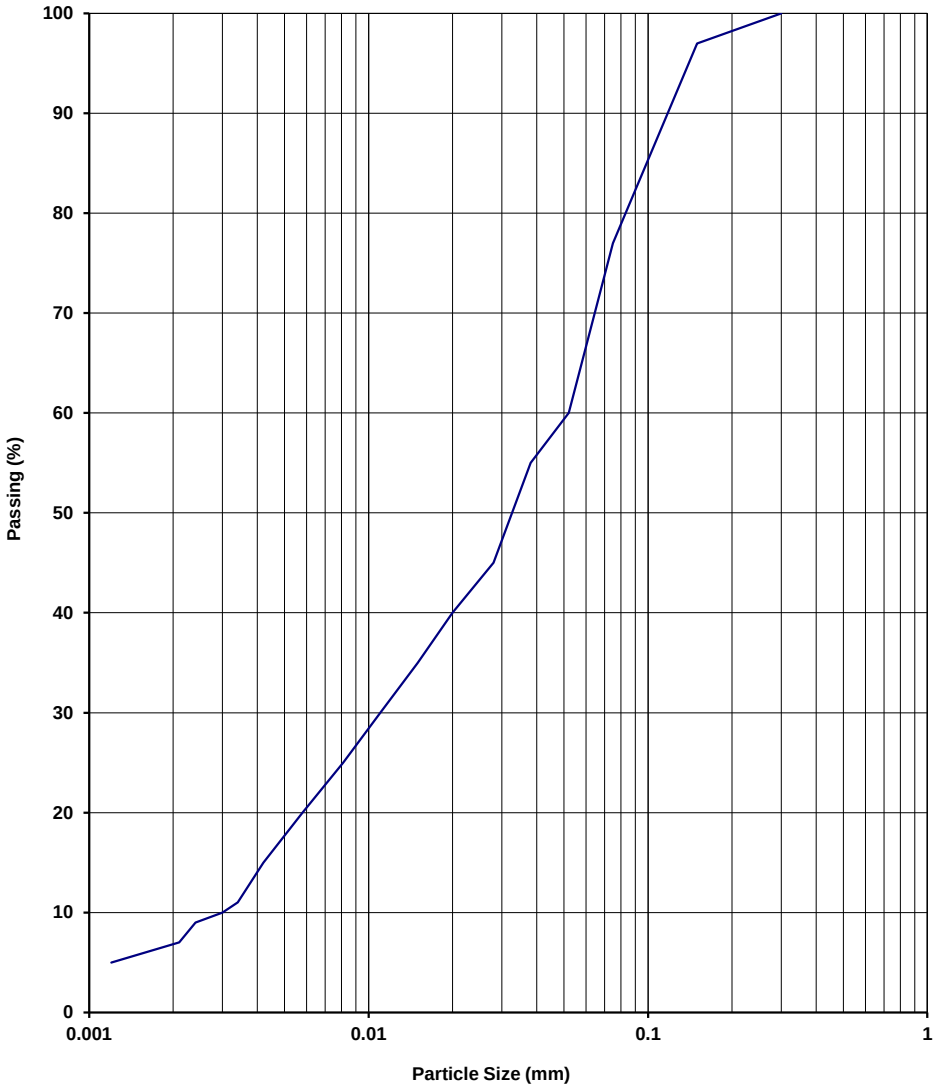
WA 6107
Ph: +61 8 9258 8323

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1

Client	Structerre Consulting Engineers	**Report No.**	P 18120017-G
Address	PO Box 792 BALCATTA WA 6914		
Project	S906559	**Test Date**	18/12/2018-21/12/2018
		Report Date	21/12/2018
Client ID	Tailing Sample (S906559-A)	**Depth (m)**	Not Supplied

Sieve Size (mm)	Passing %
150.0	
75.0	
53.0	
37.5	
26.5	
19.0	
9.5	
4.75	
2.36	
1.18	
0.600	
0.425	
0.300	100
0.150	97
0.075	77
0.052	60
0.038	55
0.028	45
0.02	40
0.015	35
0.011	30
0.0081	25
0.0058	20
0.0042	15
0.0034	11
0.0030	10
0.0024	9
0.0021	7
0.0012	5



NOTES/REMARKS:

Moisture Content 59.6%

-2.36mm Soil Particle Density(t/m^3) 2.91

Sample/s supplied by the client

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 Perth Laboratory

Authorised Signatory

G. Creely

NATA ACCREDITED FOR TECHNICAL COMPETENCE

Laboratory No. 9926

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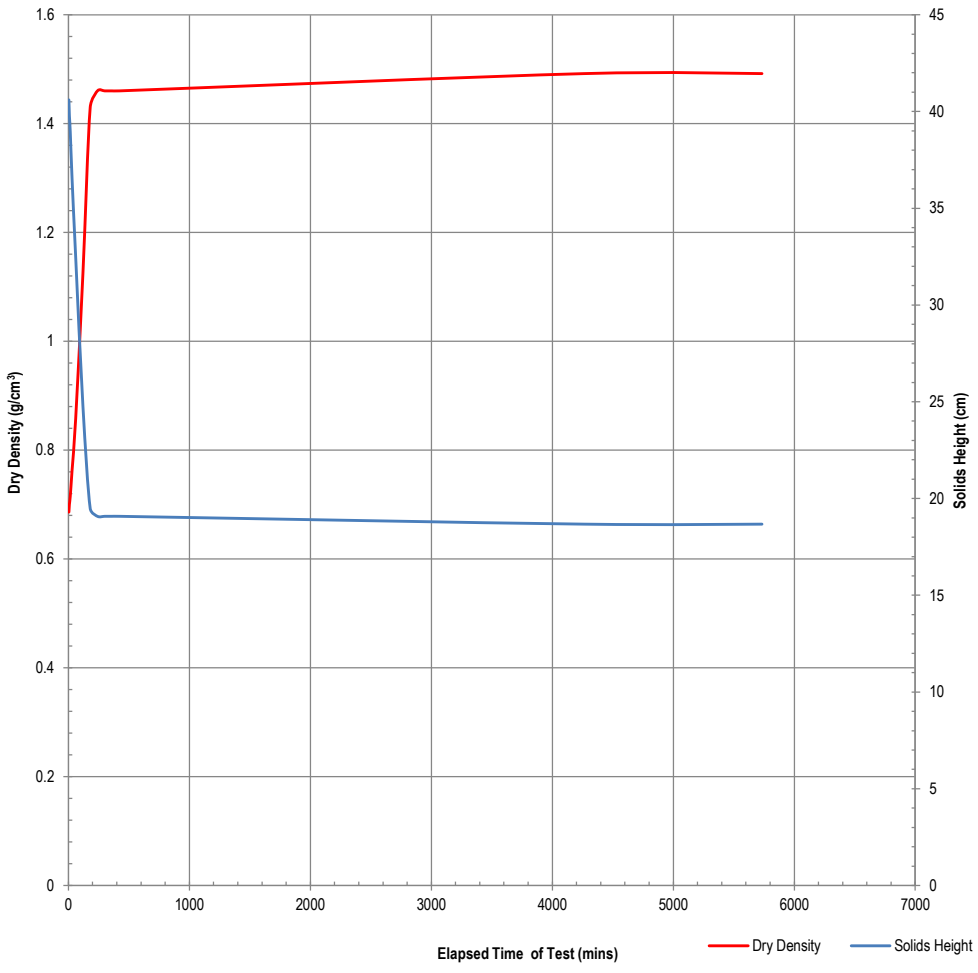
SETTLING TEST REPORT

Settling Test Procedure - as Supplied by Client

Client	Golder Associates Pty Ltd	**Report No.**	181120017-SETL
Address	PO Box 1914 WEST PERTH WA 6872	**Test Date**	14/12/2018-18/12/2018
		Report Date	20/12/2018
Project	18104178 - Metronet TCL Thornlie to Cockburn Link		
Client ID	TCL-TP014 - Sample ID 6	**Depth (m)**	0.50-1.00
Description	SILT - grey	**Sample Type**	Drained

RESULTS OF TESTING

Initial Mass of Slurry (g):	2870.9	**Volume of water in Cylinder (ml)**		2000.0
Settling Test Type:	Drained	**Mass of dry waste material (g)**		1372.5



Elapsed Time (min)	Solids Height (cm)	Dry Density (g/cm³)
0.5	40.60	0.686
1	40.60	0.686
2	40.60	0.686
4	40.60	0.686
8	39.78	0.700
15	38.97	0.715
30	36.54	0.763
60	32.48	0.858
120	24.76	1.125
180	19.49	1.430
240	19.08	1.460
300	19.08	1.460
360	19.08	1.460
420	19.08	1.460
4263	18.67	1.492
5733	18.67	1.492

Remarks:

Sample/s supplied by client

Authorised Signatory

G. Creely

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

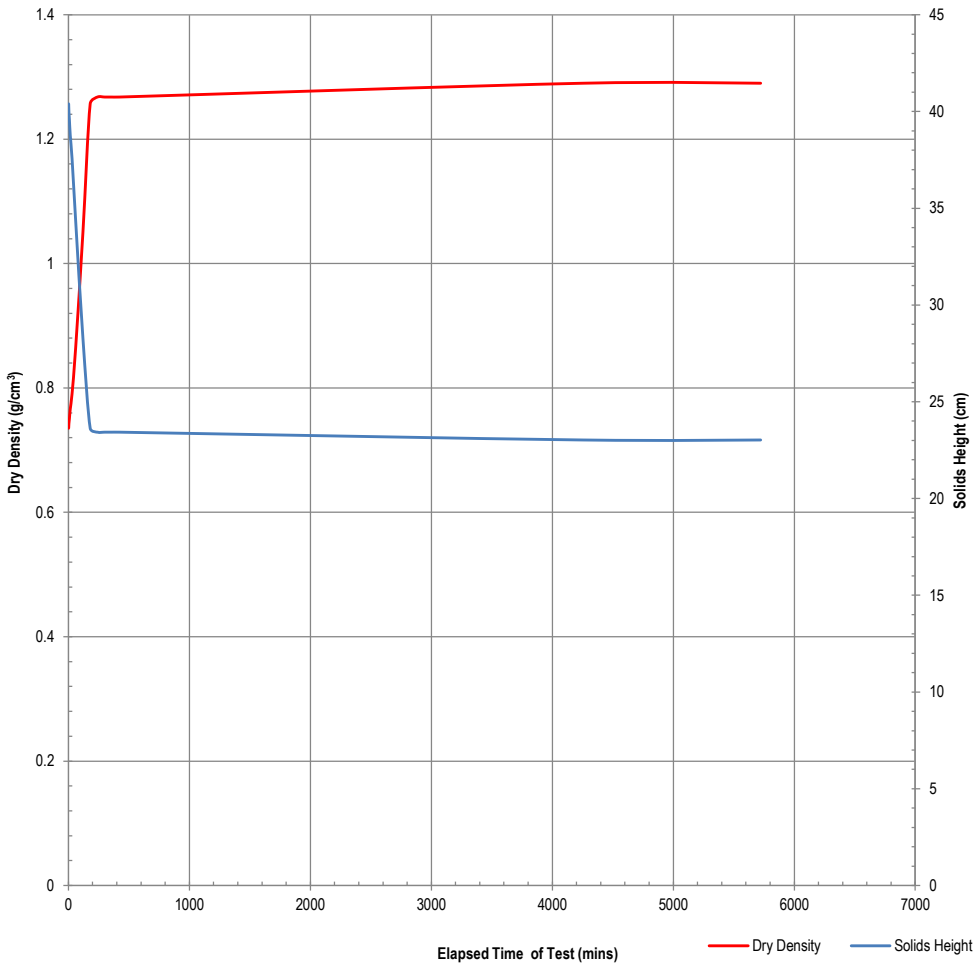
SETTLING TEST REPORT

Settling Test Procedure - as Supplied by Client

Client	Structerre Consulting Engineers	**Report No.**	18120017-SETL
Address	PO Box 792 BALCATTA WA 6914	**Test Date**	14/12/2018-18/12/2018
		Report Date	20/12/2018
Project	S906559		
Client ID	Tailing Sample (S906559-A)	**Depth (m)**	Not Supplied
Description	SILT - grey	**Sample Type**	Undrained

RESULTS OF TESTING

Initial Mass of Slurry (g):	2877.3	**Volume of water in Cylinder (ml)**		2000.0
Settling Test Type:	Undrained	**Mass of dry waste material (g)**		1470.5



Elapsed Time (min)	Solids Height (cm)	Dry Density (g/cm³)
0.5	40.39	0.735
1	40.39	0.735
2	40.39	0.735
4	39.99	0.743
8	39.58	0.750
15	38.78	0.766
30	37.56	0.791
60	34.33	0.865
120	28.27	1.050
180	23.63	1.257
240	23.43	1.268
300	23.43	1.268
360	23.43	1.268
420	23.43	1.268
4252	23.02	1.290
5722	23.02	1.290

Remarks:

Sample/s supplied by client

Authorised Signatory

G. Creely

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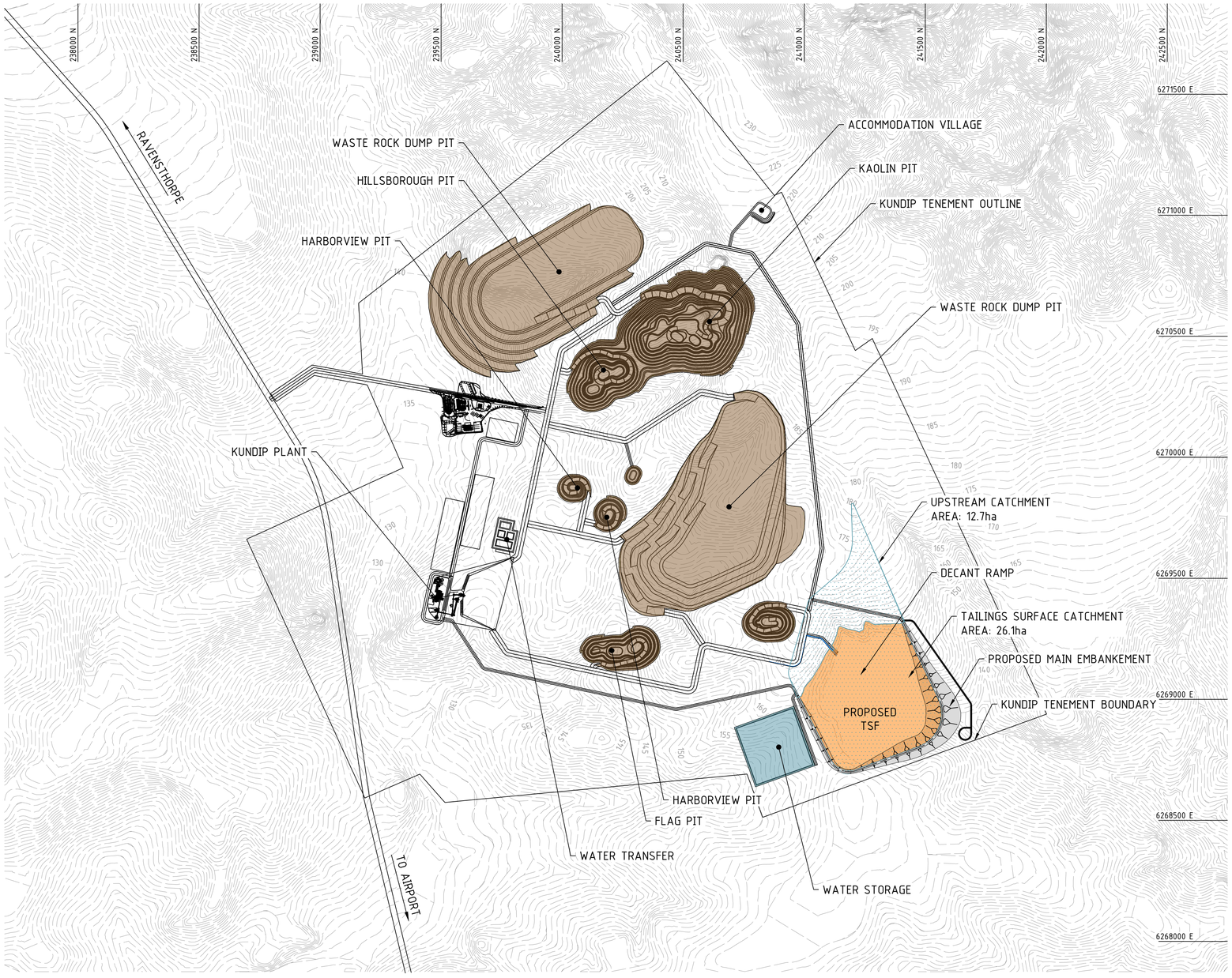
Trilab Pty Ltd ABN 25 065 630 506

ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

Appendix F

TSF Feasibility Study Drawings



PLAN
1:10000

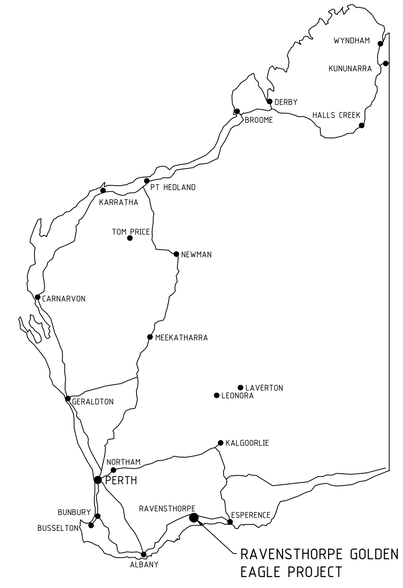
NOTES:

1. HORIZONTAL DATUM: MGA94 ZONE 51
   VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM (AHD)m
2. SURVEY SUPPLIED BY:
   - ACH MINERALS (OCT' 2017)
3. DESIGN LEVELS SHOWN ARE TO TOP OF CLAY AND TOP OF TAILINGS UNLESS NOTED OTHERWISE.
4. THESE DRAWINGS ARE PROVIDED FOR INFORMATION ONLY AS PART OF THE RAVENSTHORPE GOLD PROJECT FEASIBILITY STUDY. NOT FOR CONSTRUCTION.
5. DIMENSIONS SHOWN IN METRES U.N.O.
6. USE FIGURED DIMENSIONS, DO NOT SCALE OFF DRAWING.
7. EXISTING UNDERGROUND SERVICES ARE NOT SHOWN ON THIS DRAWING U.N.O. THE CONTRACTOR SHALL CONTACT THE RELEVANT AUTHORITIES TO DETERMINE THE PRESENCE OF UNDERGROUND SERVICES PRIOR TO COMMENCEMENT OF ANY WORKS.
8. ALL RELEVANT WORKING PERMITS SHALL BE ACQUIRED PRIOR TO COMMENCEMENT OF ANY WORKS.

DRAWING INDEX

CIVIL:

DE-001 - SITE LAYOUT PLAN AND DRAWING INDEX
DE-002 - MAIN EMBANKMENT GENERAL ARRANGEMENT
DE-003 - MAIN EMBANKMENT CROSS SECTIONS - SHEET 1 OF 5
DE-004 - MAIN EMBANKMENT CROSS SECTIONS - SHEET 2 OF 5
DE-005 - MAIN EMBANKMENT CROSS SECTIONS - SHEET 3 OF 5
DE-006 - MAIN EMBANKMENT CROSS SECTIONS - SHEET 4 OF 5
DE-007 - MAIN EMBANKMENT CROSS SECTIONS - SHEET 5 OF 5
DE-008 - MAIN EMBANKMENT SECTIONS
DE-009 - MAIN EMBANKMENT SECTIONS AND DETAILS
DE-010 - DECANT - ARRANGEMENT AND DETAILS
DE-011 - TAILINGS DISTRIBUTION NETWORK GENERAL ARRANGEMENT
DE-012 - TAILINGS DISTRIBUTION NETWORK SECTIONS AND DETAILS
DE-013 - CONCEPTUAL CLOSURE PLAN



GEOGRAPHICAL LOCATION
NOT TO SCALE

FOR INFORMATION ONLY

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200 0 200 400 600 Metres
SCALE 1 : 10,000

REV	DATE	AMENDMENTS	DRG. NO.	REFERENCE DRAWING
C	08/08/18	ISSUED FOR CLIENT REVIEW		
B	09/07/18	ISSUED FOR CLIENT REVIEW		
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CLIENT ACH

