GEOTECHNICAL & GROUNDWATER INVESTIGATION

Proposed Sand Mine at 4226 Nelson Bay Road, Anna Bay

Prepared for Tattersall Lander

Prepared by RCA Australia

RCA ref 13280-201/2

August 2018

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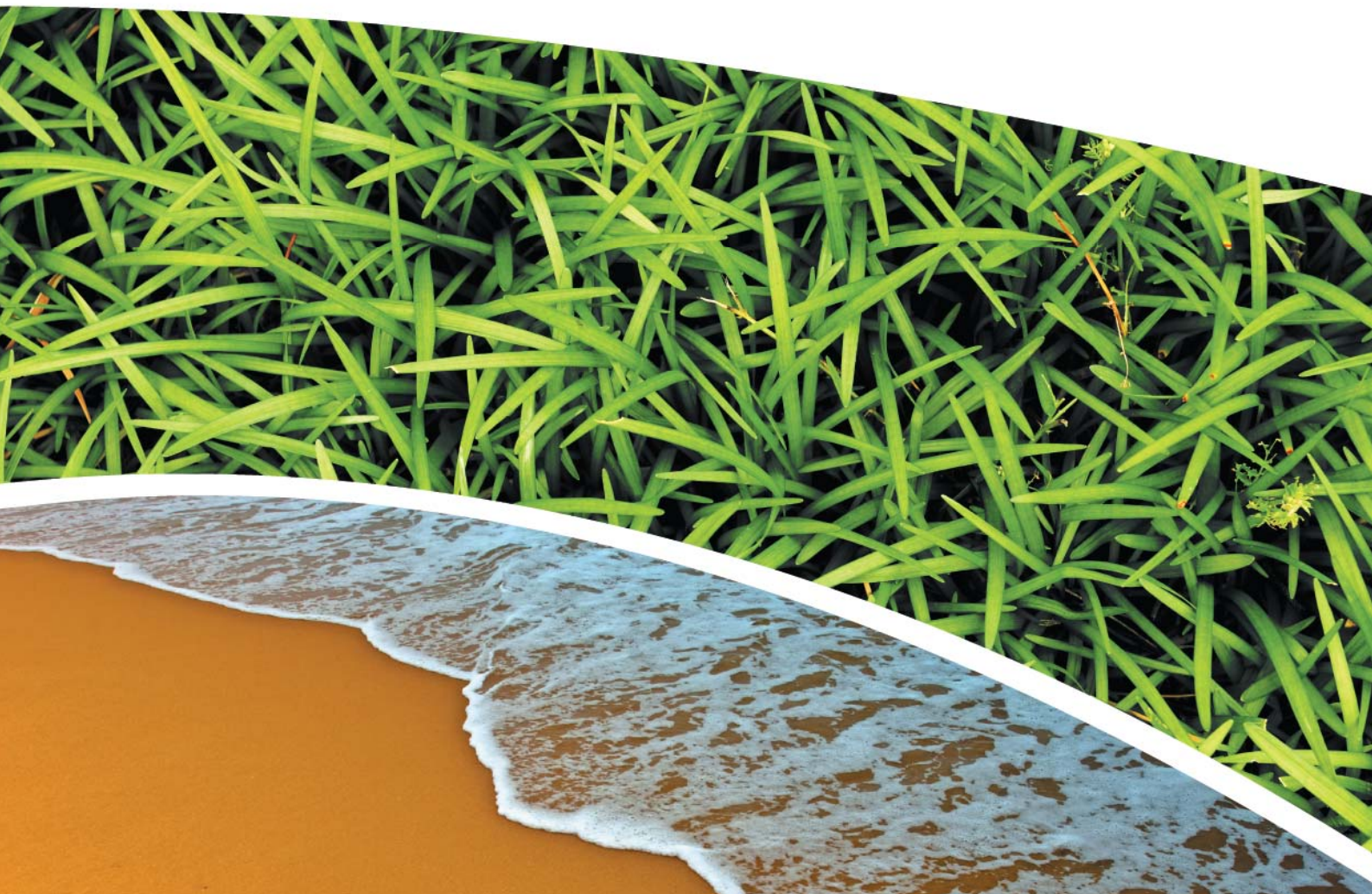

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RCA ref 13280-201/2

22 August 2018

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Attention: Julie Wells

GEOTECHNICAL & GROUNDWATER INVESTIGATION
PROPOSED SAND MINE AT 4226 NELSON BAY ROAD, ANNA BAY

1 SUMMARY

A proposed sand mine and ancillary development are proposed at 4226 Nelson Bay Road, Anna Bay.