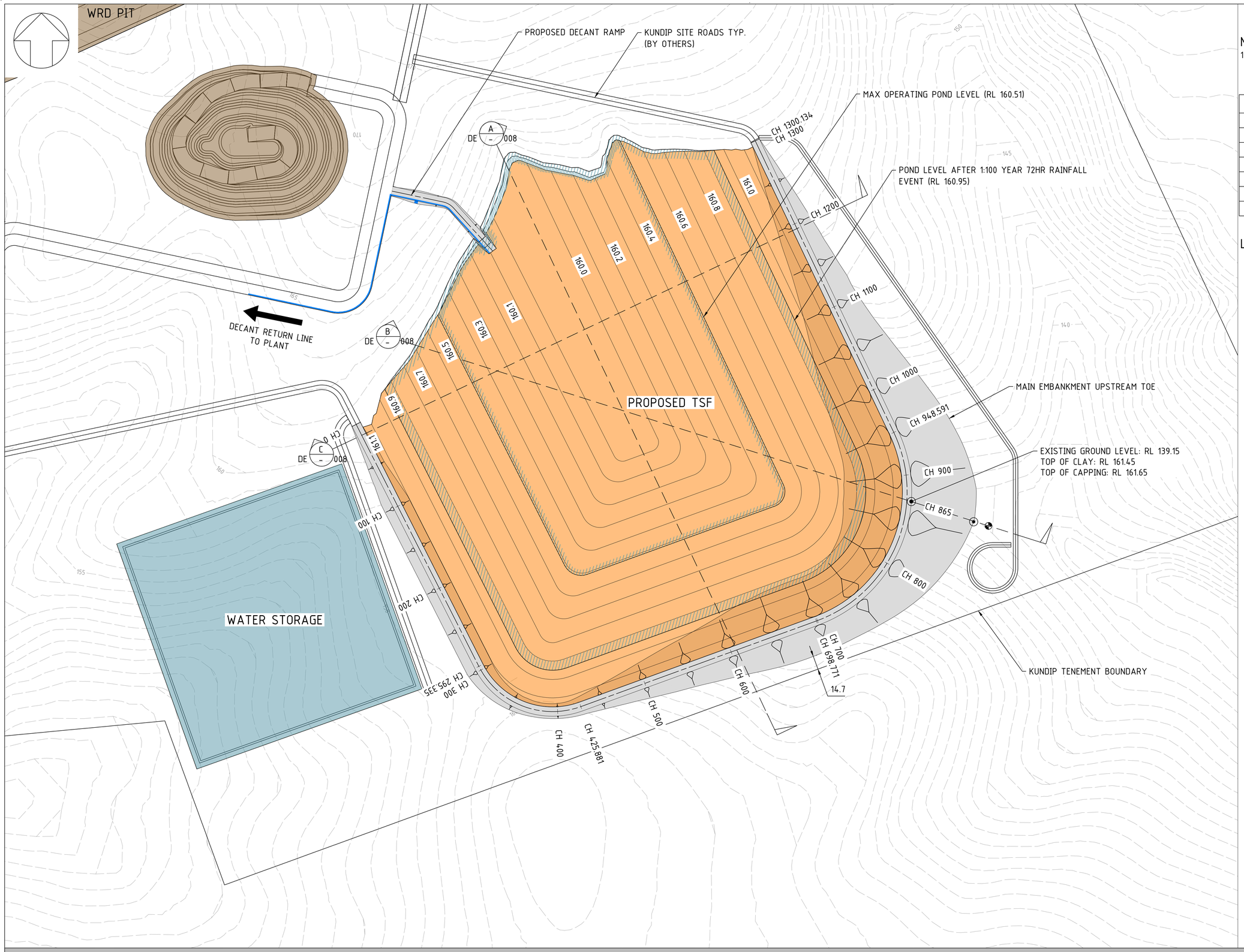
	BY	DATE	INITIAL
DRAWN :	D.SIBANIC	30/06/18	
DESIGNED :	M.HANGER	30/06/18	
CHECKED :	M.HANGER	06/07/18	
ORIGINATOR :			
COMPANY :			
APPROVED :			

TITLE
ACH MINERALS PTY LTD
GOLDEN EAGLE PROJECT PRELIMINARY DESIGN
SITE LAYOUT AND DRAWINGS INDEX

SCALE
1:10,000 @ A1

DRAWING No. DE-001

REV C



NOTES:

1. REFER TO DRG. DE-001 FOR NOTES.

MAIN EMBANKMENT SETOUT				
CHAINAGE	EASTING (m)	NORTHING (m)	RL (m)	RADIUS
0.000	240972.025	6269013.989	161.350	-
295.335	241105.543	6268750.559		90
425.881	241216.582	6268706.668		
698.771	241473.038	6268799.939		150
948.591	241557.258	6269005.270		
1300.134	241406.412	6269322.804		-

LEGEND:

- PROPOSED MAIN EMBANKMENT
- PROPOSED FINAL TAILINGS SURFACE
- POND EXTENTS
- 160.6 — PROPOSED CONTOUR AND HEIGHT
- 140 — EXISTING CONTOUR AND HEIGHT
- PROPOSED VIBRATING WIRE PIEZOMETER
- PROPOSED MONITORING BORE

FOR INFORMATION ONLY

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40 0 40 80 120 Metres

SCALE 1 : 2,000

REV	DATE	AMENDMENTS	DRG. NO.	REFERENCE DRAWING
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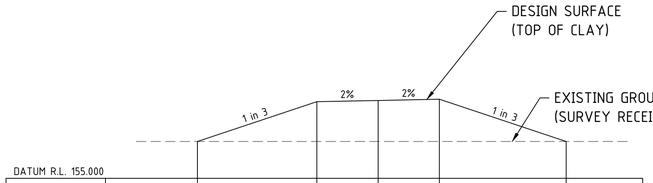
DESIGNED :	M.HANGER	30/06/18	
CHECKED :	M.HANGER	06/07/18	
ORIGINATOR :			
COMPANY :			
APPROVED :			

TITLE
ACH MINERALS PTY LTD
GOLDEN EAGLE PROJECT PRELIMINARY DESIGN
MAIN EMBANKMENT
GENERAL ARRANGEMENT

SCALE 1:2,000 @ A1

DRAWING No. DE-002

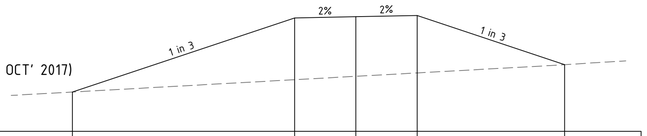
REV C



DATUM R.L. 155.000

DESIGN SURFACE (TOP OF CLAY)	158.000	161.250	161.350	161.450	158.000	
DEPTH CUT - / FILL +	0.000	3.250	3.350	3.450	0.000	
SURVEY	158.000	158.000	158.000	158.000	158.000	
OFFSET FROM REF. LINE	-14.750	-5.000	0.000	5.000	15.350	

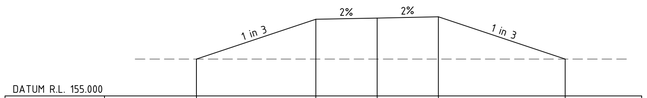
CH 295.335



DATUM R.L. 152.000

DESIGN SURFACE (TOP OF CLAY)	155.205	161.250	161.350	161.450	157.438	
DEPTH CUT - / FILL +	0.000	5.039	4.863	4.686	0.000	
SURVEY	155.205	156.211	156.487	156.764	157.438	
OFFSET FROM REF. LINE	-23.136	-5.000	0.000	5.000	17.036	

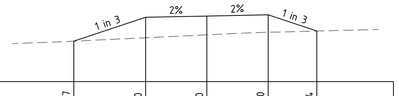
CH 500



DATUM R.L. 155.000

DESIGN SURFACE (TOP OF CLAY)	158.000	161.250	161.350	161.450	158.000	
DEPTH CUT - / FILL +	0.000	3.250	3.350	3.450	0.000	
SURVEY	158.000	158.000	158.000	158.000	158.000	
OFFSET FROM REF. LINE	-14.750	-5.000	0.000	5.000	15.350	

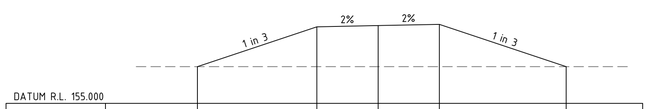
CH 200



DATUM R.L. 156.000

DESIGN SURFACE (TOP OF CLAY)	159.297	161.250	161.350	161.450	160.124	
DEPTH CUT - / FILL +	0.000	1.673	1.534	1.427	0.000	
SURVEY	159.297	159.577	159.816	160.023	160.124	
OFFSET FROM REF. LINE	-10.858	-5.000	0.000	5.000	8.977	

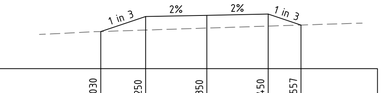
CH 425.881



DATUM R.L. 155.000

DESIGN SURFACE (TOP OF CLAY)	158.000	161.250	161.350	161.450	158.000	
DEPTH CUT - / FILL +	0.000	3.250	3.350	3.450	0.000	
SURVEY	158.000	158.000	158.000	158.000	158.000	
OFFSET FROM REF. LINE	-14.750	-5.000	0.000	5.000	15.350	

CH 100



DATUM R.L. 157.000

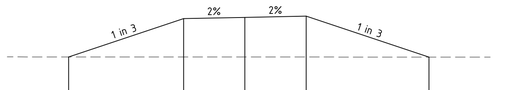
DESIGN SURFACE (TOP OF CLAY)	160.030	161.250	161.350	161.450	160.557	
DEPTH CUT - / FILL +	0.000	1.102	1.041	0.980	0.000	
SURVEY	160.030	160.148	160.309	160.470	160.557	
OFFSET FROM REF. LINE	-8.661	-5.000	0.000	5.000	7.680	

CH 400

DATUM R.L. 158.000

DESIGN SURFACE (TOP OF CLAY)	161.352	161.250	161.350	161.450	161.371	
DEPTH CUT - / FILL +	0.000	-0.102	-0.001	0.080	0.000	
SURVEY	161.352	161.352	161.351	161.370	161.371	
OFFSET FROM REF. LINE	-5.305	-5.000	0.000	5.000	5.236	

CH 0



DATUM R.L. 155.000

DESIGN SURFACE (TOP OF CLAY)	158.121	161.250	161.350	161.450	158.109	
DEPTH CUT - / FILL +	0.000	3.133	3.235	3.337	0.000	
SURVEY	158.121	158.117	158.115	158.113	158.109	
OFFSET FROM REF. LINE	-14.388	-5.000	0.000	5.000	15.024	

CH 300

NOTES:
1. REFER TO DRG. DE-001 FOR NOTES.
2. REFER TO DRG. DE-009 FOR TYPICAL SECTION.

FOR INFORMATION ONLY

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5 0 5 10 15 Metres

SCALE 1 : 250

REV	DATE	AMENDMENTS	DRG. NO.	REFERENCE DRAWING
C	08/08/18	ISSUED FOR CLIENT REVIEW		
B	09/07/18	ISSUED FOR CLIENT REVIEW		
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	BY	DATE	INITIAL
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DESIGNED :	M.HANGER	30/06/18	
CHECKED :	M.HANGER	06/07/18	
ORIGINATOR :			
COMPANY :			
APPROVED :			

TITLE
ACH MINERALS PTY LTD
GOLDEN EAGLE PROJECT PRELIMINARY DESIGN
MAIN EMBANKMENT
CROSS SECTIONS - SHEET 1 OF 5

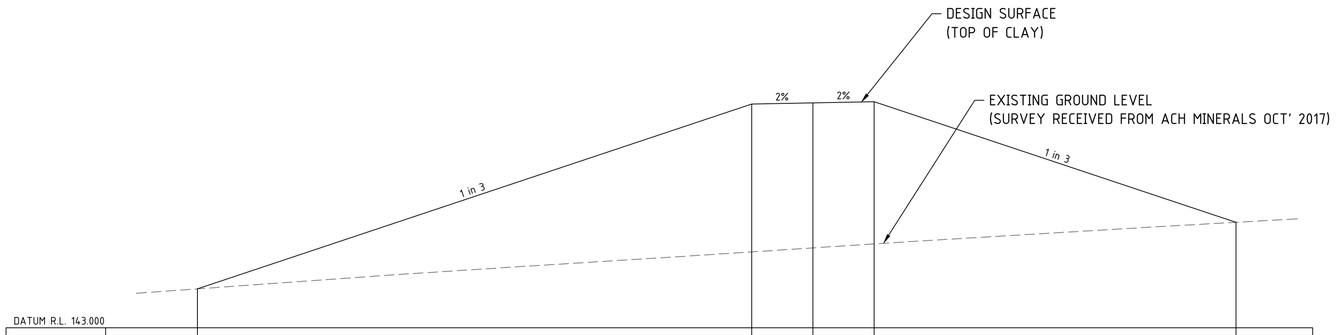
SCALE 1:250 @ A1

DRAWING No. DE-003

REV C

Cad File: C:\Users\MHA Geotechnical\REC Group\MHA Geotechnical - 1. MHA Project Folders\3 - Projects 2017\P17-02 ACH Minerals Ltd\2. Project Information\Drawings\Working\DE-003.dwg 8-Aug-18 - 03:35:32 PM

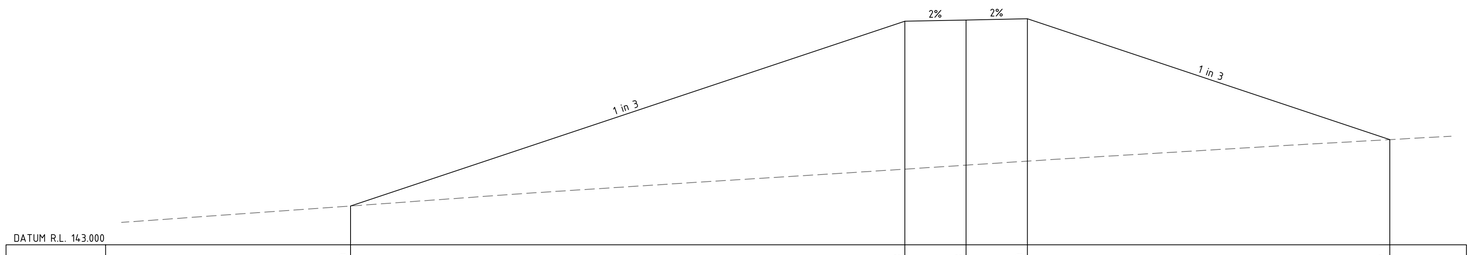
A1 Border v1.4



DATUM R.L. 143.000

DESIGN SURFACE (TOP OF CLAY)	146.170	161.250	161.350	161.450	151.604		
DEPTH CUT - / FILL +	0.000	12.061	11.835	11.608	0.000		
SURVEY	146.170	149.189	149.515	149.841	151.604		
OFFSET FROM REF. LINE	-50.240	-5.000	0.000	5.000	34.536		

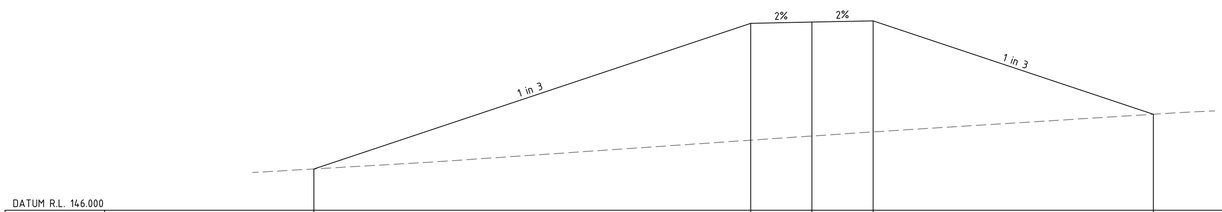
CH 700



DATUM R.L. 143.000

DESIGN SURFACE (TOP OF CLAY)	146.170	161.250	161.350	161.450	151.587		
DEPTH CUT - / FILL +	0.000	12.072	11.846	11.620	0.000		
SURVEY	146.170	149.178	149.504	149.830	151.587		
OFFSET FROM REF. LINE	-50.238	-5.000	0.000	5.000	34.589		

CH 698.771



DATUM R.L. 146.000

DESIGN SURFACE (TOP OF CLAY)	149.364	161.250	161.350	161.450	153.827		
DEPTH CUT - / FILL +	0.000	9.538	9.297	9.061	0.000		
SURVEY	149.364	151.712	152.053	152.389	153.827		
OFFSET FROM REF. LINE	-40.657	-5.000	0.000	5.000	27.869		

CH 600

NOTES:
1. REFER TO DRG. DE-001 FOR NOTES.
2. REFER TO DRG. DE-009 FOR TYPICAL SECTION.

FOR INFORMATION ONLY

NOT FOR CONSTRUCTION

5 0 5 10 15 Metres

SCALE 1 : 250

REV	DATE	AMENDMENTS	DRG. NO.	REFERENCE DRAWING
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B	09/07/18	ISSUED FOR CLIENT REVIEW		
A	05/07/18	ISSUED FOR INTERNAL REVIEW		

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CLIENT: ACH

	BY	DATE	INITIAL
DRAWN :	D.SIBANIC	30/06/18	
DESIGNED :	M.HANGER	30/06/18	
CHECKED :	M.HANGER	06/07/18	
ORIGINATOR :			
COMPANY :			
APPROVED :			

TITLE
ACH MINERALS PTY LTD
GOLDEN EAGLE PROJECT PRELIMINARY DESIGN
MAIN EMBANKMENT
CROSS SECTIONS - SHEET 2 OF 5

SCALE: 1:250 @ A1

DRAWING No.: DE-004

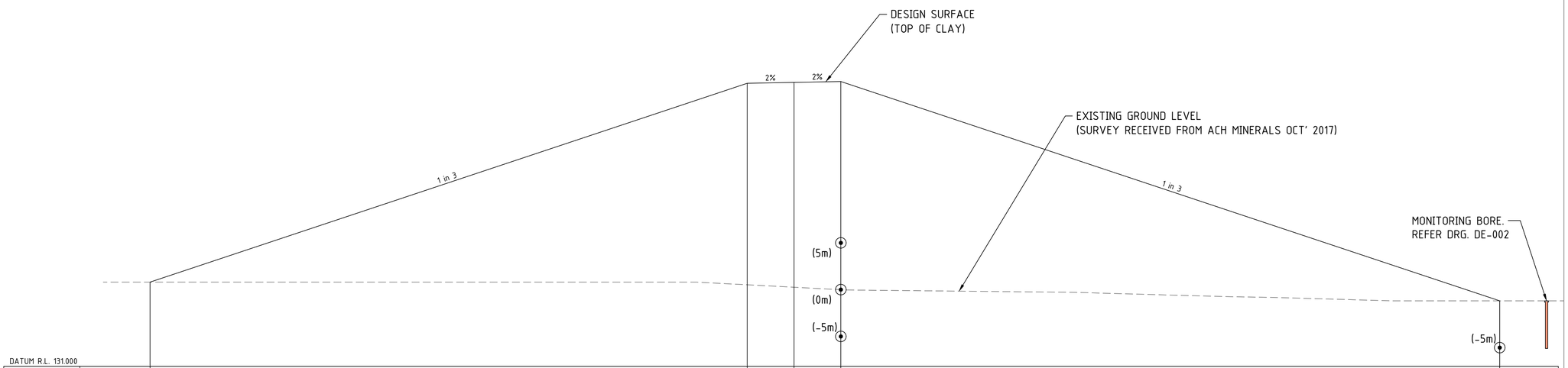
REV: C

NOTES:

1. REFER TO DRG. DE-001 FOR NOTES.
2. REFER TO DRG. DE-009 FOR TYPICAL SECTION.

LEGEND:

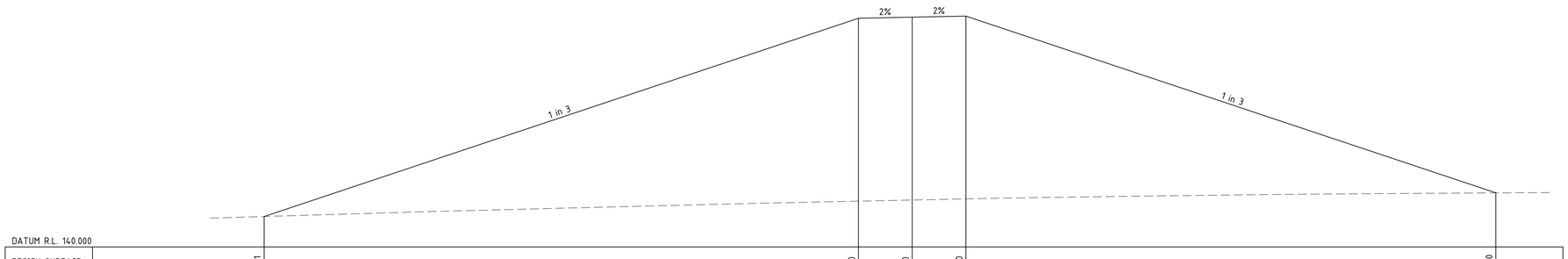
(5m) ⊙ PROPOSED VIBRATING WIRE PIEZOMETER (RELATIVE EXISTING GROUND LEVEL DEPTH IN METRES)



DATUM R.L. 131.000

DESIGN SURFACE (TOP OF CLAY)	140.000	161.250	161.350	161.450	138.000	
DEPTH CUT - / FILL +	0.000	21.531	21.894	22.256	0.000	
SURVEY	140.000	139.719	139.456	139.194	138.000	
OFFSET FROM REF. LINE	-68.750	-5.000	0.000	5.000	75.350	

CH 865



DATUM R.L. 140.000

DESIGN SURFACE (TOP OF CLAY)	142.821	161.250	161.350	161.450	145.020	
DEPTH CUT - / FILL +	0.000	17.001	16.995	16.990	0.000	
SURVEY	142.821	144.249	144.355	144.460	145.020	
OFFSET FROM REF. LINE	-60.286	-5.000	0.000	5.000	54.291	

CH 800

FOR INFORMATION ONLY

NOT FOR CONSTRUCTION

5 0 5 10 15 Metres

SCALE 1 : 250

REV	DATE	AMENDMENTS	DRG. NO.	REFERENCE DRAWING
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CHECKED :	M.HANGER	06/07/18	
ORIGINATOR :			
COMPANY :			
APPROVED :			

TITLE
ACH MINERALS PTY LTD
GOLDEN EAGLE PROJECT PRELIMINARY DESIGN
MAIN EMBANKMENT
CROSS SECTIONS - SHEET 3 OF 5

SCALE 1:250 @ A1

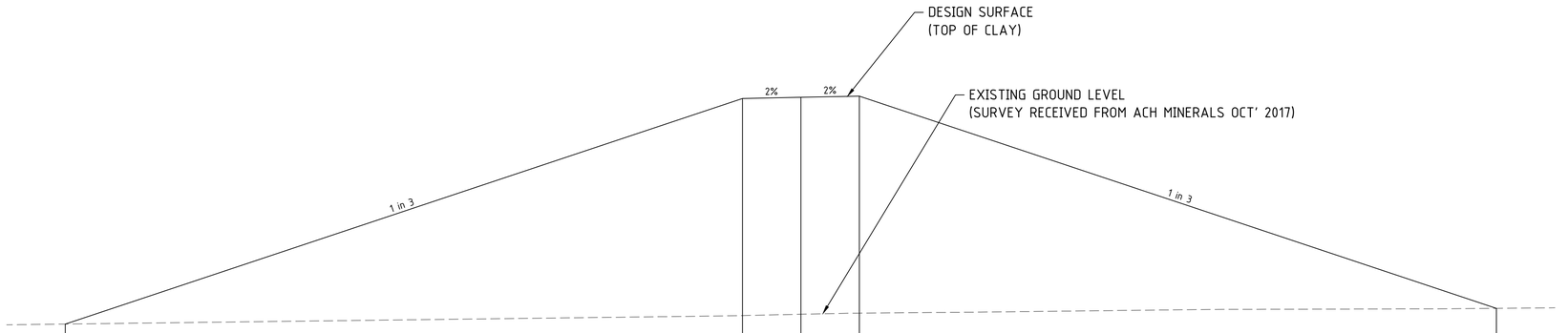
DRAWING No. DE-005

REV C

Cad File: C:\Users\MHA Geotechnical\REC Group\MHA Geotechnical - 1. MHA Project Folders\3 - Projects 2017\P17-02 ACH Minerals Ltd\2. Project Information\Drawings\Working\DE-005.dwg 8-Aug-18 - 03:44:47 PM

A1 Border v1.4

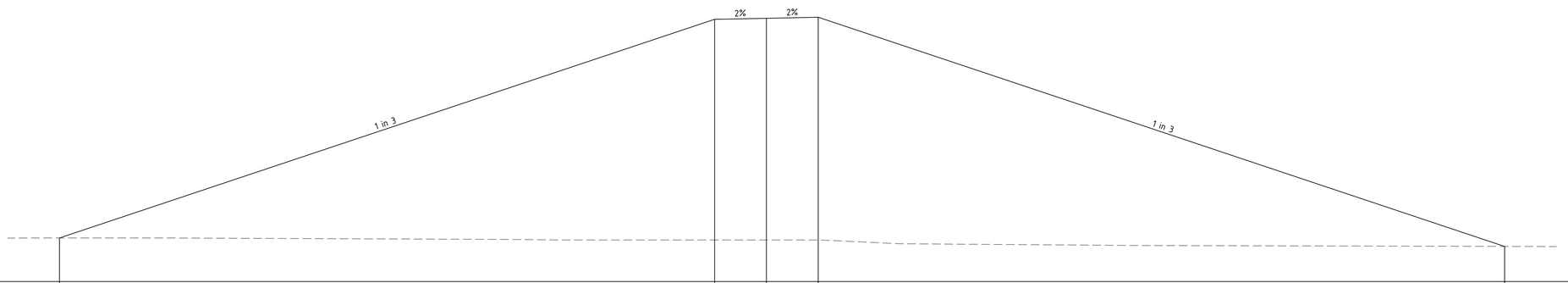
NOTES:
1. REFER TO DRG. DE-001 FOR NOTES.
2. REFER TO DRG. DE-009 FOR TYPICAL SECTION.