The base of the proposed sand mine is at the approximate level of the existing ground surface at an existing electricity easement which runs approximately east to west across the property.

The sand dune system is advancing to the north towards the electricity easement at the south-eastern corner of the property. It is understood that sand mining is proposed to control the advancement of the dunes.

Ground levels vary from approximately RL9mAHD in the vicinity of the electricity easement up to approximately RL17mAHD in the vicinity of the proposed sand mine.

A subsurface investigation has been carried out to assess the soil and groundwater conditions across the site. The investigation comprised drilling of bores up to 12 m deep, construction of groundwater monitoring wells (fitting of one well with an automatic data logger), infiltration testing and laboratory testing of the soils for particle size distribution and presence of acid sulfate soils.

Soils beneath the site comprise a quatzose aeolian sand profile. Ground water was encountered at a depth corresponded to a level of approximately 2m AHD.

The groundwater present beneath the site forms part of the Stockton Groundwater Resource and falls under the Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources.

Based on long term monitoring in nearby monitoring wells and published information, it is considered that the level of the groundwater surface may rise up to 2.8m below the base of the proposed sand mine operational during extreme wet climatic periods.

Surface water infiltration testing yielded infiltration rates which varied from 4 to $5x10^{-4}$m/sec.

The sand mining operations are not expected to encounter actual acid sulfate (AAS) nor potential acid sulfate soils (PASS).

In regard to geotechnical stability of batter associated with the sand mine, it is suggested that when the mine is not actively loading out that batters be limited to a maximum of 1.5H:1V and for long term stability against mass failure that the slopes be battered at a maximum 2H:1V.

2 INTRODUCTION

This report presents the findings of a geotechnical and groundwater investigation undertaken for a proposed sand mine at Lot 591 DP1191380, 4226 Nelson Bay Road, Anna Bay. The investigation was undertaken at the request of Julie Wells from Tattersall Lander on behalf of Hay Enterprises.

Ancillary development for the proposed sand mine at the site includes:

- A machinery shed/storage area and caretaker residence with amenities; and
- An upgraded 6m wide haul route from Nelson Bay Road realigned around the proposed machinery shed and caretaker residence.

This investigation has been undertaken to provide information to address a number of the Secretary's Environmental Assessment Requirements (SEARs) as requested by Tattersall Lander for the preparation of an Environmental Impact Statement (EIS) for the proposed sand mine. The SEARs to be addressed by RCA and the scope of work are shown in **Table 1**.

Table 1 *SEARs to be addressed by RCA and scope of work*

Secretary's Requirement	**RCA scope of work**
A detailed consideration of maintenance of and adequate buffer between all excavations and the highest predicted groundwater table	Details of the predicted highest groundwater level at the development site. RCA to drill piezometer borehole and install data logger to monitor groundwater depth below ground surface and predict maximum likely groundwater level.
An assessment of potential impacts on the quality and quantity of existing surface and groundwater resources, including a detailed assessment of proposed water discharge quantities and quality against receiving water quality and flow objectives	RCA to provide results of infiltration testing on soils.
Potential impacts on acid sulfate soils including proposed management strategies	RCA to drill and sample to confirm that acid sulfate soils conditions are not present in dune sands above RL9mAHD and liaise with Tattersall Lander to prepare an Acid Sulfate Management Plan if required.
Potential impacts on landforms (topography), paying particular attention to the long-term geotechnical stability of any new landforms	RCA to provide advice on suitable landform batter slopes for: - Long-term remediated batter slopes; - Working quarry staging batter slopes; for input into Tattersall Lander design.