DATUM R.L. 139.000

DESIGN SURFACE (TOP OF CLAY)	141.957	161.250	161.350	161.450	143.301	
DEPTH CUT - / FILL +	0.000	18.564	18.554	18.561	0.000	
SURVEY	141.957	142.686	142.795	142.889	143.301	
OFFSET FROM REF. LINE	-62.819	-5.000	0.000	5.000	59.448	

CH 948.591



DATUM R.L. 136.000

DESIGN SURFACE (TOP OF CLAY)	140.188	161.250	161.350	161.450	139.381	
DEPTH CUT - / FILL +	0.000	21.250	21.350	21.450	0.000	
SURVEY	140.188	140.000	140.000	140.000	139.381	
OFFSET FROM REF. LINE	-68.187	-5.000	0.000	5.000	71.208	

CH 900

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NOT FOR CONSTRUCTION

5 0 5 10 15 Metres
SCALE 1 : 250

REV	DATE	AMENDMENTS	DRG. NO.	REFERENCE DRAWING
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CHECKED :	M.HANGER	06/07/18	
ORIGINATOR :			
COMPANY :			
APPROVED :			

TITLE
ACH MINERALS PTY LTD
GOLDEN EAGLE PROJECT PRELIMINARY DESIGN
MAIN EMBANKMENT
CROSS SECTIONS - SHEET 4 OF 5

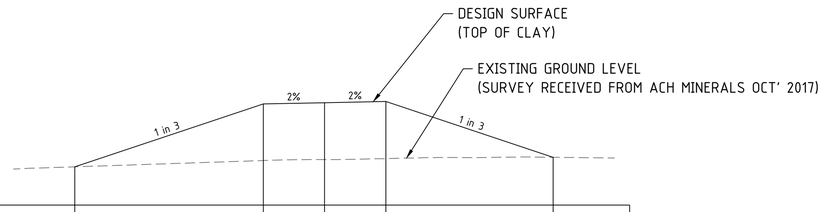
SCALE 1:250 @ A1

DRAWING No. DE-006

REV C

Cad File: C:\Users\MHA Geotechnical\REC Group\MHA Geotechnical - 1. MHA Project Folders\3 - Projects 2017\P17-02 ACH Minerals Ltd\2. Project Information\Drawings\Working\DE-006.dwg 8-Aug-18 - 03:11:59 PM

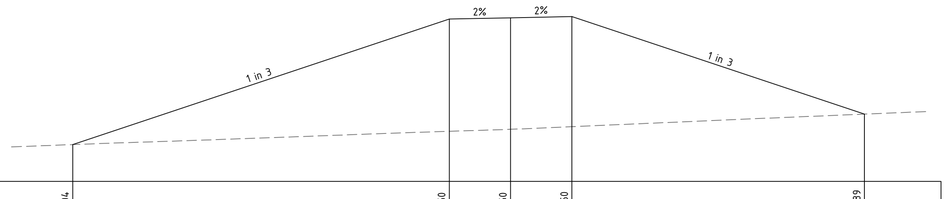
A1 Border v1.4



DATUM R.L. 153.000

DESIGN SURFACE (TOP OF CLAY)	156.122	161.250	161.350	161.450	156.898
DEPTH CUT - / FILL +	0.000	4.616	4.636	4.658	0.000
SURVEY	156.122	156.634	156.714	156.792	156.898
OFFSET FROM REF. LINE	-20.385	-5.000	0.000	5.000	18.655

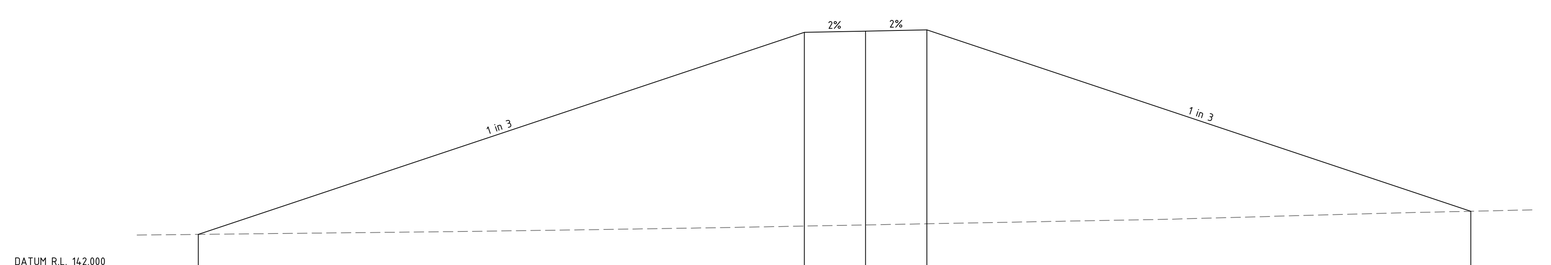
CH 1200



DATUM R.L. 148.000

DESIGN SURFACE (TOP OF CLAY)	151.004	161.250	161.350	161.450	153.489
DEPTH CUT - / FILL +	0.000	9.162	9.100	8.986	0.000
SURVEY	151.004	152.088	152.250	152.464	153.489
OFFSET FROM REF. LINE	-35.737	-5.000	0.000	5.000	28.882

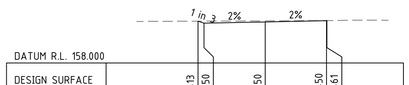
CH 1100



DATUM R.L. 142.000

DESIGN SURFACE (TOP OF CLAY)	144.762	161.250	161.350	161.450	146.651
DEPTH CUT - / FILL +	0.000	15.808	15.815	15.821	0.000
SURVEY	144.762	145.442	145.535	145.629	146.651
OFFSET FROM REF. LINE	-54.463	-5.000	0.000	5.000	49.398

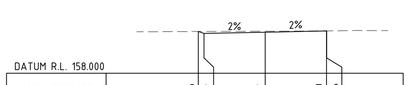
CH 1000



DATUM R.L. 158.000

DESIGN SURFACE (TOP OF CLAY)	161.413	161.250	161.350	161.450	161.461	
DEPTH CUT - / FILL +	0.000	-0.165	-0.086	-0.010	0.000	
SURVEY	161.413	161.415	161.436	161.460	161.461	
OFFSET FROM REF. LINE	-5.489	-5.000	0.000	5.000	5.032	

CH 1300.134



DATUM R.L. 158.000

DESIGN SURFACE (TOP OF CLAY)	161.406	161.250	161.350	161.450	161.454
DEPTH CUT - / FILL +	0.000	-0.158	-0.079	-0.004	0.000
SURVEY	161.406	161.408	161.428	161.454	161.454
OFFSET FROM REF. LINE	-5.467	-5.000	0.000	5.000	5.011

CH 1300

NOTES:
1. REFER TO DRG. DE-001 FOR NOTES.
2. REFER TO DRG. DE-009 FOR TYPICAL SECTION.

FOR INFORMATION ONLY

NOT FOR CONSTRUCTION

5 0 5 10 15 Metres
SCALE 1 : 250

REV	DATE	AMENDMENTS	DRG. NO.	REFERENCE DRAWING
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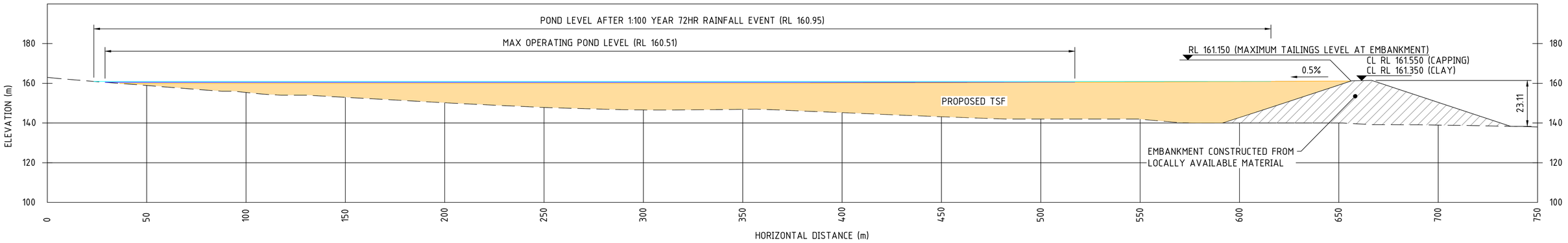
DESIGNED :	M.HANGER	30/06/18	
CHECKED :	M.HANGER	06/07/18	
ORIGINATOR :			
COMPANY :			
APPROVED :			

TITLE
ACH MINERALS PTY LTD
GOLDEN EAGLE PROJECT PRELIMINARY DESIGN
MAIN EMBANKMENT
CROSS SECTIONS - SHEET 5 OF 5

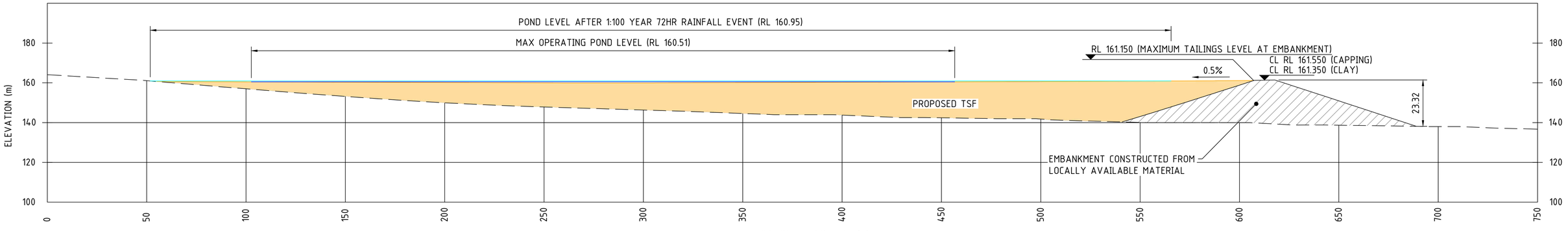
SCALE 1:250 @ A1

DRAWING No. DE-007

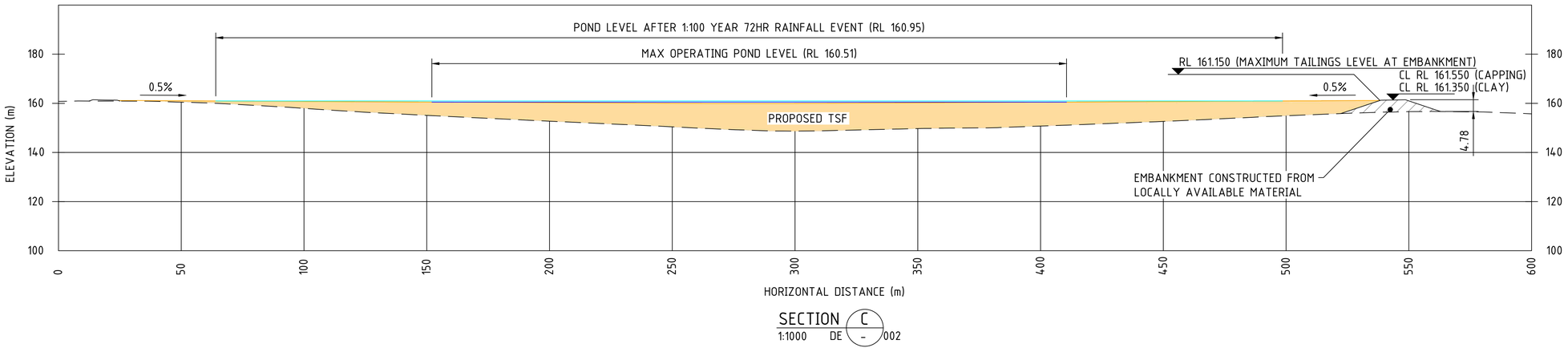
REV C



SECTION A
1:1000 DE - 002



SECTION B
1:1000 DE - 002



SECTION C
1:1000 DE - 002

NOTES:
1. REFER TO DRG. DE-001 FOR NOTES.
2. REFER TO DRG. DE-009 FOR TYPICAL SECTION.

FOR INFORMATION ONLY

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20 0 20 40 60 Metres
SCALE 1 : 1000

REV	DATE	AMENDMENTS	DRG. NO.	REFERENCE DRAWING
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ORIGINATOR :			
COMPANY :			
APPROVED :			

TITLE
ACH MINERALS PTY LTD
GOLDEN EAGLE PROJECT PRELIMINARY DESIGN
MAIN EMBANKMENT
SECTIONS

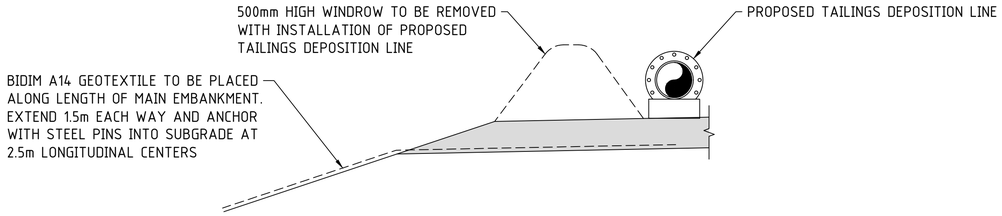
SCALE
1:1000 @ A1

DRAWING No. DE-008

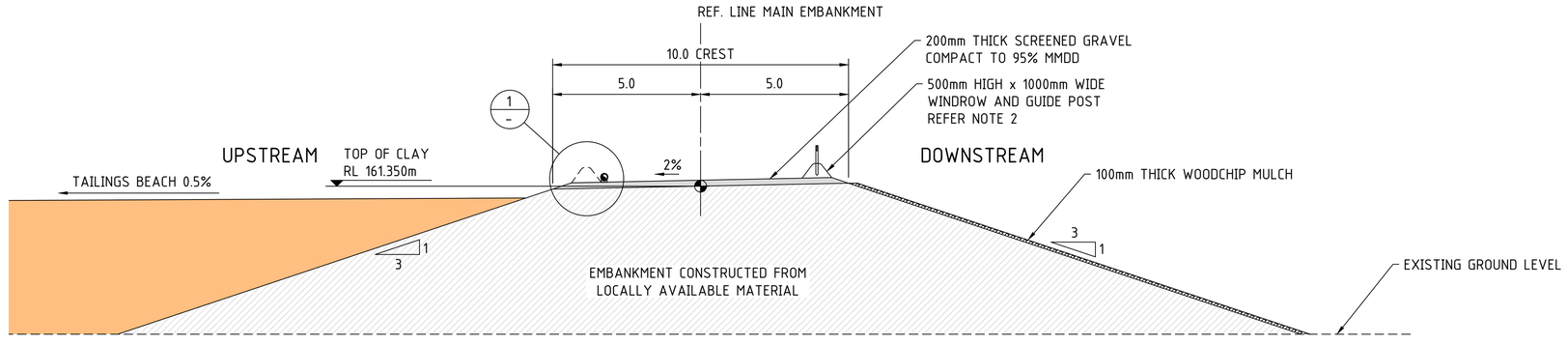
REV C

Cad File: C:\Users\MHA Geotechnical\REC Group\MHA Geotechnical - 1. MHA Project Folders\3 - Projects 2017\P17-02 ACH Minerals Ltd\2. Project Information\Drawings\Working\DE-008.dwg 8-Aug-18 - 03:14:23 PM

A1 Border v1.4



DETAIL 1/-
1:20



TYPICAL SECTION - MAIN EMBANKMENT
1:100

NOTES:
1. REFER TO DRG. DE-001 FOR NOTES.

REFERENCE DRAWINGS
DE-001 - SITE LAYOUT AND DRAWING INDEX
DE-002 - MAIN EMBANKMENT GENERAL ARRANGEMENT

FOR INFORMATION ONLY

NOT FOR CONSTRUCTION

0.4 0 0.4 0.8 1.2 Metres
SCALE 1 : 20

2 0 2 4 6 Metres
SCALE 1 : 100

REV	DATE	AMENDMENTS	DRG. NO.	REFERENCE DRAWING
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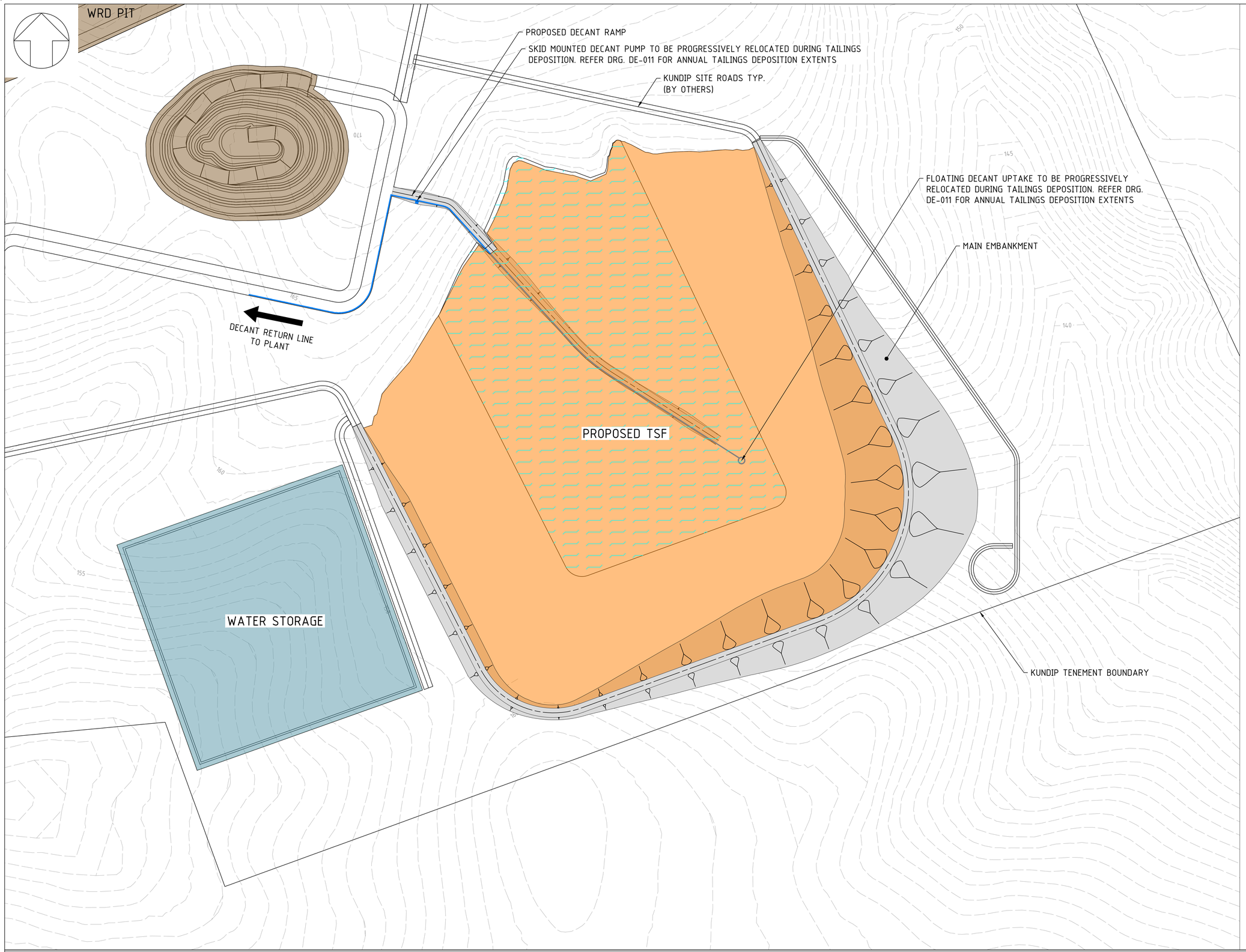
ORIGINATOR :			
COMPANY :			
APPROVED :			

TITLE
ACH MINERALS PTY LTD
GOLDEN EAGLE PROJECT PRELIMINARY DESIGN
MAIN EMBANKMENT
SECTIONS AND DETAILS

SCALE
AS SHOWN @ A1

DRAWING No. DE-009

REV C



NOTES:

1. REFER TO DRG. DE-001 FOR NOTES.

LEGEND:

- MAXIMUM TAILINGS DEPOSITION EXTENTS (RL 161.15 AT EMBANKMENT)
- MAXIMUM NORMAL OPERATING POND EXTENT (RL 160.510)
- RETURN WATER LINE AND SKID MOUNTED DECANT PUMP

FOR INFORMATION ONLY

NOT FOR CONSTRUCTION

40 0 40 80 120 Metres

SCALE 1 : 2,000

REV	DATE	AMENDMENTS	DRG. NO.	REFERENCE DRAWING
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B	09/07/18	ISSUED FOR CLIENT REVIEW		
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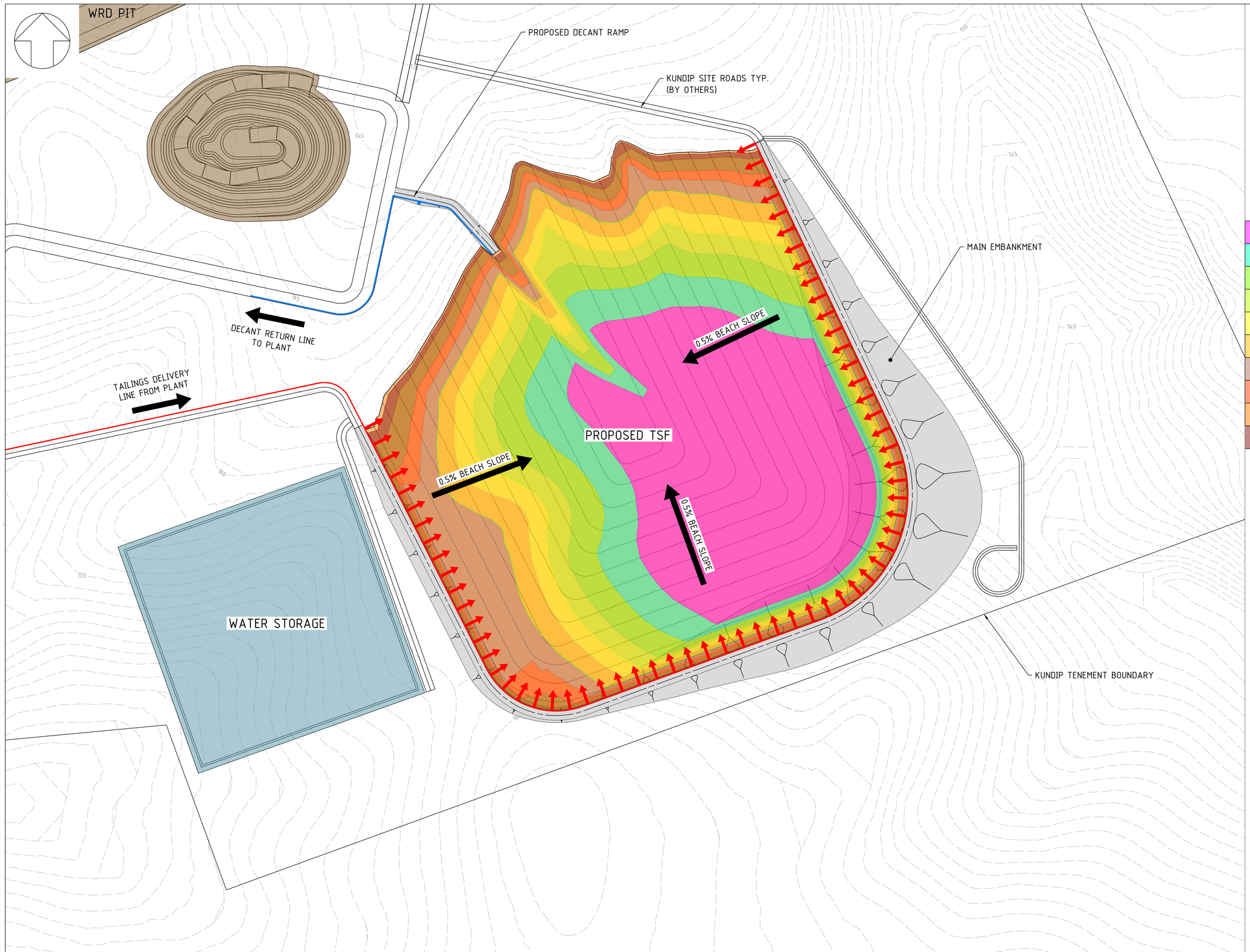
ORIGINATOR :			
COMPANY :			
APPROVED :			

TITLE
ACH MINERALS PTY LTD
GOLDEN EAGLE PROJECT PRELIMINARY DESIGN
DECANT
ARRANGEMENT AND DETAILS

SCALE: 1:2,000 @ A1

DRAWING No.: DE-010

REV: C



NOTES:

1. REFER TO DRG. DE-001 FOR NOTES.

LEGEND:

TAILINGS DISTRIBUTION LINE AND SPIGOTS AT 20m SPACINGS

ANNUAL TAILINGS DEPOSITION

YEAR	RL (m)	AREA (m)	VOLUME (m3)
1	150.000	86,281	276,902
2	152.200	114,862	476,002
3	154.000	139,720	687,479
4	155.400	160,143	884,117
5	156.600	178,597	1,076,217
6	157.800	197,442	1,291,566
7	158.800	222,387	1,495,082
8	159.600	233,107	1,672,648
9	160.600	244,099	1,906,593
10	161.000	246,811	2,003,623

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40 0 40 80 120 Metres

SCALE 1 : 2,000

REV	DATE	AMENDMENTS	DRG. NO.	REFERENCE DRAWING
C	08/08/18	ISSUED FOR CLIENT REVIEW		
B	09/07/18	ISSUED FOR CLIENT REVIEW		
A	05/07/18	ISSUED FOR INTERNAL REVIEW		

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CLIENT ACH

	BY	DATE	INITIAL
DRAWN :	D.SIBANIC	30/06/18	
DESIGNED :	M.HANGER	30/06/18	
CHECKED :	M.HANGER	06/07/18	
ORIGINATOR :			
COMPANY :			
APPROVED :			

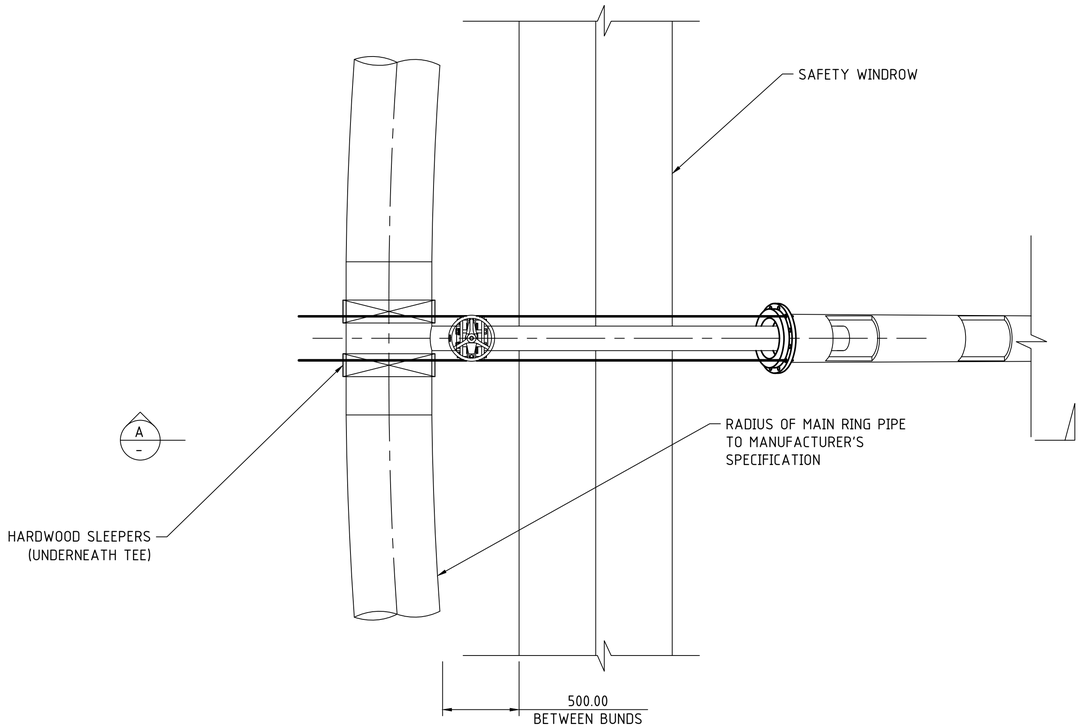
TITLE
ACH MINERALS PTY LTD
GOLDEN EAGLE PROJECT PRELIMINARY DESIGN
TAILINGS DISTRIBUTION NETWORK
GENERAL ARRANGEMENT

SCALE 1:2,000 @ A1

DRAWING No. DE-011

REV C

NOTES:
1. REFER TO DRG. DE-001 FOR NOTES.



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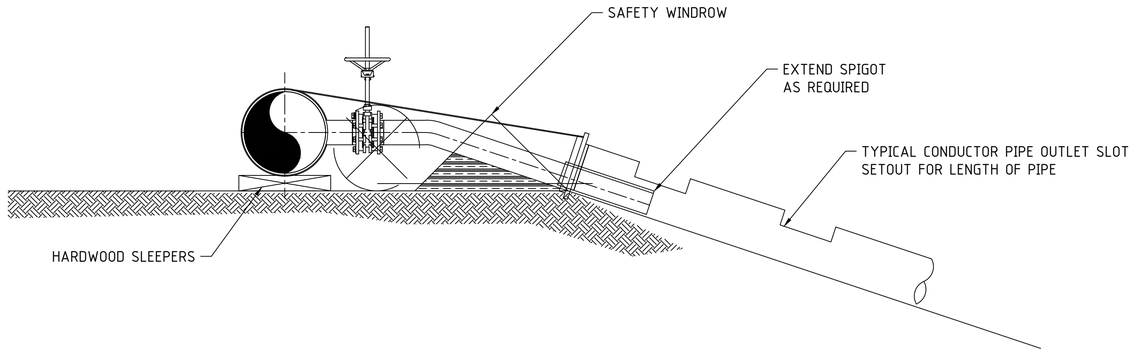

SECTION A
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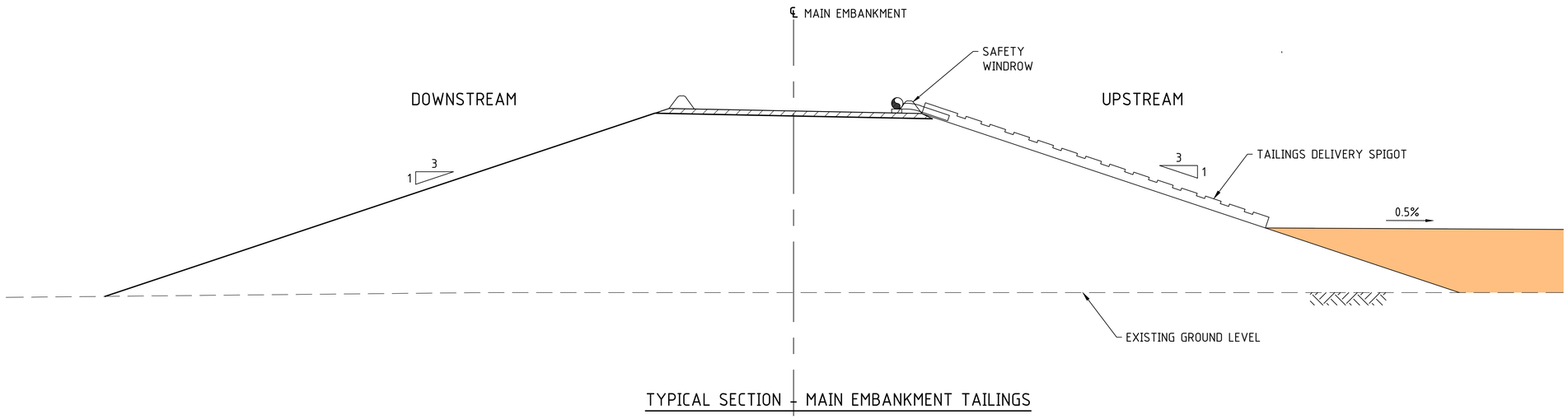
-



TYPICAL SECTION - MAIN EMBANKMENT TAILINGS
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SCALE 1 : 20

2 0 2 4 6 Metres
SCALE 1 : 100

REV	DATE	AMENDMENTS	DRG. NO.	REFERENCE DRAWING
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B	09/07/18	ISSUED FOR CLIENT REVIEW		
A	05/07/18	ISSUED FOR INTERNAL REVIEW		

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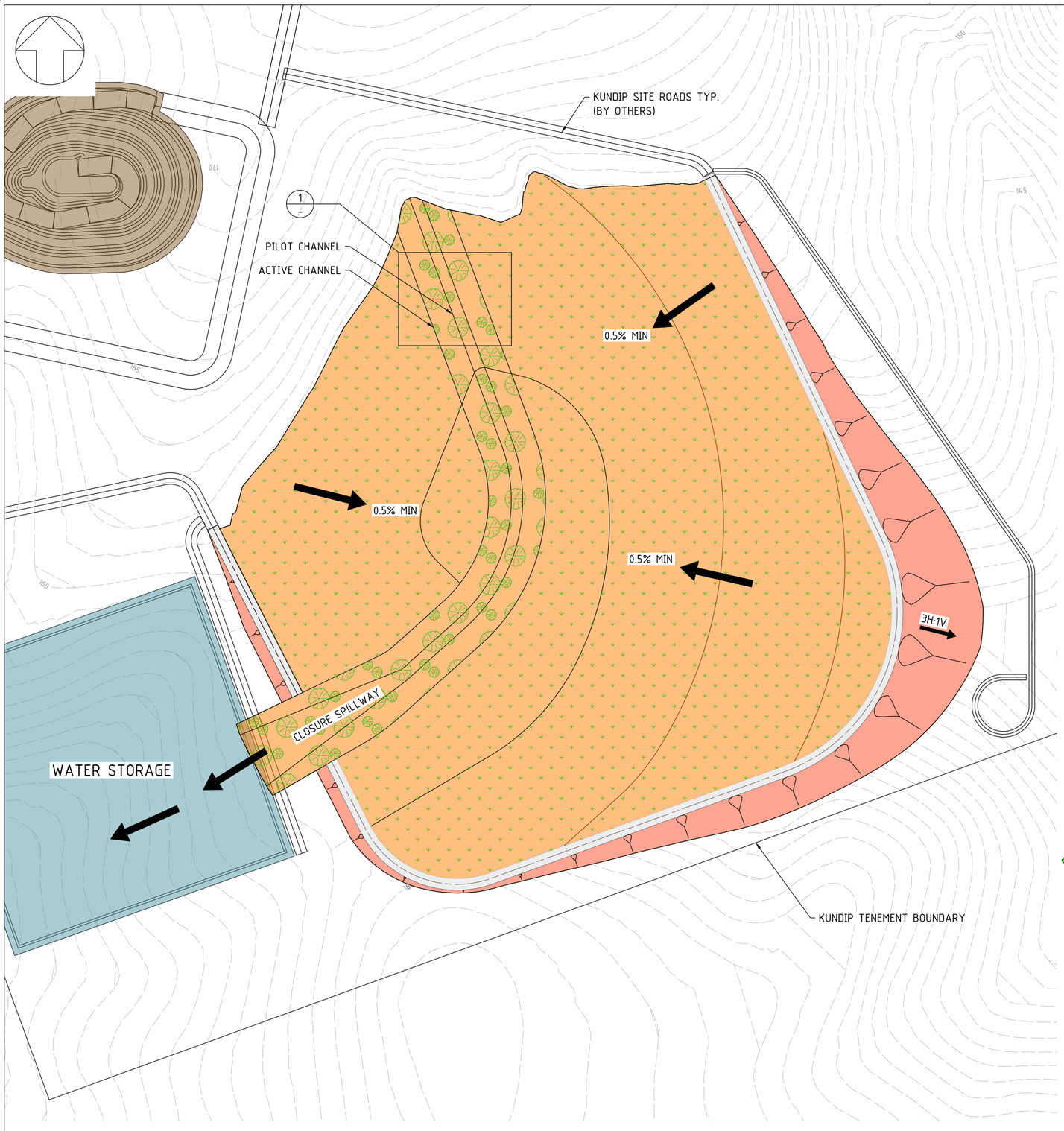
ORIGINATOR :			
COMPANY :			
APPROVED :			

TITLE
ACH MINERALS PTY LTD
GOLDEN EAGLE PROJECT PRELIMINARY DESIGN
TAILINGS DISTRIBUTION NETWORK
SECTIONS AND DETAILS

SCALE: AS SHOWN @ A1

DRAWING No. DE-012

REV C



PLAN
1:2000

NOTES:
1. REFER TO DRG. DE-001 FOR NOTES.

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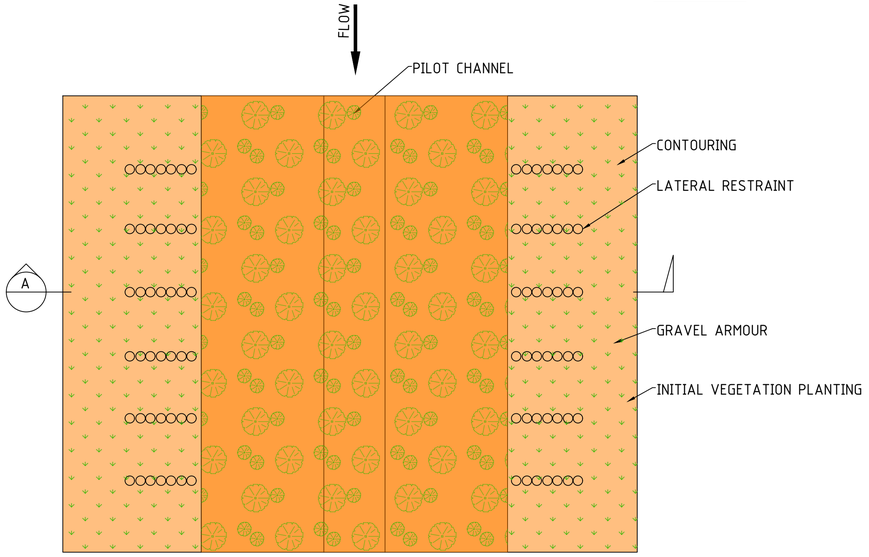
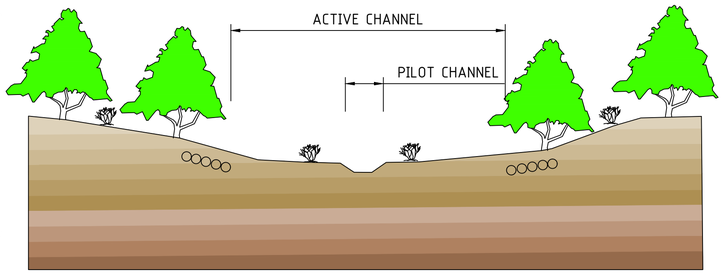
- EMBANKMENT CREST
- WASTE BACKFILL COVER
- ACTIVE CHANNEL



ACTIVE CHANNEL

WIDTH SCALED FROM PRE-MINING TOPOGRAPHY
PHOTOGRAPHY QW > 100 YEARS ARI

DETAIL 1 / N.T.S. -



SECTION A / N.T.S. -

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SCALE 1 : 2,000

REV	DATE	AMENDMENTS	DRG. NO.	REFERENCE DRAWING
C	08/08/18	ISSUED FOR CLIENT REVIEW		
B	09/07/18	ISSUED FOR CLIENT REVIEW		
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DRAWN :	D.SIBANIC	30/06/18	
DESIGNED :	M.HANGER	30/06/18	
CHECKED :	M.HANGER	06/07/18	
ORIGINATOR :			
COMPANY :			
APPROVED :			

TITLE
ACH MINERALS PTY LTD
GOLDEN EAGLE PROJECT PRELIMINARY DESIGN
CONCEPTUAL CLOSURE PLAN

SCALE: 1:2,000 @ A1

DRAWING No.: DE-013

REV: C

Appendix B: Populations of five Priority Flora species in the Kundip Development Envelope (Dr G.F. Craig)

ACH Minerals Pty Ltd
Ravensthorpe Gold Project ERD

Populations of five Priority Flora species in the Kundip Development Envelope

A report prepared for
ACH Minerals Pty Ltd
Lot 1968 Hopetoun-Ravensthorpe Rd, Ravensthorpe WA 6346

January 2020

Dr G F Craig
Environmental Consultant
ABN: 96 108 756 719
PO Box 130, Ravensthorpe 6346
P 08 9838 1071

DISCLAIMER

In undertaking this work, the author has made every effort to ensure the accuracy of the information used. Any conclusions drawn or recommendations made in the report and maps are done in good faith and the consultant takes no responsibility for how this information is used subsequently by others.

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Cover photo:

Melaleuca sophisma at Ravensthorpe Gold Project area, Kundip

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Executive Summary

The Ravensthorpe Gold Project (RGP) is a proposal by ACH Minerals Pty Ltd to mine for gold and copper on the Kundip mining leases (tenements M74/41, 51, 53 & 135 and P74/153) located approximately 17 km south-east of Ravensthorpe and 31 km north of the coastal town of Hopetoun.

Five Priority flora species occur within the RGP Development Envelope.The Department of Biodiversity, Conservation and Attactions (DBCA) requested further information on the known populations of these species, especially abundance data.

Searches were made of the WA Herbarium specimen database (WAHerb) and the Threatened and Priority Flora database (TPFL). It was found that DBCA had not updated their TPFL databases for 10 years for these species. Subsequently, copies were obtained of Threatened and Priority Flora report forms that had not been databased. Data from DBCA, previous surveys in the Kundip area and targeted surveys in December 2019 of the known locations within the RGP Development Envelope and a 20 m buffer were collated into a single database.