This report includes the following:

- Site description.
- Description of fieldwork undertaken which includes drilling of boreholes, penetration testing, installation of instrumented groundwater piezometers and surface water infiltration testing.
- Description of the laboratory testing undertaken which comprise particle size distribution (PSD) and acid sulfate soil (ASS) testing.
- Details of the subsurface conditions encountered by way of logs of boreholes and results of surface water infiltration tests.
- The results of laboratory testing.
- The monitoring of the groundwater level with time.
- Assessment of maximum likely groundwater levels and fluctuations.

- Assessment of the presence of acid sulfate soils.
- Assessment of batter stability of the sand mine batters with respect to short-term and long-term applications.

For the purpose of the investigation the following was provided:

- Development plans drawn by Tattersall Lander comprising a locality sketch and drawings of the overall layout, staging plan, site section, adjoining mining operations and rehabilitation plan.
- A map and coordinates of the location of protected diuris praecox orchids provided by WILDTHING Environmental Consultants (a division of Tattersall Lander).

3 SITE DESCRIPTION

3.1 SITE DESCRIPTION

The proposed sand mine is to be situated in the sand dunes on the southern portion of 4226 Nelson Bay Road, Anna Bay south of an electricity transmission easement which runs approximately east to west across the property. The approximate location of the sand dune system is shown on the site location plan which is attached as **Drawing 1**, in **Appendix A** which also shows the approximate investigation test locations carried out for this report and the indicative location of proposed site developments (Machinery Shed, Caretakers Residence and Access).

The ground surface level in the vicinity of the proposed mine is variable. Away from the sand dunes the existing ground surface slopes across the site are gently undulating with slopes typically of the order of 0 to 5 degrees.

In the area of the electricity easement the ground surface has been modified and is roughly level at approximately RL 9mAHD. South of the electricity easement the ground surface levels rise abruptly at about 30 to 33 degrees up into the sand dunes to approximately RL17mAHD in the vicinity of the proposed sand mine. Slopes on top of the sand dune system are variable with slopes typically in the order of 0 to 10 degrees with localised sand dune faces having slopes up to 30 degrees.

Drainage across the site comprised infiltration drainage in the permeable sand.

Vegetation on the site at the time of the field investigation comprised mostly mature trees with visible treetops protruding through the inundating sand dune system. Some bitou bush was located atop the sand dune system. Grass and small plants including the protected diuris praecox orchid was found in the electricity transmission easement where the trees had been cleared.

Site photographs are shown on **Figure 1**.

Photograph 1 *Looking east atop the sand dune in the proposed sand mine initial area of operation.*

Photograph 2 *Looking west along the southern boundary where the vegetated area is being inundated with sand.*

Photograph 3 *Looking west along the electricity transmission easement from the eastern site boundary.*

Photograph 4 *Looking east across the sand dune slope.*

Photograph 5 *Looking south across the location of the proposed machinery shed and caretaker residence.*

Photograph 6 *Looking north across the location of the proposed machinery shed and caretaker residence and haul road.*

Figure 1 *Site Photographs taken on 30 January 2018.*

3.2 BACKGROUND

3.2.1 PROPOSED SAND MINE

As may be seen from Photographs 7 & 8 in **Figure 2** the sand dune system is advancing to the north towards the electricity easement at the south-eastern corner of the property. It is understood that sand mining is proposed to control the advancement of the dunes.

Photograph 7 *Aerial photograph taken from Nearmap 8 May 2010.*

Photograph 8 *Aerial photograph taken from Nearmap 5 July 2017.*

Figure 2 *Aerial photographs showing the dynamic nature of the sand dune system- showing the northward advancement of the sand dunes during the time between the photographs.*

It is understood that the body of dune sand currently proposed to be mined has a volume of approximately 37,000m^3. It is also understood that the proposed sand extraction area may extend to the west and northeast of the current proposed extraction area in the future as the dune system advances.

3.3 SOIL LANDSCAPE, GEOLOGICAL AND HYDROGEOLOGICAL SETTING

3.3.1 GEOLOGICAL SETTING

Reference to the New South Wales Zone 56 Seamless Geology, version 1 [Digital Dataset] (Ref [1]) shows the site to overlay Quaternary age dune sand deposits.

3.3.2 SOIL LANDSCAPE AND ACID SULFATE RISK MAPS

The Port Stephens 1:100,000 Soil Landscape Series Sheet 9332 indicates that the majority of the site is situated in the Hawks Nest soil landscape (an Aeolian soil landscape) with the proposed sand mine to the south situated in the Stockton Beach soil landscape.

The Hawks Nest soil landscape is noted to generally comprise stable, gently undulating, Holocene sand sheets and beach ridges.

The Stockton Beach soil landscape is noted to generally comprise beaches, foredunes and often extensive and unstable dunes and blowouts on Holocene marine and Aeolian sand. Very well-drained Calcareous Sands are expected in the sand dunes.

The Morna Point Acid Sulfate Soil Risk Map published by the Department of Land and Water Conservation indicates that there is a low probability of the occurrence of acid sulfate soil materials at depths greater than 3m below the ground surface in the areas

from which sand extraction is proposed. It is noted however that lowlands to the west of the site associated with Tilligerry Creek estuary/ flood plain have a well-known acid sulfate setting.

3.3.3 *HYDROGEOLOGICAL SETTING*

The site overlies part of the North Stockton sand beds and forms part of the Stockton Groundwater Resource and falls under the Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources.

The sand aquifer extends from the mouth of the Hunter River in the south to Anna Bay in the north and is bounded by the Newcastle Bight/Tasman Sea in the east and the Tilligerry Creek estuary and flood plains in the west. **Figure 3** presents a schematic cross-section of the geological/hydrogeological conceptual model of the site and its environs.

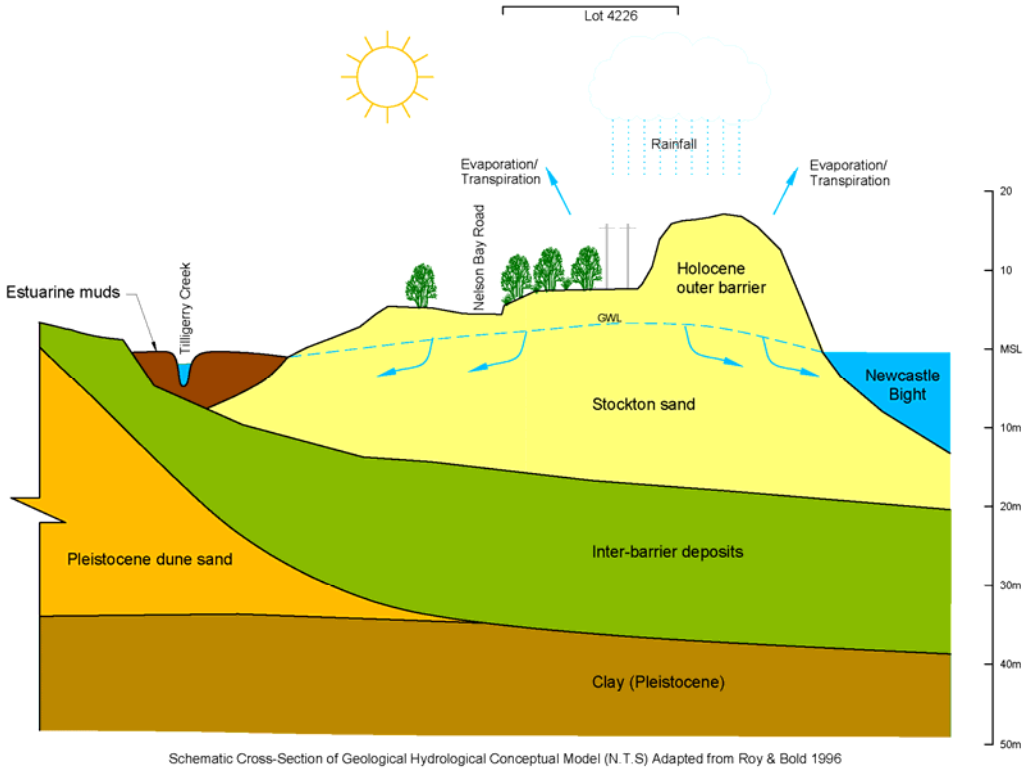


Figure 3 *Schematic Cross-section of Geological/Hydrogeological Conceptual Model (adapted with modification from Ref [2])*