The results are summarized in the following table:

TaxonName	WAConStat	TOTAL known plants	Abundance in Development Envelope & buffer	Percentage of known populations (%)
Calothamnus roseus	P1	4,700	3,200	68
Melaleuca sophisma	P1	60,247	347	0.6
Hydrocotyle tuberculata	P2	237	-[1]	-
Thomasia sp. Hopetoun (K.R. Newbey 4896)	P2	243	44	18
Dampiera sp. Ravensthorpe (G.F. Craig 8277)	P3	36,893	-[2]	-

[1] annual plant not found in Dec 2019 survey; c. 60 plants in 2011; previously 110 plants in 2005
[2] not found in Dec 2019 survey; 1500 plants in 2009

The December 2019 survey failed to find either the annual *Hydrocotyle tuberculata* due to the dry conditions or *Dampiera* sp. Ravensthorpe (G.F. Craig 8277). It is not known whether the latter species is a short-lived perennial and has disappeared from the site until another fire or disturbance occurs, or the author was unable to find this cryptic species because it was not flowering. Seed banks of both species would still remain at their known sites. Surveys in winter-spring for *Dampiera* sp. Ravensthorpe and in October for *Hydrocotyle tuberculata* are recommended.

Introduction

ACH Minerals propose to mine for gold and copper on the Kundip mining leases (tenements M74/41, 51, 53 & 135 and P74/153) which comprise approximately 664 ha, the majority of which is located east of the Hopetoun-Ravensthorpe Road, 17 km south east of Ravensthorpe and 31 km north of the coastal town of Hopetoun.

ACH Minerals requested that further information on known populations of five species within the Development Envelope of their Ravensthorpe Gold Project and at 'Ard Patrick' to the north be surveyed and collated (Figs 1 and 2, Table 1).

Table 1 – Five Priority species targeted for survey

Priority	Taxon	Work required
P1	*Calothamnus roseus*	• Visit the known population within Development Envelope and undertake population counts. • Undertake a population count of the known population in a 20 m buffer adjoining the Development Envelope.
P1	*Melaleuca sophisma*	• Visit the known populations within Development Envelope and undertake population counts. • Undertake a population count of the known population in a 20 m buffer adjoining the Development Envelope. • Visit the known population at Ard Patrick and undertake a population count.
P2	*Hydrocotyle tuberculata*	• Visit the known populations within Development Envelope and undertake population counts (if possible, species is an annual).
P2	*Thomasia* sp. Hopetoun (KR Newbey 4896)	• Visit the two known locations within Development Envelope and undertake population counts. • Collect all available data on plant counts from other locations.
P3	*Dampiera* sp. Ravensthorpe (GF Craig 8277)	• Visit the one known location within Development Envelope and undertake a population count. • Collect all available data on plant counts from other locations.

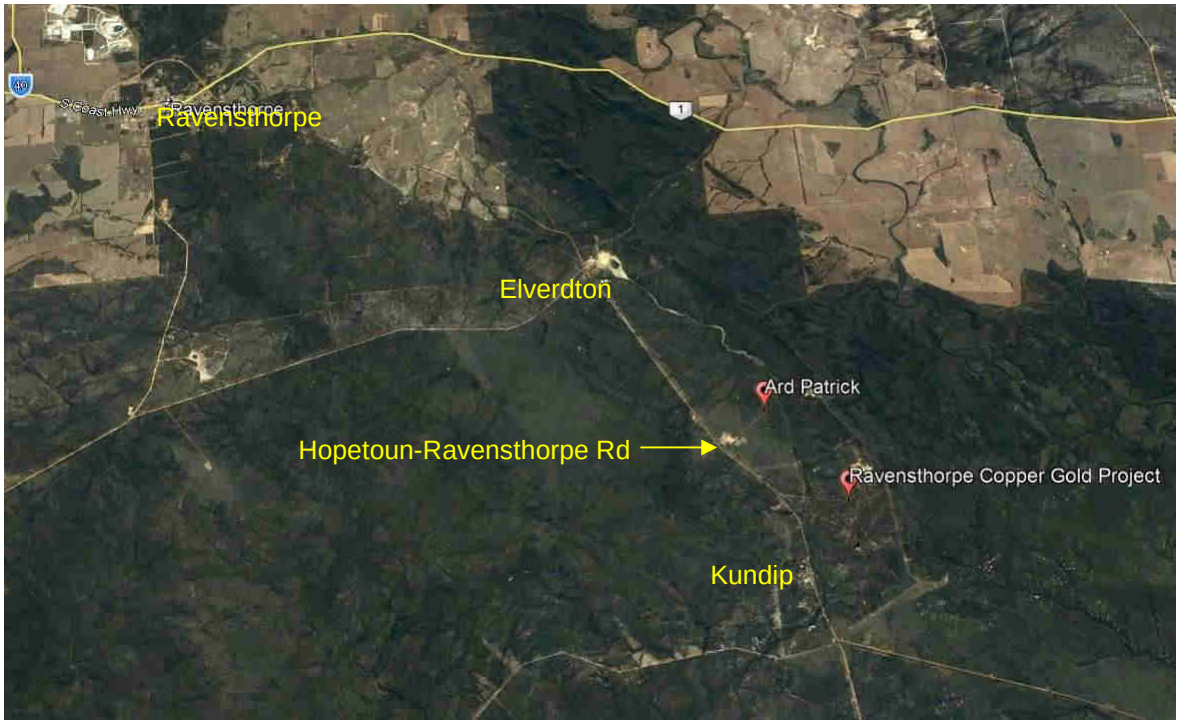

Figure 1 – Location of the ACH Minerals' Ravensthorpe Gold Project and 'Ard Patrick'.

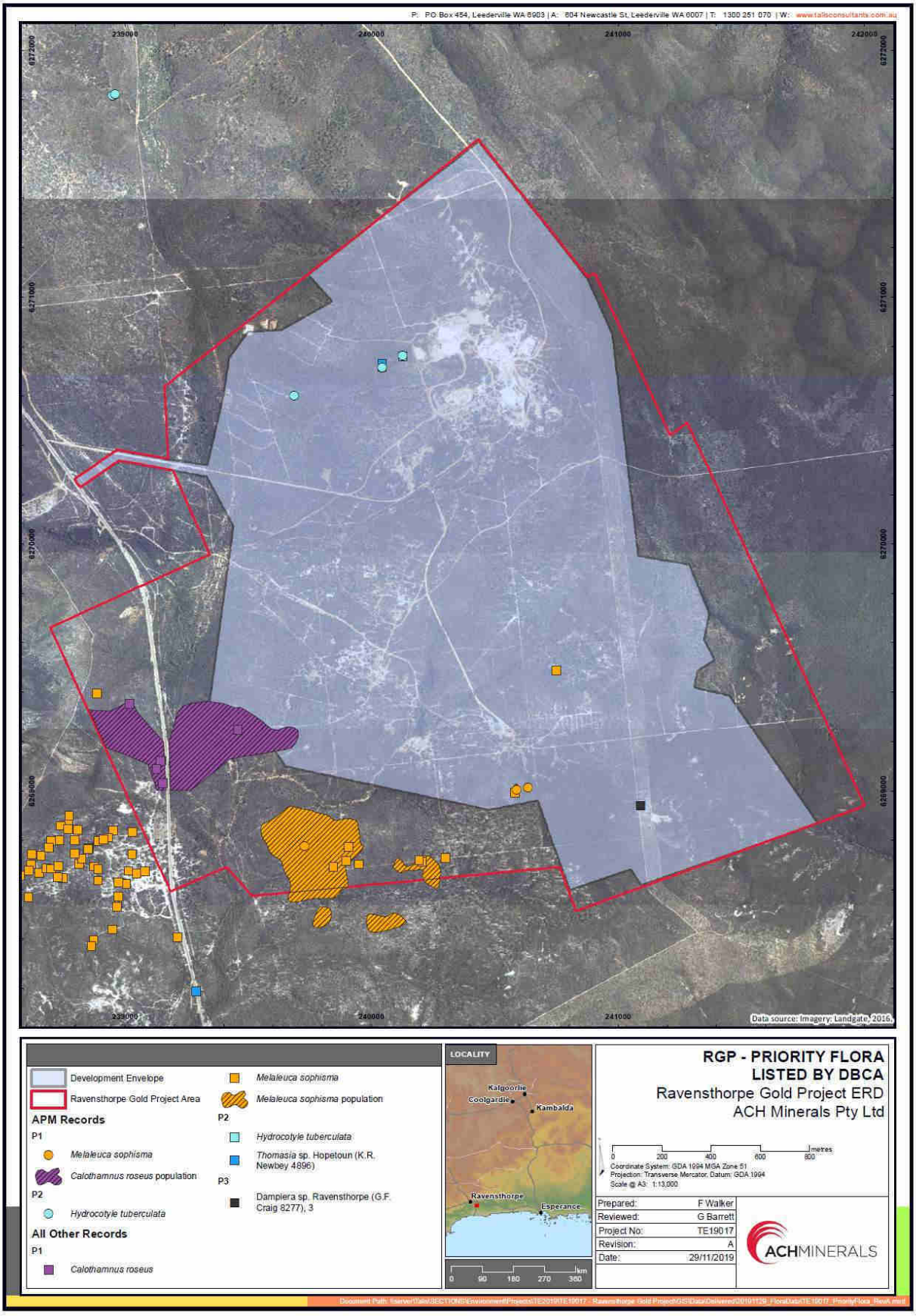

Figure 2 – Location of five Priority species in the Kundip mining area.

Methods

Desktop
Priority flora population data of the five species which had been collated by Talis Consultants (Fig 1) which included data from APM (2017), McQuoid (2009), Hickman (2007, 2009) and database searches from the Department of Biodiversity, Conservation and Attractions (DBCA). The latter was recorded as 'DBCA Record' rather than whether the source was the WA Herbarium specimen database (WAHerb) or the Threatened and Priority Flora database (TPFL).

A request was made for DBCA database searches of WAHerb and TPFL for the five Priority flora species on 10 December 2019. Also, Sarah Barrett, Threatened Flora Officer, DBCA Albany District was asked for any additional information on these species.

All data was collated into an Excel file, including survey data from Craig (2004, 2011) which included information on *Melaleuca sophisma* (previously known as *Melaleuca* sp. Kundip) and *Hydrocotyle tuberculata* (previously known as *H. decipiens* ms). The Excel table was imported into a QGIS mapping program to obtain an overview of the distribution of the five species.

The polygon for *Calothamnus roseus* (Fig 2) was deleted from the database as it could not be ascertained whether this was a surveyed boundary by APM or extrapolated from known point locations.

Data was then packaged for the Index of Biodiversity Surveys for Assessments (IBSA). The Environmental Protection Authority (EPA), Department of Water and Environmental Regulation and Department of Mines, Industry Regulation and Safety require IBSA Data Packages to support assessment and compliance under the *Environmental Protection Act 1986*.

Field survey
The known populations of the five species, *Calothamnus roseus* (P1), *Melaleuca sophisma* (P1), *Hydrocotyle tuberculata* (P2), *Thomasia* sp. Hopetoun (KR Newbey 4896) (P2) and *Dampiera* sp. Ravensthorpe (GF Craig 8277) (P3) were surveyed within the Development Envelope and an adjoining 20 m buffer on 9 December 2019. Weather conditions were warm (max 26^{o}C) and dry. Each patch was GPSed and actual counts of plants made, except for the three large patches of *Calothamnus roseus.* The boundary of each patch of >100 plants was tracked.

On 17 December 2019, an estimate of population size of the three large patches of *Calothamnus roseus* was made using the Wandering Quarter method (Catana, 1963) assisted by Vern Jones, Project Manager, ACH Minerals. Also, the 'Ard Patrick' site was surveyed for *Melaleuca sophisma.*

Results

Desktop
DBCA provided WAHerb and TPFL database information on 17/12/2019 (Ref: 20-1219FL), although their Flora Technical Officer noted that "not all Priority flora populations have been entered into the database. Therefore there were no results of a search of this database for the following species as these species are yet to be databased on TPFL:

- *Calothamnus roseus*
- *Thomasia* sp. Hopetoun (KR Newbey 4896)
- *Dampiera* sp. Ravensthorpe (GF Craig 8277).

There is also additional information on our [DBCA] files that has not yet been entered into TPFL for the following species (including the date of the last time the information on the file was entered into TPFL):

- *Calothamnus roseus*
- *Melaleuca sophisma* (February 2009)
- *Thomasia* sp. Hopetoun (KR Newbey 4896)
- *Dampiera* sp. Ravensthorpe (GF Craig 8277)."

Sarah Barrett (Threatened Flora Officer, DBCA Albany) provided additional Threatened Flora Report Forms for:

- *Calothamnus roseus* (2012)
- *Thomasia* sp. Hopetoun (KR Newbey 4896) (2011,2013, 2015)
- *Dampiera* sp. Ravensthorpe (GF Craig 8277) (2010 – which equated to WAHerb specimen data)

Tim Hammer, a botanist with Spectrum Ecology, accessed Threatened and Priority Flora (TPF) report forms on DBCA's files on 9/1/2020. These were sent to the author for inclusion in the collated database.

APM (2019), McQuoid (2009), Hickman (2007), Craig (2004 & 2011) provided information on all five species. It should be noted that there are five TPF reports by McQuoid (dated 17/3/2009) which duplicate the information given in McQuoid (2009). The latter were not added to the database. All desktop and new field data was collated into shapefiles:

- ACH_2B_Flora_ALL_pt.shp (includes point data on all five species)
- ACH_2B_Flora_Calothamnus roseus_py.shp
- ACH_2B_Flora_Melaleuca sophisma_py. shp

Field survey

Calothamnus roseus (P1)

The known range of *Calothamnus roseus* is 11 km with three main populations, i.e. Kundip Nature Reserve, Road Eleven and the Kundip area (which includes a number of sub-populations). Interrogation of the WAHerb data found two specimens that had incorrect lat/longs compared to the location description.

Survey of the sub-population that occurs within the Development Envelope plus 20 m buffer found 8 discrete patches, varying in size from 6 to an estimated 1250 plants (Figs 3 & 4). This represents 68% of the known plants of *C. roseus* (Table 2).

Plate 1 – *Calothamnus roseus* fruits

Table 2 – Population summary of *Calothamnus roseus*

SiteName	Abundance	Percentage of known populations (%)
Eastern end of Kundip Plateau, Kundip Nature Reserve*	100	2
Road Eleven, WSW of Kundip	800	17
Small hill, W side of the Ravensthorpe - Hopetoun Road, 1.4 km N of Kundip	200	4
Kundip, Hopetoun-Ravensthorpe Rd	500	11
Ravensthorpe Gold Project - Development Envelope (DE)	**1700**	36
Ravensthorpe Gold Project - 20 m buffer adjoining DE	**1500**	32
TOTAL	4700	

*abundance = "common on summit only" so nominated 100 plants

Melaleuca sophisma (P1)

Melaleuca sophisma (previously known as *Melaleuca* sp. Kundip (GF Craig 6020)) is an erect, robust shrub, 1-2 m tall with recurved leaves and white flowers. It is an obligate seeder that grows in dense stands, with individual plants often only a few centimetres apart. It is very vulnerable to disturbance, being killed by fire and maintenance activities such as firebreaks.

Plate 2 – *Melaleuca sophisma* flowers

McQuoid (2009) found that although *M. sophisma* is locally common in the immediate Kundip vicinity, it has a very restricted distribution within a 2.5 km x 1.5 km area (Fig 5). He considered there to be one population with an estimated 60,000 plants, which included five relatively indistinct sub-populations. One of these occurs in the Development Envelope and comprises less than 1% of the known plants (Table 3).

A search for the two locations at 'Ard Patrick', previously recorded by APM (2017) failed to find *M. sophisma.* The very similar looking *Melaleuca undulata* was common and could have been mistaken for the former species.

Table 3 – Population summary of *Melaleuca sophisma*

SiteName	Abundance	Percentage of known populations (%)
South of Kundip Mining leases, east of Hopetoun-Ravensthorpe Rd	1500	2.5
Kundip Mining Leases, east of Hopetoun-Ravensthorpe Rd (excl. DE)	26200	43.5
Kundip townsite and west of Hopetoun-Ravensthorpe Rd	14600	24.2
Road Eleven area, west of Hopetoun-Ravensthorpe Rd	17600	29.2
Ravensthorpe Gold Project - Development Envelope (DE)	**347**	**0.6**
TOTAL	60247	

Hydrocotyle tuberculata (P2)

Hydrocotyle tuberculata is a winter annual herb, with flowering and fruiting occurring from September to November (Perkins, 2018). It grows in winter-moist drainage areas in damp sandy loams. It is known from six other locations besides the Development Envelope at Kundip, extending from near Middle Mt Barren in the Fitzgerald River National Park to north-east of Esperance, a range of 250 km (Fig 6).

Plate 3 – *Hydrocotyle tuberculata* growing with moss in 2011.

The survey on 9 December 2019 failed to find any *H. tuberculata* (previously known as *H. decipiens* ms). The Kundip area has experienced below average rainfall for the past two years, with only 230 mm recorded at Ravensthorpe in 2019 compared with an annual average of 430 mm. It is therefore unlikely that this species successfully germinated this year.

In 2011, only two of the three sub-populations of *H. tuberculata* were relocated at the known location in the Development Envelope (Craig, 2011). At these two sites, the numbers of plants had considerably diminished since the 2005 survey by Craig (2005) (Fig 7).

Table 4 - Population summary of *Hydrocotyle tuberculata*

SiteName	Abundance
Fitzgerald River National Park, ca 6 km W of Middle Mount Barren	-
20 m north of Desmond Track (between Moir Rd and Hopetoun-Ravensthorpe Rd)	2
'Ard Patrick', 3 km N of Kundip	35
28.5 km E of Ravensthorpe along South Coast Highway	-
Salt lake, S side of Scaddan Road, 5.2 km E of Coolgardie-Esperance Highway	100
Mount Ridley, ca 80 miles NE of Esperance	100
Ravensthorpe Gold Project - Development Envelope (DE)	**N/A***
TOTAL	237

*Not found in Dec 2019; c. 60 plants in 2011; previously 110 plants in 2005

Thomasia sp. Hopetoun (K.R. Newbey 4896) (P2)

This is a soft, rounded shrub that grows to about 70 cm tall, has pale green leaves and white flowers in spring. It is known from five locations in the Fitzgerald River National Park as well as in the Elverdton – Kundip area, with a range of about 100 km (Fig 8).

Plate 4 - *Thomasia* sp. Hopetoun fruiting in 2019.

Population counts at each site are low (< 80 plants recorded per site) with a total of 243 plants overall. In the Kundip Development Envelope there were two patches 90 m apart in a creekline, totaling 44 plants in 2019 (Fig 9). This population represents about 18% of known plants (Table 5).

Table 5 - Population summary of *Thomasia* sp. Hopetoun

SiteName	Abundance	Percentage of known populations (%)
Quaalup	-	
Fitzgerald River National Park, Mount Bland area	30	12
Fitzgerald River National Park, Thumb Peak area	80	33
Fitzgerald River National Park, west of Quoin Head	9	4
Fitzgerald River National Park, Whoogarup Range	20	8
Elverton Rd area, east of Hopetoun-Ravensthorpe Rd	10	4
Adjacent Hopetoun-Ravensthorpe Road at Kundip	50	21
Ravensthorpe Gold Project - Development Envelope (DE)	**44**	**18**
TOTAL	243	

Dampiera sp. Ravensthorpe (G.F. Craig 8277) (P3)

This is a low, herbaceous shrub with multiple stems from the base and blue flowers It is known from a number of scattered populations through the Ravensthorpe System – on the Ravensthorpe Range and east to near Bandalup Hill, with a range of about 30 km, plus a disjunct population near Munglinip (over 100 km to the east) (Fig 10).

Plate 5 - *Dampiera* sp. Ravensthorpe growing in the Ravensthorpe Range in 2005.

The current survey failed to find any plants of this taxon in the Development Envelope, although 1500 plants had been recorded 10 years ago on the Kundip firebreak in open shrubland regenerating after fire (Fig 11). Recently, the firebreak has been scrub-rolled again.

There were three possible scenarios as to why there were no plants; (i) the original collection by D.Rathbone DAR 255 had been wrongly identified, or (ii) the species has disappeared from the site due to it being a short-lived plant, or (iii) I just didn't find it because it wasn't flowering and it was disguised by the common *Chorizema trigonum* which has superficially similar stems.

Plate 6 – Scrub-rolled firebreak at Kundip, Dec 2019.

Subsequently, Michael Hislop (DBCA WA Herbarium) confirmed the identification of DAR 255 is *Dampiera* sp. Ravensthorpe (G.F. Craig 8277). Therefore another survey is recommended between July and October, i.e. when this taxon should be flowering, to ascertain whether it is a short-lived disturbance opportunist or is so inconspicuous that it cannot be readily seen unless flowering.