The groundwater beneath the coastal dune system forms a groundwater divide between the ocean and Tilligerry Creek. Groundwater recharge is primarily from rainfall infiltrating the dune system and discharges by evapotranspiration and from groundwater discharge down gradient to the ocean and tidal estuary/ floodplain drains.

There are a number of licenced water works (wells) within about 0.5km of the site on the Department of Industries, Office of Water (OoW) data site. These include the following:

- GW047490 adjacent to Jessie Road south of the intersection with Nelson Bay Road. The OoW work sheet record this to be a local government owned bore with a standing groundwater depth of 6.1m.
- GW079407/GW079408 approximately 0.5km along the electricity easement west of the boundary of Lot 4226. No details are contained on the OoW work sheets apart from the installation being owned by Hunter Water ref Sk9593b.
- GW079138/GW079370 approximately 0.35km along the electricity easement east of the boundary of Lot 4226. No details are contained on the OoW work sheets apart from the installation being owned by Hunter Water ref BL215A.

The nearest bore on the DIP OoW database which contains monitoring results is GW080359 also referenced as GW800083_2 and Anna Bay Public School bore 3 located approximately 3km east of the site. A plot of water depth variations contained in the data base is shown on **Figure 4**.

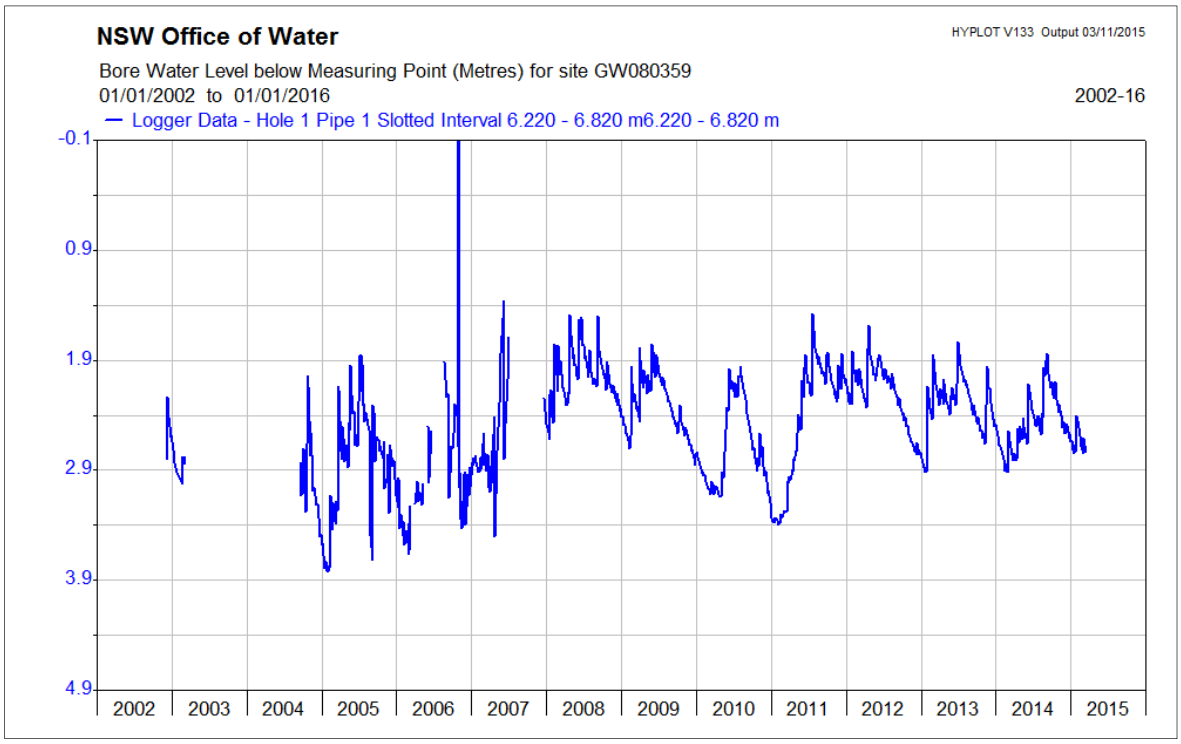


Figure 4 *Plot of water depth in GW080359 (copied from OoW database) from 2002 to 2015*

The spread sheet that accompanies the plot in the OoW data set indicates that the water level was deepest at 3.816m in earlier 2005 and spiked to 0.535m/0.498m on the 28/29 October 2006. The resulting maximum water level fluctuation is 3.318m from the lowest record over the period for which there is data. It is noted however that the rainfall records of stations (see **Figure 5** as an example) in the vicinity of the site do not record the occurrence of a significant rainfall event. Accordingly the cause of the spike is not known.

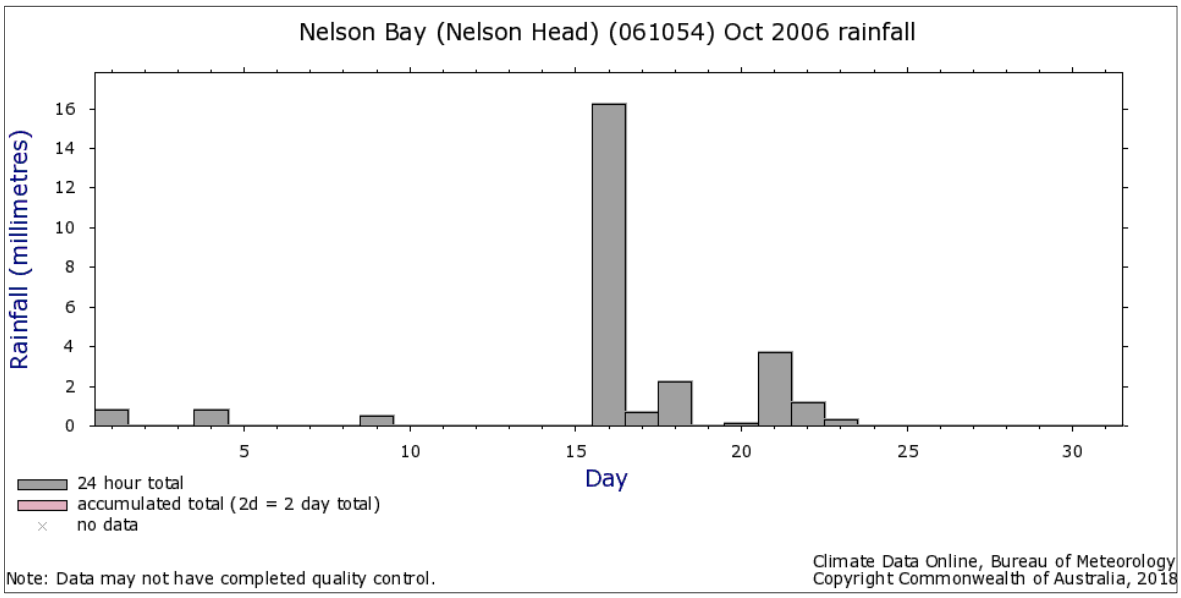


Figure 5 *Daily Rainfall Nelson Bay October 2006 from BOM site*

With reference to **Figure 4** it may be seen that in the absence of the spike in late 2006 the groundwater surface appears to have varied up to 2.5m in depth over the years of monitoring for which data is available.

Hunter Water (HW) have supplied monitoring information on the North Stockton network of monitoring bores including Sk9593b and BL215A which as noted above lie to the west and east of the site, respectively.

The monitoring results are presented on **Figure 6**.