Table 6 – Population summary of *Dampiera* sp. Ravensthorpe

SiteName	Abundance	Percentage of known populations (%)
Ravensthorpe Range, Mt McMahon-Mt Benson	44	0.1
Ravensthorpe Range, Cordingup Creek area	230	0.6
UCL north of the South Coast Highway, W of Nindabillup Road	35000	94.9
W of Hatfield Road	3	0.0
W side of Bandalup Hill	8	0.0
Shoemaker Levy, E of Bandalup Track	6	0.0
Rocky outcrop to side of Maydon link, E end of Ravensthorpe Range	2	0.0
Munglinup Mining Reserve	100	0.3
Ravensthorpe Gold Project - Development Envelope (DE)	**1500[1]**	**4.1**
TOTAL	36893	

[1] not found in Dec 2019 survey; 1500 plants in 2009

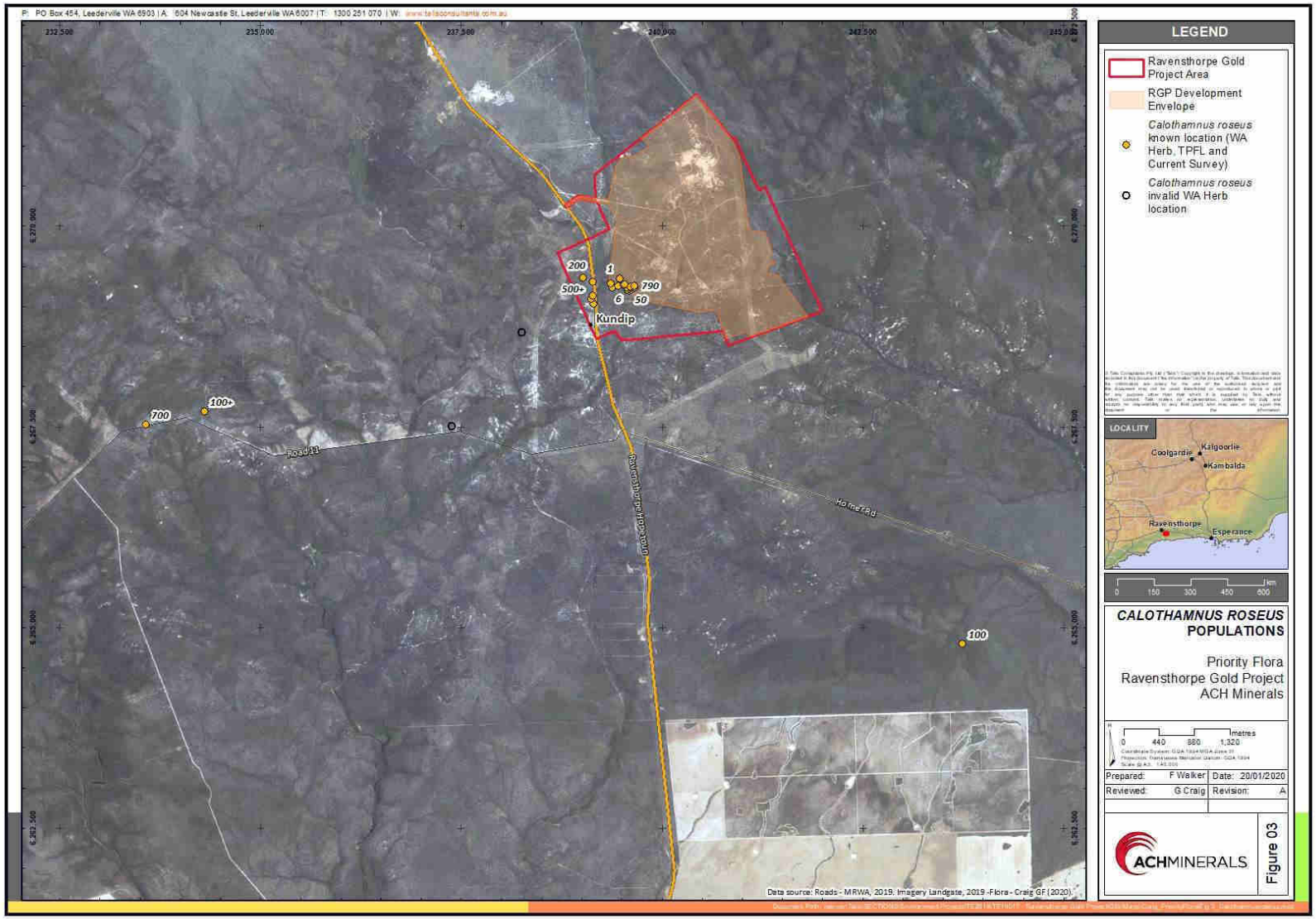

Figure 3 – Known *Calothamnus roseus* populations

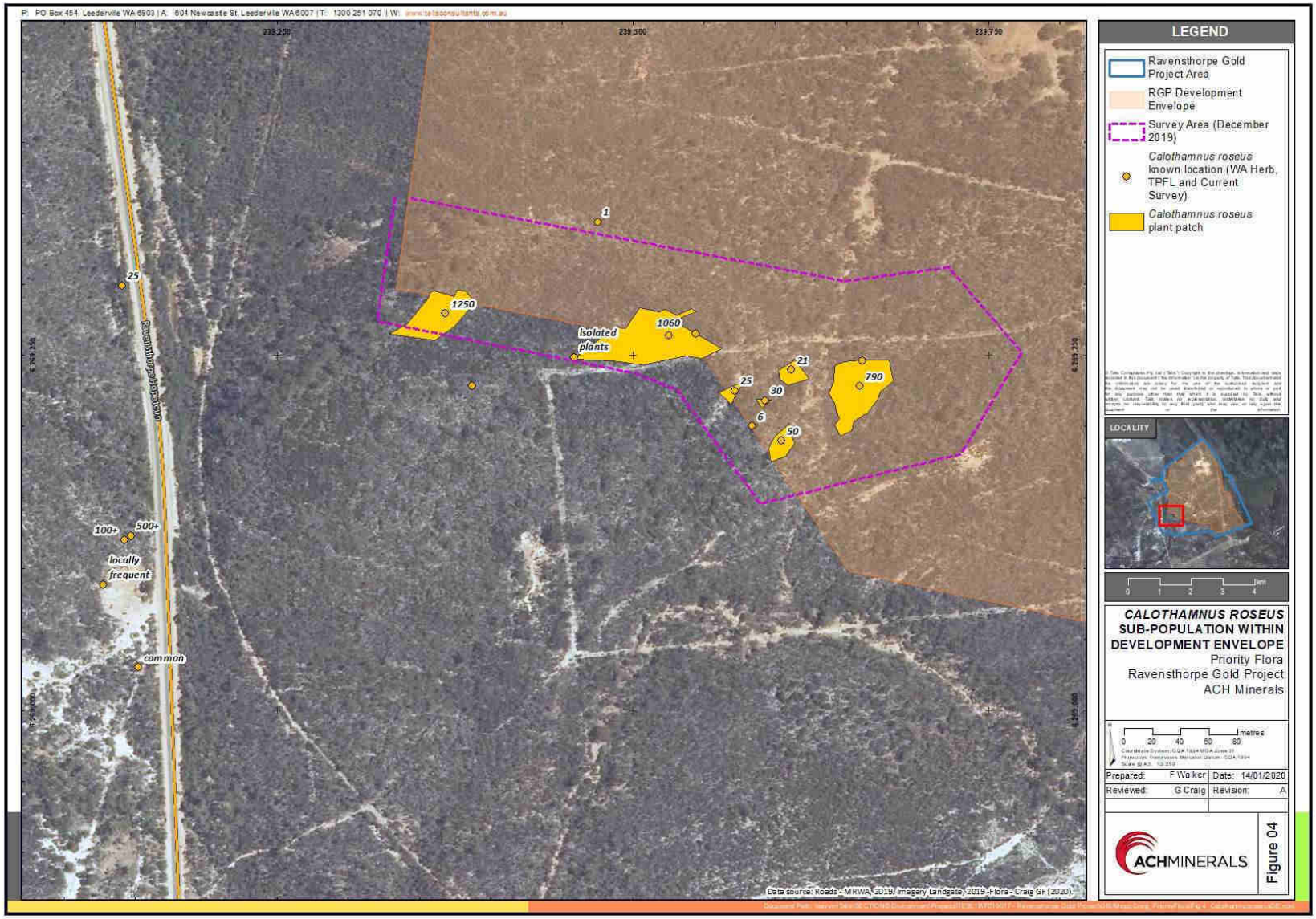

Figure 4 - Patches of *Calothamnus roseus* surveyed in the Development Envelope, plus 20 m buffer, in December 2019

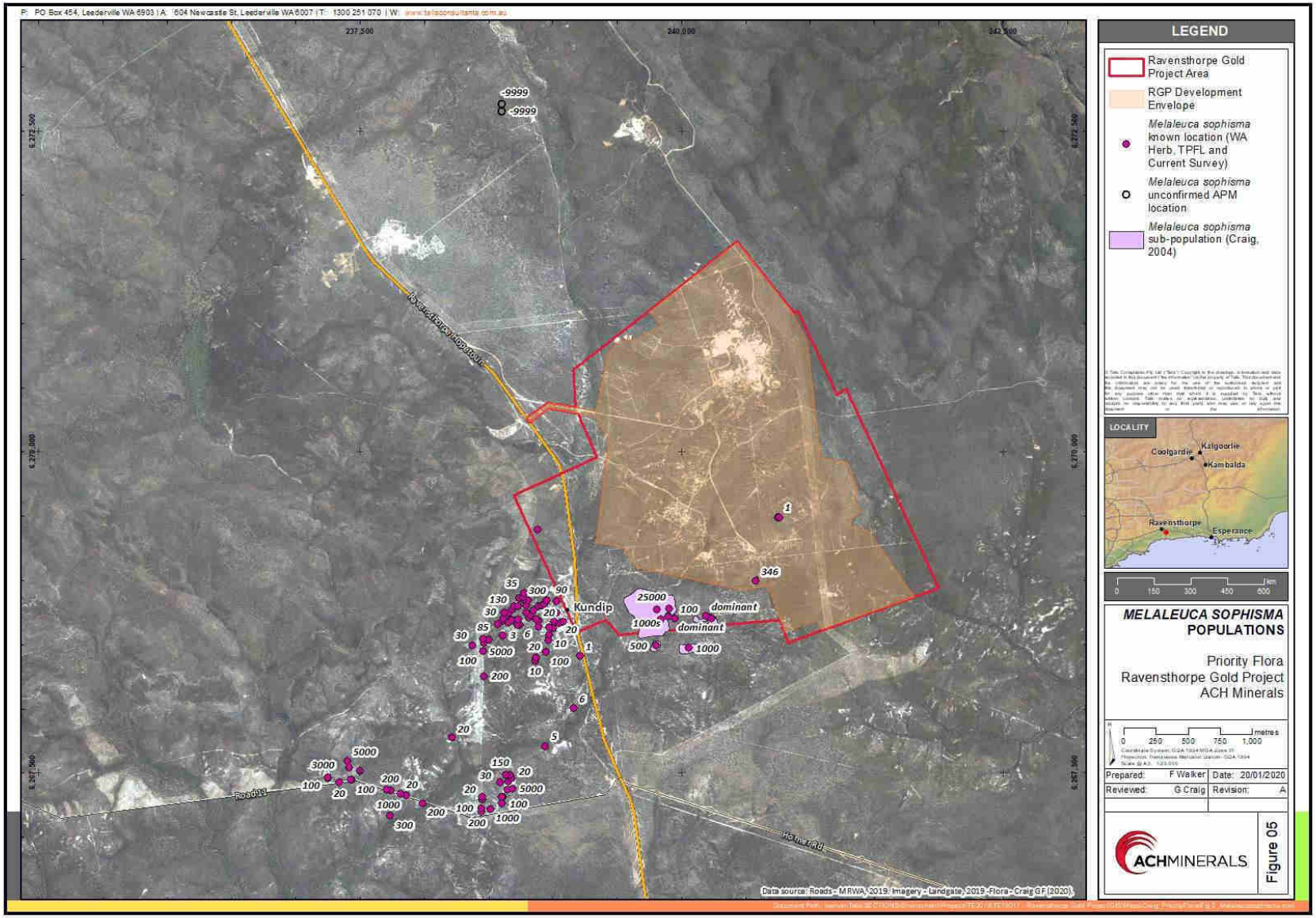

Figure 5 - Known sub-populations of *Melaleuca sophisma*

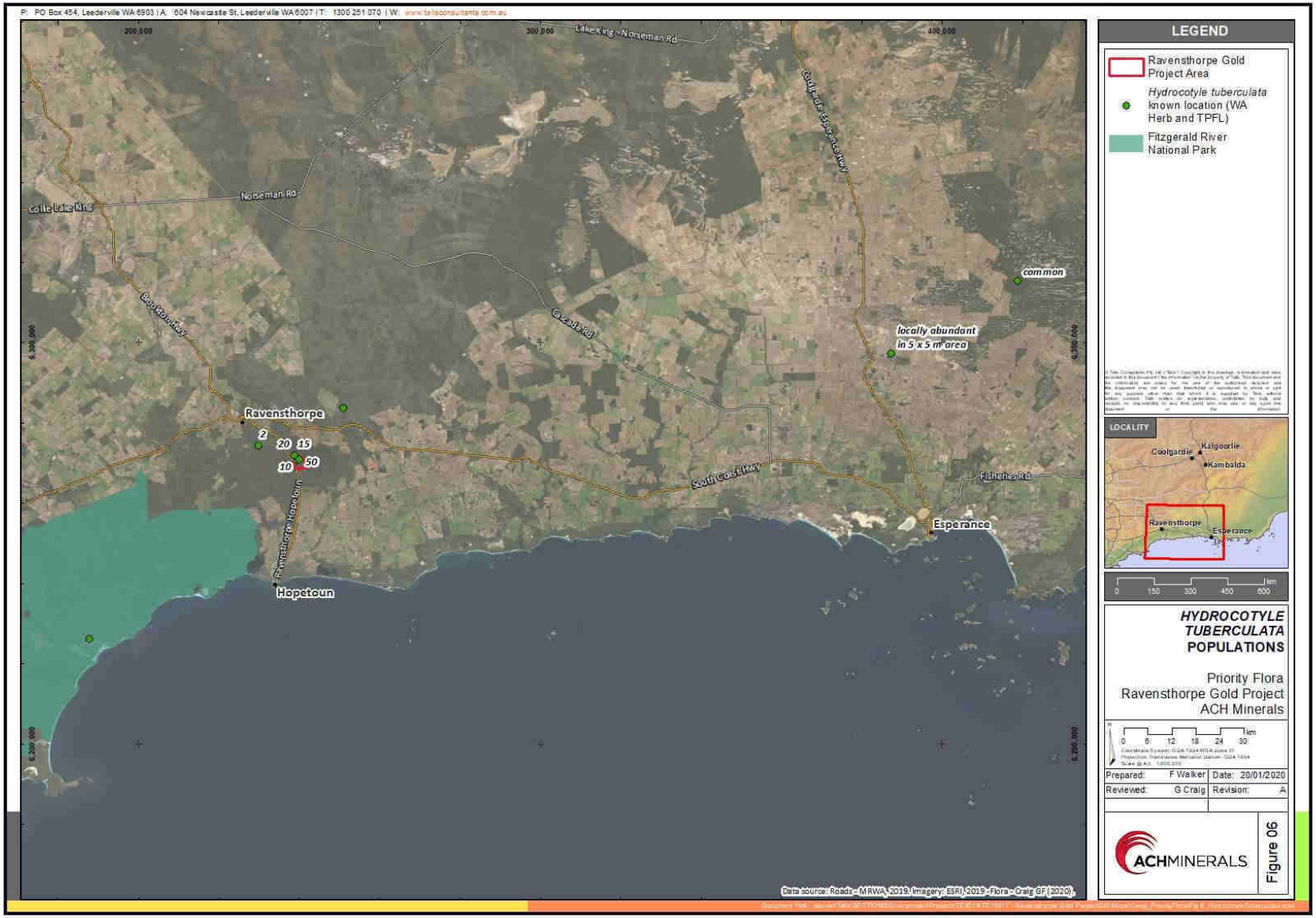

Figure 6 – Known populations of *Hydrocotyle tuberculata*

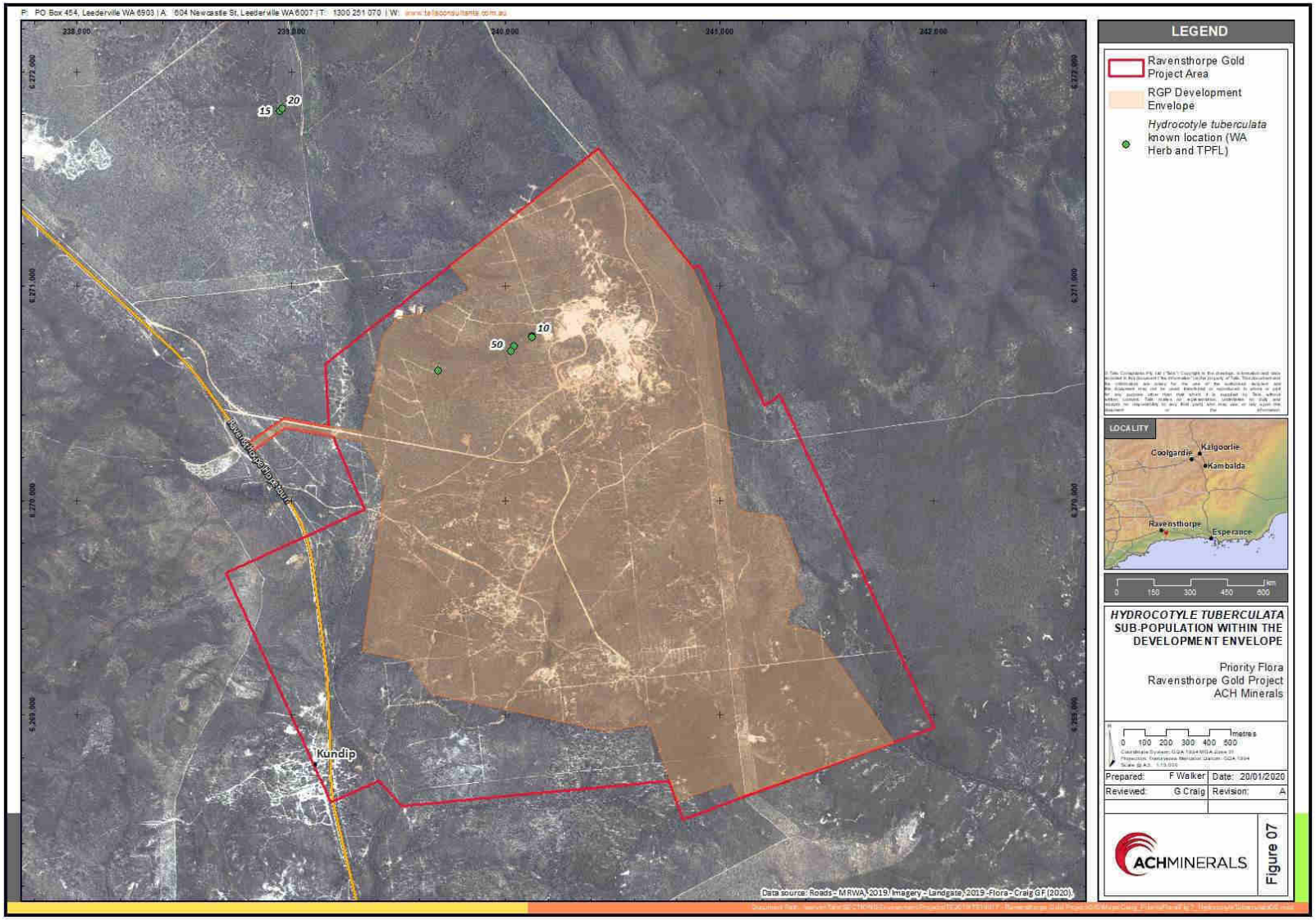

Figure 7 – Known sub-populations of *Hydrocotyle tuberculata* in the Development Envelope in 2011

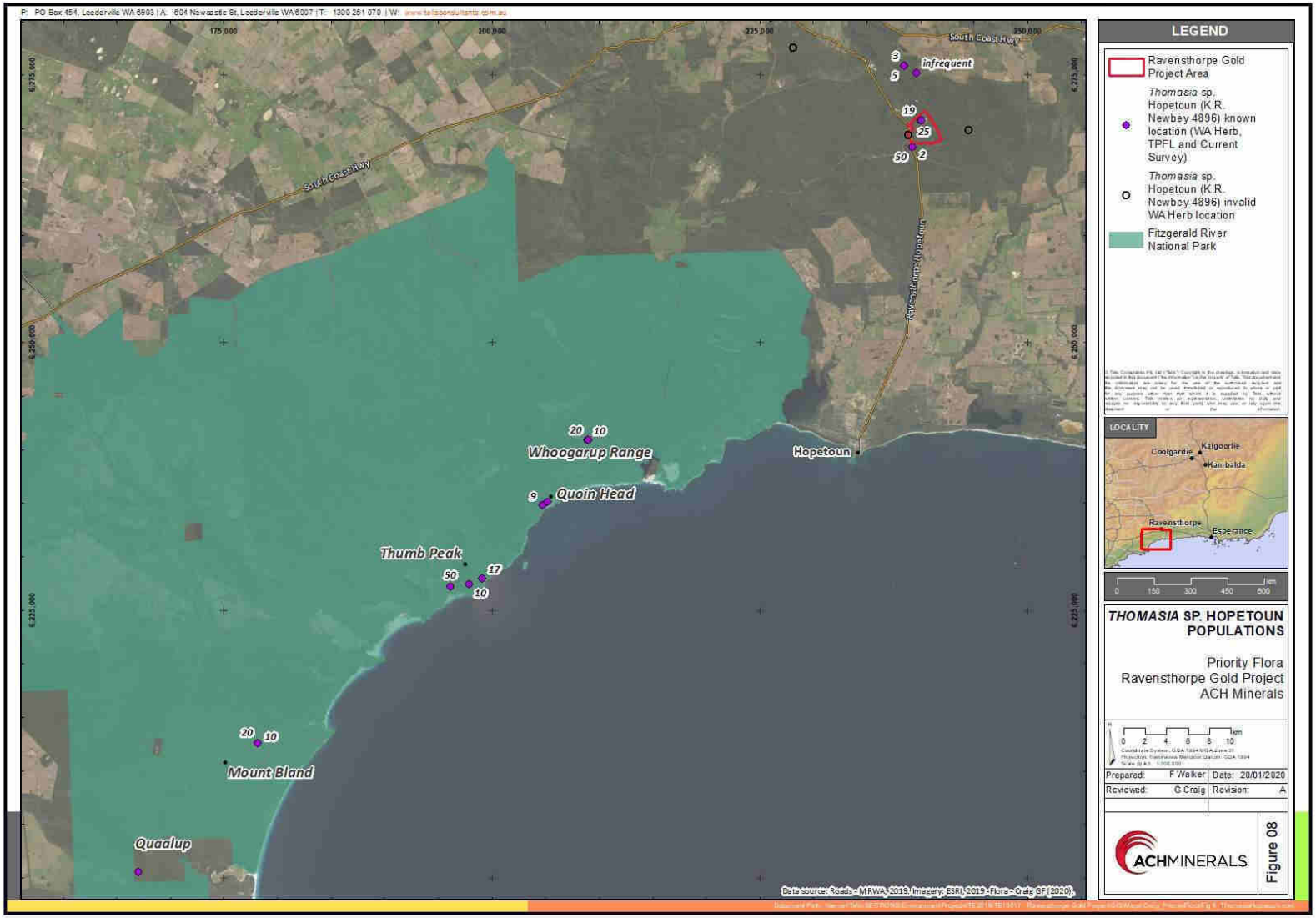

Figure 8 – Known populations of *Thomasia* sp. Hopetoun (KR Newbey 4896)