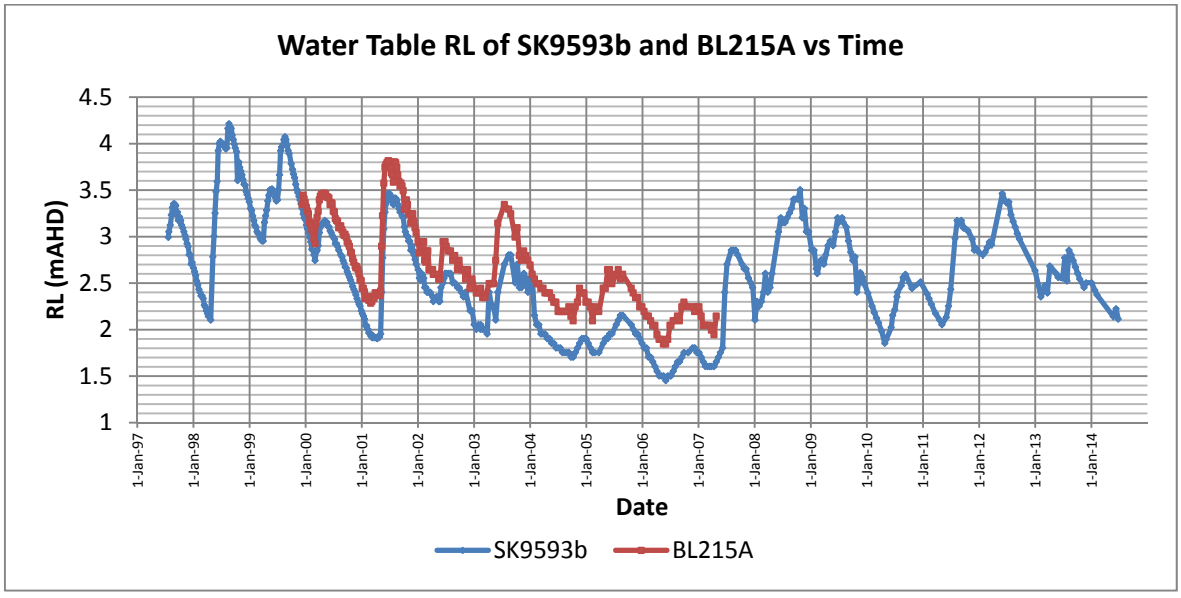


Figure 6 *Plot of groundwater level monitoring data at SK9593b and BL215A (Hunter Water data)*

It is noted that HW no longer monitors these sites and that the above is a complete data set apart from the removal of erroneous readings.

It may be seen from the **Figure 6** that the maximum variation in water level is approximately 2.8m.

4 FIELD AND LABORATORY INVESTIGATION

4.1 INVESTIGATION FIELDWORK

Field investigation was carried out on 23, 30 January 2018 and 2, 5, 12 February 2018 and involved the following:

- A visual appraisal and mapping of site conditions and features.
- Drilling, sampling and logging of five (5) hand auger bores (HA1 to HA5) to depths ranging from 0.95m to 6.0m.
- Dynamic penetrometer testing at 5 locations adjacent to the hand auger boreholes.
- Drilling, sampling and logging of two (2) boreholes (BH6 & BH7) to 12.0m. The boreholes were completed by a track mounted drilling rig using hollow flight augers.
- Installation of two (2) 50mm diameter standpipe piezometers (PZ1in BH7 & PZ2 in BH6) to depths ranging from 11.60 to 11.70m. The piezometers were installed by a licenced water well driller from Total Drilling.
- Installation of an automatic down-hole data logger (HOBO) in one piezometer (BH7/PZ1). The data logger was set to read at 0.5hr intervals.
- Conducting four (4) in situ infiltration tests (INF1 To INF4) using double ring infiltrometer methodology.

The approximate test locations together with site features are shown on the site layout drawing provided by Tattersall Lander which is attached as **Drawing 1**, in **Appendix A**. The location and level of the test sites have not been located by survey.

Engineering logs of the subsurface conditions encountered in the hand auger bores and boreholes are presented in **Appendix B** along with piezometer diagrams and explanation sheets.

Double ring infiltrometer test reports are presented in **Appendix C**.