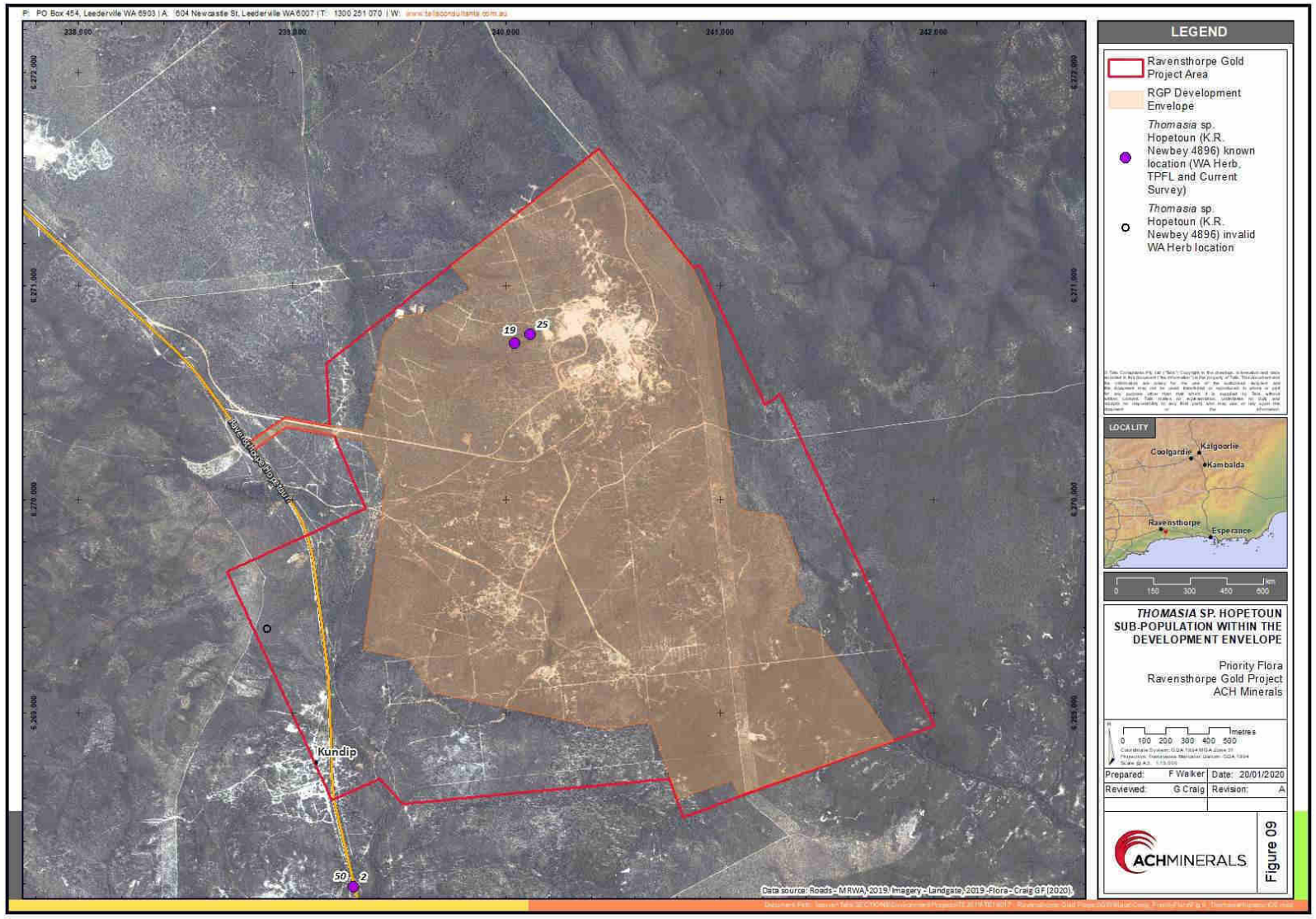

Figure 9 – Sub-population of *Thomasia* sp. Hopetoun (KR Newbey 4896) surveyed in the Development Envelope in December 2019

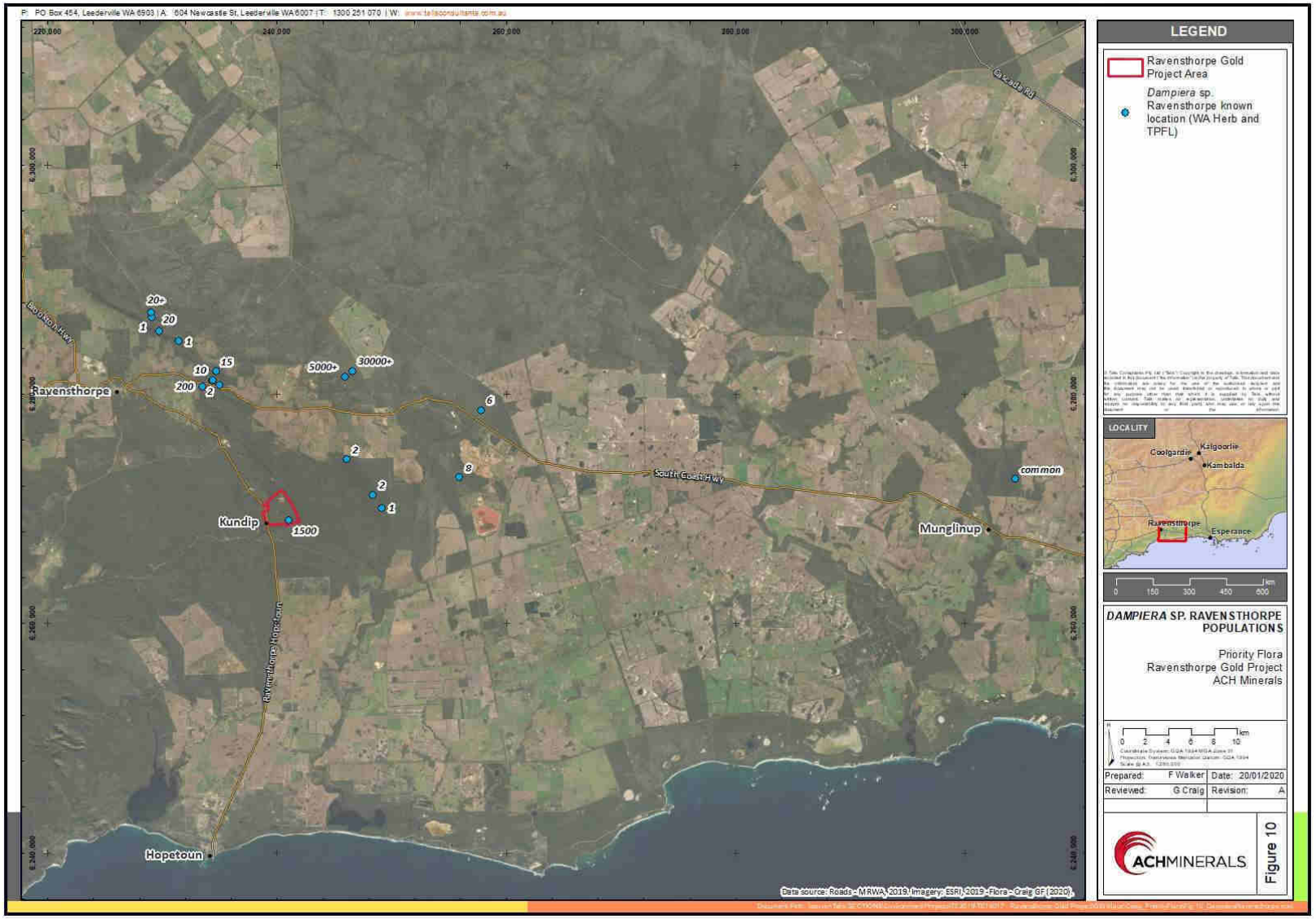

Figure 10 – Known populations of *Dampiera* sp. Ravensthorpe (GF Craig 8277)

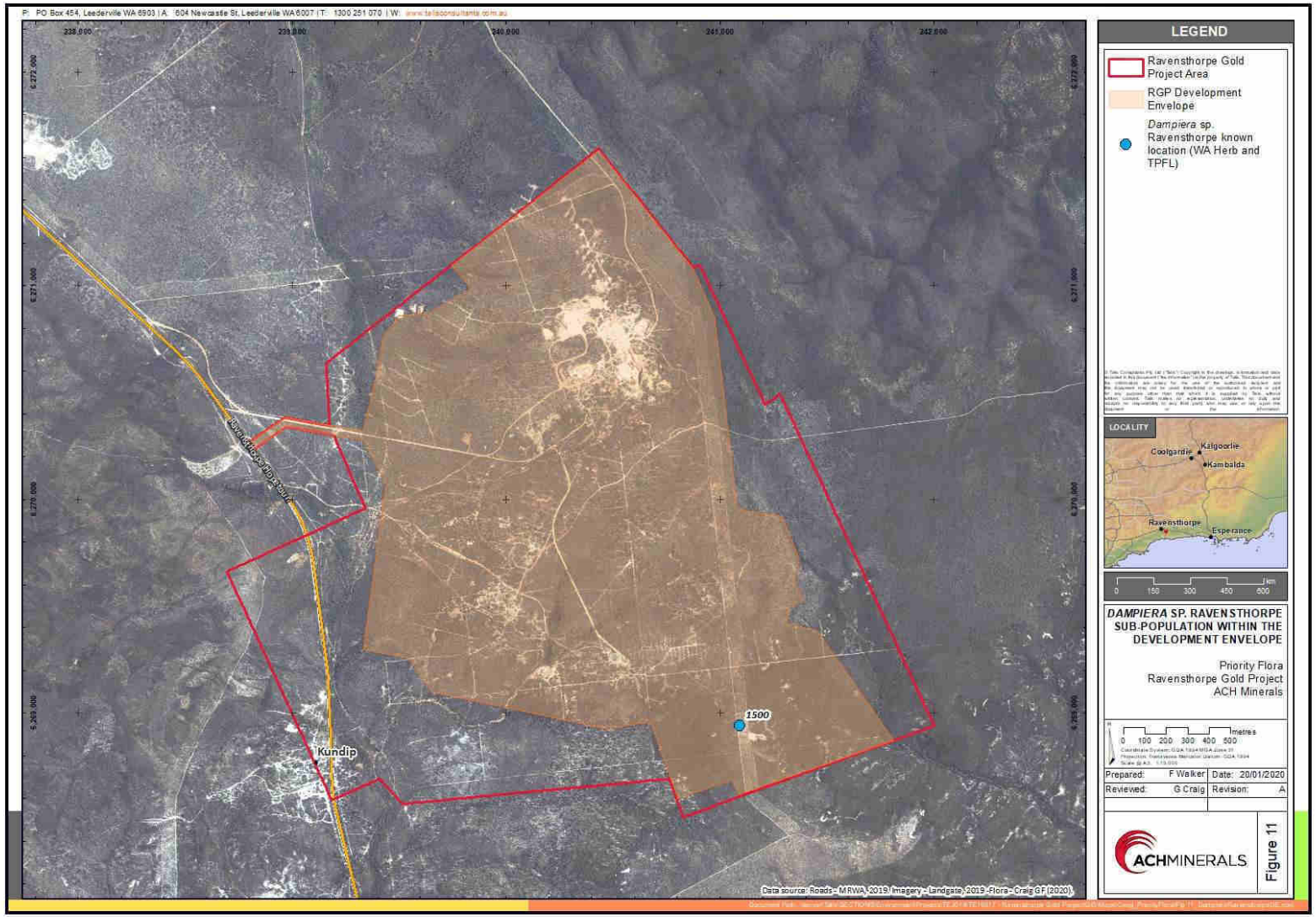

Figure 11 – Known population of *Dampiera* sp. Ravensthorpe (GF Craig 8277) in the Development Envelope in 2009

Discussion

Desktop

There are major flaws with the DBCA databases when one is attempting to interrogate species population data. Some of these are recognized by DBCA, e.g. old specimen records without GPS locations which have been manually given geographic coordinates that don't tally with the location description. However, by today's standards their TPFL system is archaic because:

- species' population data is based on hard copy Threatened Flora Report Forms. Therefore, it is no surprise that DBCA have not updated the data for the five priority species here, for at least 10 years. In contrast, data provided digitally could be uploaded within days.
- TPFL information is based a single point within a population – it is not possible to provide polygon or multiple-point population data to DBCA. Therefore DBCA has (i) no method for determining loss or increase to a particular population's area, or (ii) whether two separate points represent a continuum of a single population or are disparate groups of plants.
- TPFL and WAHerb data does not provide the collector's name, although it is possible to cross-reference using DBCA's Florabase (the author has Level 4 access) which is a tedious process. It would help if this data was included, so that it could be cross-referenced with published and unpublished reports that may be available.
- It was also found that some populations were repeated in both the WAHerb and TPFL databases, so care was needed not to simply sum all the abundance data, otherwise one would double the population size. It would be preferable that if a specimen is lodged in PERTH and therefore appears on the WAHerb database, that a Threatened Flora Report Form does not need to be filled out too.

Formating the spreadsheet to be compliant with IBSA standards was time consuming:

- data was in a number of different geographic coordinate systems and needed to be transformed (in this case) to decimal degrees;
- column headings were inconsistent between WAHerb, TPFL and IBSA. It would be a great benefit if these government datasets were integrated.

Field survey

The field survey in December 2019 found three of the five Priority Flora species. The information from the desktop analysis and the survey are summarized in Table 7.

Table 7 – Summary of desktop analysis and field survey of Priority Flora species in the RGP Development Envelope and 20 m buffer.

TaxonName	WAConStat	TOTAL known plants	Abundance in Development Envelope & buffer	Percentage of known populations (%)
Calothamnus roseus	P1	4,700	3,200	68
Melaleuca sophisma	P1	60,247	347	0.6
Hydrocotyle tuberculata	P2	237	-[1]	-
Thomasia sp. Hopetoun (K.R. Newbey 4896)	P2	243	44	18
Dampiera sp. Ravensthorpe (G.F. Craig 8277)	P3	36,893	-[2]	-

[1] annual plant not found in Dec 2019 survey; c. 60 plants in 2011; previously 110 plants in 2005

[2] not found in Dec 2019 survey; 1500 plants in 2009

The December 2019 survey failed to find either the annual *Hydrocotyle tuberculata* due to the dry conditions or *Dampiera* sp. Ravensthorpe (G.F. Craig 8277). It is not known whether the latter species is a short-lived perennial and has disappeared from the site until another fire or disturbance occurs, or the author was unable to find this cryptic species because it was not flowering. Seed banks of both species would still remain at their known sites. Surveys in winter-spring for *Dampiera* sp. Ravensthorpe and in October for *Hydrocotyle tuberculata* are recommended.

Acknowledgements

The assistance of the following people in preparing this report is gratefully acknowledged:

Greg Barrett – Talis Consultants
Sarah Barrett – DBCA Albany
David Groombridge – ACH Minerals
Tim Hammer – Spectrum Ecology
Michael Hislop – DBCA WA Herbarium
Vern Jones – ACH Minerals
Felicity Walker – Talis Consultants

References

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Catana AJ Jr (1963) *The Wandering Quarter Method of Estimating Population Density*. *Ecology* 44 (2): 349-360.

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Craig GF (2011) Hydrocotyle decipiens *survey*. Report prepared for Phillips River Mining NL, Victoria Park. November 2011.

Hickman E (2007) *Kundip Mining Leases Monitoring Quadrat Survey*. Unpublished report for Tectonic Resources NL.

Hickman E (2009) *Kundip Mining Leases Additional Monitoring Quadrat Survey*. Unpublished report for Tectonic Resources NL.

McQuoid N (2009) *Targeted and Regional Survey for* Melaleuca *sp. Kundip and* Melaleuca stramentosa. Unpublished report for Tectonic Resources NL.

Perkins AJ (2018) Hydrocotyle eichleri, H. papilionella *and* H. tuberculata *(Araliaceae), three new annual species from Western Australia. Nuytsia* 29: 240-243.

Appendix 1 – Threatened and Priority Flora report forms

Please complete as much of the form as possible, with emphasis on those sections bordered in black. For information on how to complete the form please refer to the Threatened & Priority Flora Report Form (TPRF) manual on the DBCA website at http://dpaw.wa.gov.au/ under *Standard Report Forms*

TAXON: Calothamnus roseus **TPFL Pop. No:**

OBSERVATION DATE: 17/12/2019 **CONSERVATION STATUS:** P1 New population ☐

OBSERVER/S: Gillian Craig **PHONE:** 98381071

ROLE: Botanist **ORGANISATION:**

DESCRIPTION OF LOCATION (Provide at least nearest town/named locality, and the distance and direction to that place)**:**

17 km SE of Ravensthorpe. Located ca 250 m E of Ravensthorphe - Hopetoun Road in Kundip Mining leases

Reserve No:

DBCA DISTRICT: Albany **LGA:** Ravensthorpe Land manager present: ☐

DATUM:
GDA94 / MGA94 ☒
AGD84 / AMG84 ☐
WGS84 ☐
Unknown ☐

COORDINATES: (If UTM coords provided, **Zone** is also required)
DecDegrees ☒ DegMinSec ☐ UTMs ☐
Lat / Northing: 33.684654
Long / Easting: 120.190196
ZONE:

METHOD USED:
GPS ☒ Differential GPS ☐ Map ☐
No. satellites: _____ Map used: _____
Boundary polygon captured: ☒ Map scale: _____

LAND TENURE:

Nature reserve ☐	Timber reserve ☐	Private property ☐	Rail reserve ☐	Shire road reserve ☐
National park ☐	State forest ☐	Pastoral lease ☐	MRWA road reserve ☐	Other Crown reserve ☐
Conservation park ☐	Water reserve ☐	UCL ☐	SLK/Pole _____ to _____	Specify other: mining lease

AREA ASSESSMENT: Edge survey ☐ Partial survey ☒ Full survey ☐ Area observed (m²): 100,000

EFFORT: Time spent surveying (minutes): 8 hrs No. of minutes spent / 100 m^2: _____

POP'N COUNT ACCURACY: Actual ☐ Extrapolation ☒ Estimate ☐ Count method: (Refer to field manual for list) Wandering quarter

WHAT COUNTED: Plants ☒ Clumps ☐ Clonal stems ☐

TOTAL POP'N STRUCTURE:	**Mature:**	**Juveniles:**	**Seedlings:**	**Totals:**
Alive	3000	200		3200
Dead				

Area of pop (m²): 30,000

Note: Pls record count as numbers (not percentages) for database.

QUADRATS PRESENT: No. _____ Size _____ Data attached ☐ Total area of quadrats (m²): _____

Summary Quad. Totals: Alive				

REPRODUCTIVE STATE: Clonal ☐ Vegetative ☐ Flowerbud ☐ Flower ☐
Immature fruit ☐ Fruit ☒ Dehisced fruit ☐ Percentage in flower: 0%

CONDITION OF PLANTS: Healthy ☒ Moderate ☐ Poor ☐ Senescent ☐

COMMENT:

THREATS - type, agent and supporting information: Eg clearing, too frequent fire, weed, disease. Refer to field manual for list of threats & agents. **Specify agent** where relevant. Rate current and potential threat impact: N=Nil, L=Low, M=Medium, H=High, E=Extreme Estimate time to potential impact: S=Short (<12mths), M=Medium (<5yrs), L=Long (5yrs+)	**Current impact (N-E)**	**Potential Impact (L-E)**	**Potential Threat Onset (S-L)**
Development Envelope for ACH Minerals' Ravensthorpe Gold Project	N	_____	_____

HABITAT INFORMATION:

LANDFORM:	ROCK TYPE:	LOOSE ROCK:	SOIL TYPE:	SOIL COLOUR:	DRAINAGE:
Crest ☐	Granite ☐	(on soil surface; eg gravel, quartz fields)	Sand ☒	Red ☐	Well drained ☒
Hill ☐	Dolerite ☐		Sandy loam ☐	Brown ☒	Seasonally inundated ☐
Ridge ☐	Laterite ☐		Loam ☐	Yellow ☐	
Outcrop ☐	Ironstone ☐	0-10% ☐	Clay loam ☐	White ☐	Permanently inundated ☐
Slope ☒	Limestone ☐	10-30% ☐	Light clay ☐	Grey ☒	Tidal ☐
Flat ☐	Quartz ☒	30-50% ☒	Peat ☐	Black ☐	
Open depression ☐	Specify other:	50-100% ☐	Specify other:	Specify other:	
Drainage line ☐					
Closed depression ☐					
Wetland ☐					

Specific **Landform** Element: _____
(Refer to field manual for additional values)

CONDITION OF SOIL: Dry ☒ Moist ☐ Waterlogged ☐ Inundated ☐

VEGETATION CLASSIFICATION*:
Eg: **1**. Banksia woodland (B. attenuata, B. ilicifolia); **2**. Open shrubland (Hibbertia sp., Acacia spp.) ; **3**. Isolated clumps of sedges (Mesomelaena tetragona)

1. Very open mallee (Eucalyptus ecostata, E. pleurocarpa)
2. Thicket (Calothamnus pinifolia, C. roseus, C. quadrifidus, Taxandria spathulata)
3.
4.

ASSOCIATED SPECIES:

Other (non-dominant) spp

* Please record up to four of the most representative vegetation layers (with up to three dominant species in each layer). Structural Formations should follow 2009 *Australian Soil and Land Survey Field Handbook* guidelines – refer to field manual for further information and structural formation table.

CONDITION OF HABITAT: Pristine ☐ Excellent ☒ Very good ☐ Good ☐ Degraded ☐ Completely degraded ☐

COMMENT: Old tracks which have regrown intersect the area.

FIRE HISTORY: **Last Fire:** Season/Month: _____ Year: _____ **Fire Intensity:** High ☐ Medium ☐ Low ☐ No signs of fire ☒

FENCING: Not required ☐ Present ☐ Replace / repair ☐ Required ☐ Length req'd: _____

ROADSIDE MARKERS: Not required ☐ Present ☐ Replace / reposition ☐ Required ☐ Quantity req'd: _____

OTHER COMMENTS: (Please include recommended management actions and/or implemented actions - include date. Also include details of additional data available, and how to locate it.)

Eight distinct patches of plants were located within the Development Envelope and 20 m buffer survey area.

Full details of the survey and maps are available in report:

Craig GF (2020) Populations of five Priority Flora species in the Kundip Development Envelope. A report prepared for ACH Minerals Pty Ltd, Ravensthorpe Gold Project. January 2020.

DRF PERMIT/ LICENCE No: FB62000115 Note if only observing plants (i.e. no specimens or plant matieral is taken) then no permit/licence is required. For further information on permit and licening requirements see the Threatened Flora and Wildlife Licensing pages on DBCA's website. Any actions carried out under licence/permit should be recorded above in the OTHER COMMENTS section.

SPECIMEN: Collectors No: _____ WA Herb. ☐ Regional Herb. ☐ District Herb. ☐ Other: _____

ATTACHED: Map ☐ Mudmap ☐ Photo ☐ GIS data ☐ Field notes ☐ Other: _____

COPY SENT TO: Regional Office ☐ District Office ☒ Other:

Submitter of Record: Gillian Craig Role: Botanist Signed: _____ Date: 6/1/2020

Please complete as much of the form as possible, with emphasis on those sections bordered in black. For information on how to complete the form please refer to the Threatened & Priority Flora Report Form (TPRF) manual on the DBCA website at http://dpaw.wa.gov.au/ under *Standard Report Forms*

TAXON: Melaleuca sophisma **TPFL Pop. No:**

OBSERVATION DATE: 9/12/2019 **CONSERVATION STATUS:** P1 New population ☐

OBSERVER/S: Gillian Craig **PHONE:** 98381071

ROLE: Botanist **ORGANISATION:**

DESCRIPTION OF LOCATION (Provide at least nearest town/named locality, and the distance and direction to that place)**:**

1.6 km E of old Kundip townsite. [= original sub-population Mx-4 of Craig (2004); collection GFC 6020]

Reserve No:

DBCA DISTRICT: Albany **LGA:** Ravensthorpe Land manager present: ☐

DATUM:
GDA94 / MGA94 ☒
AGD84 / AMG84 ☐
WGS84 ☐
Unknown ☐

COORDINATES: (If UTM coords provided, **Zone** is also required)
DecDegrees ☒ DegMinSec ☐ UTMs ☐
Lat / Northing: -33.687357
Long / Easting: 120.2015
ZONE:

METHOD USED:
GPS ☒ Differential GPS ☐ Map ☐
No. satellites: _____ Map used: _____
Boundary polygon captured: ☒ Map scale: _____

LAND TENURE:

Nature reserve ☐ Timber reserve ☐ Private property ☐ Rail reserve ☐ Shire road reserve ☐
National park ☐ State forest ☐ Pastoral lease ☐ MRWA road reserve ☐ Other Crown reserve ☐
Conservation park ☐ Water reserve ☐ UCL ☐ SLK/Pole _____ to _____ Specify other: mining lease

AREA ASSESSMENT: Edge survey ☐ Partial survey ☒ Full survey ☐ Area observed (m²): 700

EFFORT: Time spent surveying (minutes): 90 No. of minutes spent / 100 m²: _____

POP'N COUNT ACCURACY: Actual ☒ Extrapolation ☐ Estimate ☐ Count method: _____
(Refer to field manual for list)

WHAT COUNTED: Plants ☒ Clumps ☐ Clonal stems ☐

TOTAL POP'N STRUCTURE:	**Mature:**	**Juveniles:**	**Seedlings:**	**Totals:**
Alive	346			346
Dead				

Area of pop (m²): 700

Note: Pls record count as numbers (not percentages) for database.

QUADRATS PRESENT: No. _____ Size _____ Data attached ☐ Total area of quadrats (m²): _____

Summary Quad. Totals: Alive				

REPRODUCTIVE STATE: Clonal ☐ Vegetative ☐ Flowerbud ☐ Flower ☒
Immature fruit ☐ Fruit ☒ Dehisced fruit ☐ Percentage in flower: 10%

CONDITION OF PLANTS: Healthy ☒ Moderate ☐ Poor ☐ Senescent ☐

COMMENT:

THREATS - type, agent and supporting information: Eg clearing, too frequent fire, weed, disease. Refer to field manual for list of threats & agents. **Specify agent** where relevant. Rate current and potential threat impact: N=Nil, L=Low, M=Medium, H=High, E=Extreme Estimate time to potential impact: S=Short (<12mths), M=Medium (<5yrs), L=Long (5yrs+)	**Current impact (N-E)**	**Potential Impact (L-E)**	**Potential Threat Onset (S-L)**
• Development Envelope for ACH Minerals' Ravensthorpe Gold Project	N		

HABITAT INFORMATION:

LANDFORM:	ROCK TYPE:	LOOSE ROCK:	SOIL TYPE:	SOIL COLOUR:	DRAINAGE:
Crest ☐	Granite ☐	(on soil surface; eg gravel, quartz fields)	Sand ☐	Red ☐	Well drained ☒
Hill ☐	Dolerite ☐		Sandy loam ☐	Brown ☐	Seasonally inundated ☐
Ridge ☐	Laterite ☐		Loam ☒	Yellow ☐	
Outcrop ☐	Ironstone ☐	0-10% ☐	Clay loam ☐	White ☐	Permanently inundated ☐
Slope ☒	Limestone ☐	10-30% ☐	Light clay ☐	Grey ☒	Tidal ☐
Flat ☐	Quartz ☒	30-50% ☐	Peat ☐	Black ☐	
Open depression ☐	Specify other:	50-100% ☒	Specify other:	Specify other:	
Drainage line ☐					
Closed depression ☐					
Wetland ☐					

Specific **Landform** Element: _____
(Refer to field manual for additional values)

CONDITION OF SOIL: Dry ☒ Moist ☐ Waterlogged ☐ Inundated ☐

VEGETATION CLASSIFICATION*:
Eg: **1**. Banksia woodland (B. attenuata, B. ilicifolia); **2**. Open shrubland (Hibbertia sp., Acacia spp.) ; **3**. Isolated clumps of sedges (Mesomelaena tetragona)

1. Open Woodland (Eucalyptus aff. astringens)
2. Open to mid-dense shrubs (Melaleuca sophisma, M. glaberrrima)
3.
4.

ASSOCIATED SPECIES:

Other (non-dominant) spp

* Please record up to four of the most representative vegetation layers (with up to three dominant species in each layer). Structural Formations should follow 2009 *Australian Soil and Land Survey Field Handbook* guidelines – refer to field manual for further information and structural formation table.

CONDITION OF HABITAT: Pristine ☒ Excellent ☒ Very good ☐ Good ☐ Degraded ☐ Completely degraded ☐

COMMENT:

FIRE HISTORY: **Last Fire:** Season/Month: _____ Year: _____ **Fire Intensity:** High ☐ Medium ☐ Low ☐ No signs of fire ☒

FENCING: Not required ☐ Present ☐ Replace / repair ☐ Required ☐ Length req'd: _____

ROADSIDE MARKERS: Not required ☐ Present ☐ Replace / reposition ☐ Required ☐ Quantity req'd: _____

OTHER COMMENTS: (Please include recommended management actions and/or implemented actions - include date. Also include details of additional data available, and how to locate it.)

Recently a narrow vehicle has driven through sub-population knocking over 5 plants.

Full details of the survey and maps are available in report:

Craig GF (2020) Populations of five Priority Flora species in the Kundip Development Envelope. A report prepared for ACH Minerals Pty Ltd, Ravensthorpe Gold Project. January 2020.

Note: 1 outlier shrub found 530 m NNE of this sub-population, previously noted by Hickman (2007)

DRF PERMIT/ LICENCE No: FB62000115 Note if only observing plants (i.e. no specimens or plant matieral is taken) then no permit/licence is required. For further information on permit and licening requirements see the Threatened Flora and Wildlife Licensing pages on DBCA's website. Any actions carried out under licence/permit should be recorded above in the OTHER COMMENTS section.

SPECIMEN: Collectors No: _____ WA Herb. ☐ Regional Herb. ☐ District Herb. ☐ Other: _____

ATTACHED: Map ☐ Mudmap ☐ Photo ☐ GIS data ☐ Field notes ☐ Other: _____

COPY SENT TO: Regional Office ☐ District Office ☒ Other:

Submitter of Record: Gillian Craig Role: Botanist Signed: _____ Date: 7/1/2020

Please complete as much of the form as possible, with emphasis on those sections bordered in black. For information on how to complete the form please refer to the Threatened & Priority Flora Report Form (TPRF) manual on the DBCA website at http://dpaw.wa.gov.au/ under *Standard Report Forms*

TAXON: Thomasia sp. Hopetoun (KR Newbey 4896) **TPFL Pop. No:**

OBSERVATION DATE: 9/12/2019 **CONSERVATION STATUS:** P2 New population ☐

OBSERVER/S: Gillian Craig **PHONE:** 98381071

ROLE: Botanist **ORGANISATION:**

DESCRIPTION OF LOCATION (Provide at least nearest town/named locality, and the distance and direction to that place)**:**

Kundip Mining Leases, 2.5 km NE of old Kundip townsite

Reserve No:

DBCA DISTRICT: Albany **LGA:** Ravensthorpe Land manager present: ☐

DATUM:
GDA94 / MGA94 ☒
AGD84 / AMG84 ☐
WGS84 ☐
Unknown ☐

COORDINATES: (If UTM coords provided, **Zone** is also required)
DecDegrees ☒ DegMinSec ☐ UTMs ☐
Lat / Northing: -33.671583
Long / Easting: 120.19619
ZONE:

METHOD USED:
GPS ☒ Differential GPS ☐ Map ☐
No. satellites: _____ Map used: _____
Boundary polygon captured: ☒ Map scale: _____

LAND TENURE:

Nature reserve ☐ Timber reserve ☐ Private property ☐ Rail reserve ☐ Shire road reserve ☐
National park ☐ State forest ☐ Pastoral lease ☐ MRWA road reserve ☐ Other Crown reserve ☐
Conservation park ☐ Water reserve ☐ UCL ☐ SLK/Pole _____ to _____ Specify other: mining lease

AREA ASSESSMENT: Edge survey ☐ Partial survey ☐ Full survey ☒ Area observed (m²): 5000

EFFORT: Time spent surveying (minutes): 90 No. of minutes spent / 100 m^2: _____

POP'N COUNT ACCURACY: Actual ☒ Extrapolation ☐ Estimate ☐ Count method: _____
(Refer to field manual for list)

WHAT COUNTED: Plants ☒ Clumps ☐ Clonal stems ☐

TOTAL POP'N STRUCTURE:	**Mature:**	**Juveniles:**	**Seedlings:**	**Totals:**
Alive	44			44
Dead				

Area of pop (m²): 1,000

Note: Pls record count as numbers (not percentages) for database.

QUADRATS PRESENT: No. _____ Size _____ Data attached ☐ Total area of quadrats (m²): _____

Summary Quad. Totals: Alive				

REPRODUCTIVE STATE: Clonal ☐ Vegetative ☐ Flowerbud ☐ Flower ☐
Immature fruit ☐ Fruit ☒ Dehisced fruit ☒ Percentage in flower: 0%

CONDITION OF PLANTS: Healthy ☒ Moderate ☐ Poor ☐ Senescent ☐

COMMENT:

THREATS - type, agent and supporting information: Eg clearing, too frequent fire, weed, disease. Refer to field manual for list of threats & agents. **Specify agent** where relevant. Rate current and potential threat impact: N=Nil, L=Low, M=Medium, H=High, E=Extreme Estimate time to potential impact: S=Short (<12mths), M=Medium (<5yrs), L=Long (5yrs+)	**Current impact (N-E)**	**Potential Impact (L-E)**	**Potential Threat Onset (S-L)**
• Development Envelope for ACH Minerals' Ravensthorpe Gold Project	N		
•			

HABITAT INFORMATION:

LANDFORM:	ROCK TYPE:	LOOSE ROCK:	SOIL TYPE:	SOIL COLOUR:	DRAINAGE:
Crest ☐	Granite ☐	(on soil surface; eg gravel, quartz fields)	Sand ☒	Red ☐	Well drained ☒
Hill ☐	Dolerite ☐		Sandy loam ☐	Brown ☒	Seasonally inundated ☐
Ridge ☐	Laterite ☐		Loam ☐	Yellow ☐	
Outcrop ☐	Ironstone ☐	0-10% ☐	Clay loam ☐	White ☐	Permanently inundated ☐
Slope ☐	Limestone ☐	10-30% ☐	Light clay ☐	Grey ☐	
Flat ☐	Quartz ☐	30-50% ☐	Peat ☐	Black ☐	Tidal ☐
Open depression ☐	Specify other:	50-100% ☐	Specify other:	Specify other:	
Drainage line ☒					
Closed depression ☐					
Wetland ☐					

Specific **Landform** Element: _____
(Refer to field manual for additional values)

CONDITION OF SOIL: Dry ☒ Moist ☐ Waterlogged ☐ Inundated ☐

VEGETATION CLASSIFICATION*:
Eg: **1**. Banksia woodland (B. attenuata, B. ilicifolia); **2**. Open shrubland (Hibbertia sp., Acacia spp.) ; **3**. Isolated clumps of sedges (Mesomelaena tetragona)

1. Woodland (Eucalyptus sporadica, E. flocktoniae)
2. Open scrub (Gastrolobium parviflorum, Dodonaea pinifolia, Acacia cyclops, A.disticha)
3.
4.

ASSOCIATED SPECIES:

Other (non-dominant) spp

* Please record up to four of the most representative vegetation layers (with up to three dominant species in each layer). Structural Formations should follow 2009 *Australian Soil and Land Survey Field Handbook* guidelines – refer to field manual for further information and structural formation table.

CONDITION OF HABITAT: Pristine ☐ Excellent ☒ Very good ☐ Good ☐ Degraded ☐ Completely degraded ☐

COMMENT:

FIRE HISTORY: **Last Fire:** Season/Month: _____ Year: _____ **Fire Intensity:** High ☐ Medium ☐ Low ☐ No signs of fire ☒

FENCING: Not required ☐ Present ☐ Replace / repair ☐ Required ☐ Length req'd: _____

ROADSIDE MARKERS: Not required ☐ Present ☐ Replace / reposition ☐ Required ☐ Quantity req'd: _____

OTHER COMMENTS: (Please include recommended management actions and/or implemented actions - include date. Also include details of additional data available, and how to locate it.)

Two distinct patches of plants were located 90 m apart in the creekline.

Full details of the survey and maps are available in report:

Craig GF (2020) Populations of five Priority Flora species in the Kundip Development Envelope. A report prepared for ACH Minerals Pty Ltd, Ravensthorpe Gold Project. January 2020.

DRF PERMIT/ LICENCE No: FB62000115 Note if only observing plants (i.e. no specimens or plant matieral is taken) then no permit/licence is required. For further information on permit and licening requirements see the Threatened Flora and Wildlife Licensing pages on DBCA's website. Any actions carried out under licence/permit should be recorded above in the OTHER COMMENTS section.

SPECIMEN: Collectors No: _____ WA Herb. ☐ Regional Herb. ☐ District Herb. ☐ Other: _____

ATTACHED: Map ☐ Mudmap ☐ Photo ☐ GIS data ☐ Field notes ☐ Other: _____

COPY SENT TO: Regional Office ☐ District Office ☒ Other:

Submitter of Record: Gillian Craig Role: Botanist Signed: _____ Date: 7/1/2020

Appendix C: RGP Potential Short Range Endemic Land Snail (Biota Environmental Sciences)

Biota Environmental Sciences

Biota (n): The living creatures of an area; the flora and fauna together

20 January 2020

Greg Barrett
Senior Environmental Consultant
Talis Consultants
(via Email)

Dear Greg

Ravensthorpe Gold Project Potential Short Range Endemic Land Snail

Further to our recent discussions, we provide here an assessment of the short range endemic (SRE) status of a land snail species recorded from of the Ravensthorpe Gold Project, and the risk that it could be restricted in distribution to the project development envelope.

1. Background

As we understand it, ACH Minerals proposes to develop the Kundip Mine Site located approximately 17 km southeast of Ravensthorpe (hereafter 'the project'). The project involves the development and operation of a gold and copper mine including open cut and underground mining, and associated infrastructure, and will result in the clearing of 197.8 ha of fauna habitat within a 428.4 ha development envelope (ACH Minerals 2019).

Several fauna surveys have been completed within the development envelope, during one of which a land snail specimen was collected belonging to the genus *Bothriembryon* (Biota 2004). Diagnosis of the specimen at the time by the Western Australian Museum indicated that it was not the relatively commonly collected *Bothriembryon dux*, which was also collected during the survey, but appeared to be an undescribed species (Biota 2004).

Submissions received during the public comment period on the project's Environmental Review Document (ACH Minerals 2019), requested further determination of the putative species' SRE status and to place it into better context in respect of potential impacts and management.

2. Statutory and Policy Context

Some SRE fauna species within Western Australia are formally listed as being of conservation significance under the *Biodiversity Conservation Act 2016*, but there are no listed species belonging to the genus *Bothriembryon* in the South Coast region of the state[1].

Two species of *Bothriembryon, B. brazieri* and *B. glauerti,* occur in the South Coast region, but these are currently only known from within and adjacent to Stirling Range National Park, north of Albany, and approximately 200 km to the southwest of the project area[2]. As both species were already described at the time of the Western Australian Museum's 2004 consideration of the project area specimen (see Section 1 above), the project area specimen does not represent either Priority 2 species.

[1] https://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/Listings/fauna_notice.pdf

[2] https://naturemap.dbca.wa.gov.au

Listing as Threatened or Priority fauna aside, all SRE fauna species are identified in Environmental Protection Authority (EPA) technical guidance as requiring specific consideration in environmental impact assessment (EPA 2016). This also sets out the lines of evidence that should be considered to assess the degree of short-range endemism and assessing potential impacts, as addressed in Section 3 below.

3. Assessment

In assessing potential short-range endemism and risk of restricted distributions, the following can be considered:

A. the habitat from which the specimen was collected (in particular, whether it occurs in isolation of as part of a geographically isolated landform feature);

B. distributions of other potential SRE taxa recorded from the same habitat; and

C. minimum distributions and patterns of endemism in other members of the same genus in the region.

A. Habitat

The habitats of the development envelope can be spatially considered through vegetation mapping. A vegetation survey of the development envelope was carried out by Craig (2004), who identified 18 vegetation types. Since that survey, other vegetation types have been mapped over the Ravensthorpe Range, with 10,200 ha of vegetation being mapped between Mt Short and Kundip (Craig et al. 2008). The land snail specimen in question, hereafter *Bothriembryon* sp., was collected from site KU8 of the Biota (2004) survey, in vegetation mapped as the 'Eflo/Mcuc' vegetation unit of Craig et al. (2008). This unit is dominated by *Melaleuca cucullata* with an overstorey of open *Eucalyptus flocktoniae* subsp. *flocktoniae* and occurs on topographically flat landforms on firm brown clay loam sandy substrates (e.g. Plate 1).

Plate 1: Habitat from which *Bothriembryon* sp. was collected (photo: Site KNDSRE01 of Biota (2014)).

This vegetation unit forms part of the Colluvium and weathered clays over granite soil-landscape grouping of Craig et al. (2004), where it shows affinities to five other units of similar substrates and habitat structure, all of which include *E. flocktoniae* and/or *M. cucullata*, and it is likely that this a consolidation of these six vegetation units is the appropriate level to consider for the purposes of fauna habitats. While Eflo/Mcuc has a mapped extent of 108.6 ha within the Ravensthorpe Range, the combined extent of Colluvium and weathered clays over granite units mapped by Craig et al. (2004) was 325.4 ha. The habitat is generally dominated by clay plains with minor drainages and would appear to not present any geomorphological discontinuities that might act to promote short-range endemism. The ERD for the project (ACH Minerals 2019), indicates that 17.6 ha in total of the vegetation units that belong to this soil-landscape habitat will be directly impacted by the project footprint, or 5.4% of the mapped extent (Craig et al. 2008).

B. Records of other Potential SRE Taxa

SRE targeted survey work completed by Biota (2014), also recorded two potential SRE mygalomorph spiders from the same vegetation unit at sites very close to the collection location of *Bothriembryon* sp. (site KNDSRE01 of Biota (2014)). While different taxa may not necessarily share distribution patterns, the level of localised restriction across groups prone to short-range endemism can be informative to assessments of less well-collected taxa such as *Bothriembryon* sp. here.

The two mygalomorph spider species recorded from the same habitat and effective location were Idiopidae sp. I78 and Nemesiidae sp. N80 Biota (2014). Molecular analysis conducted by Biota (2014) demonstrated that both species, while remaining as potential SREs, have distributions that extend outside of the development envelope, and are not locally restricted in distribution to the habitat patch from which *Bothriembryon* sp. was recorded as might have been the case if significant barriers to dispersal were present.

C. Distributions of other *Bothriembryon* in the South Coast region

Lastly then, inferences may be drawn from the size of the documented distributions of other related *Bothriembryon* occurring in the South Coast region. The three species of most relevance in this context comprise:

B. dux – a South Coast distribution exceeding 900,000 ha[3];

B. brazieri – a distribution in the Stirling Ranges of at least 36,000 ha[4]; and

B. glauerti - a distribution in the Stirling Ranges of at least 3,000 ha[4].

None of these *Bothriembryon* species have a minimum area of occupancy as small as the 428.4 ha development envelope for the project, and most are significantly larger.

4. Conclusions

The best method of further determining the SRE status of *Bothriembryon* sp. would have been to sequence tissue from the collected specimen, but consultation we completed with the Western Australian Museum indicated that the specimen cannot now be located within the collection. The SRE status of *Bothriembryon* sp. has, however, still be further informed by the review completed here, which found in summary that:

- the habitat from which the specimen was recorded belongs to a group of vegetation types that occurs more widely, only a small proportion of which will be impacted by the project (5.4%; see Section 3A above);
- other, better resolved, potential SRE taxa collected from the same location have been demonstrated to have wider distributions, consistent with the lack of habitat barriers to dispersal; suggesting that *Bothriembryon* sp. may also be similar more widely distributed (Section 3B above); and
- Other members of the same genus in the region do not show distributions that suggest *Bothriembryon* sp. could possibly be restricted to an area as small as the project development envelope (Section 3C).

Please contact me should you have any queries relating to the above.

Yours sincerely,

Biota Environmental Sciences Pty Ltd

Garth Humphreys
Principal Ecologist / Director

[3] http://ala.org.au

[4] https://naturemap.dbca.wa.gov.au

References

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