Photographs of selected investigation locations are shown below on Photographs 9 to 16 in **Figure 7**.

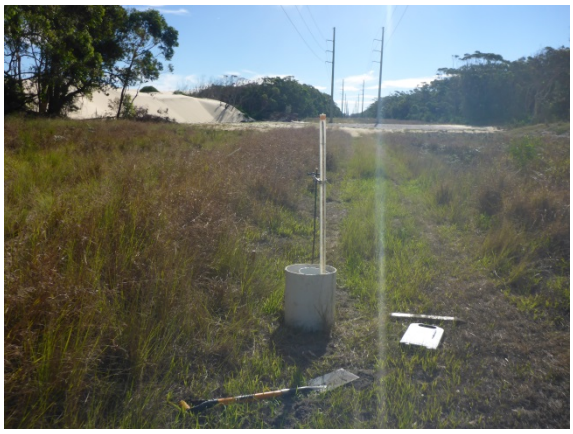
Photograph 9 *Hand auger borehole location atop the sand dune system at HA4.*

Photograph 10 *Drilling of hand auger HA3 atop the sand dune system.*

Photograph 11 *Borehole drilling at the location of BH6/PZ2.*

Photograph 12 *Installed Piezometer PZ1 at the location of BH7.*

Photograph 13 *Double ring infiltrometer apparatus set up at location INF1.*



Photograph 14 *Double ring infiltrometer apparatus set up at location INF2.*

Photograph 15 *Double ring infiltrometer apparatus set up at location INF3.*

Photograph 16 *Double ring infiltrometer apparatus set up at location INF4.*

Figure 7 *Photographs of selected fieldwork test locations*

4.2 MONITORING WELL LOCATIONS

As noted above groundwater monitoring wells PZ1 and PZ2 were installed at the locations of BH7 and BH6 respectively. PZ1 is fitted with an automatic down-hole data logger taking readings of air and water pressure at half hour intervals and is finished above ground level within a lockable, galvanised steel monument. The groundwater monitoring well PZ2 was installed where heavy machinery is likely to traffic during the operation of the sand mine and is finished 0.3m below ground level with a concrete encased gaiter cover. PZ2 was installed as a precautionary measure; in case of damage to or the vandalisation of PZ1 prior to the completion of the requirement for groundwater monitoring. The location of PZ2 is 25.0m from the closest edge of the electricity transmission pole on an imaginary line extending through the centre of both electricity transmission poles, as shown in **Photograph 17**.

Photograph 17 *Sketch of the location of BH6/PZ2 relative to the location of electricity transmission poles.*

4.3 LABORATORY TESTING

Laboratory testing comprised the following:

- Four (4) particle size distribution (PSD) tests on samples of sand from the proposed sand mine area of operation.
- Nine (9) acid sulfate screening tests conducted on samples of sand from the area of operation and above and below the water table to assess the presence of acid sulfate soils. Three (3) samples were sent for chromium reducible sulphur (CRS) testing to determine the presence or otherwise of sulphides.

Details of the laboratory testing are shown on the laboratory test reports attached in **Appendix D** and the results of the laboratory testing are summarised in Section 4.2.

5 SUBSURFACE CONDITIONS

5.1 SUBSURFACE CONDITIONS ENCOUNTERED DURING INVESTIGATION

5.1.1 SOIL PROFILE

The subsurface conditions encountered in the bores drilled and hand augered across the site of the proposed sand mine are detailed on the attached bore and hand auger report log sheets. The depths noted on the borehole logs have been recorded relative to the existing ground surface at the borehole locations at the time of the field investigation. An indicative generalised section through the section of the site of interest is shown on **Drawing 2** in **Appendix A**.

The subsurface conditions encountered in the hand augers atop the sand dune (HA3 and HA4) comprised aeolian, quartzose, fine to medium grained, pale yellow-white sand.

A plot of the dynamic penetration testing from the top of the dune sand at HA3 & HA4 is shown on **Figure 8** together with the interpreted relative density.

Dynamic penetrometer testing indicates that the density of the sand is generally medium dense in HA3 and varies from very loose to loose/medium dense with depth in HA4.

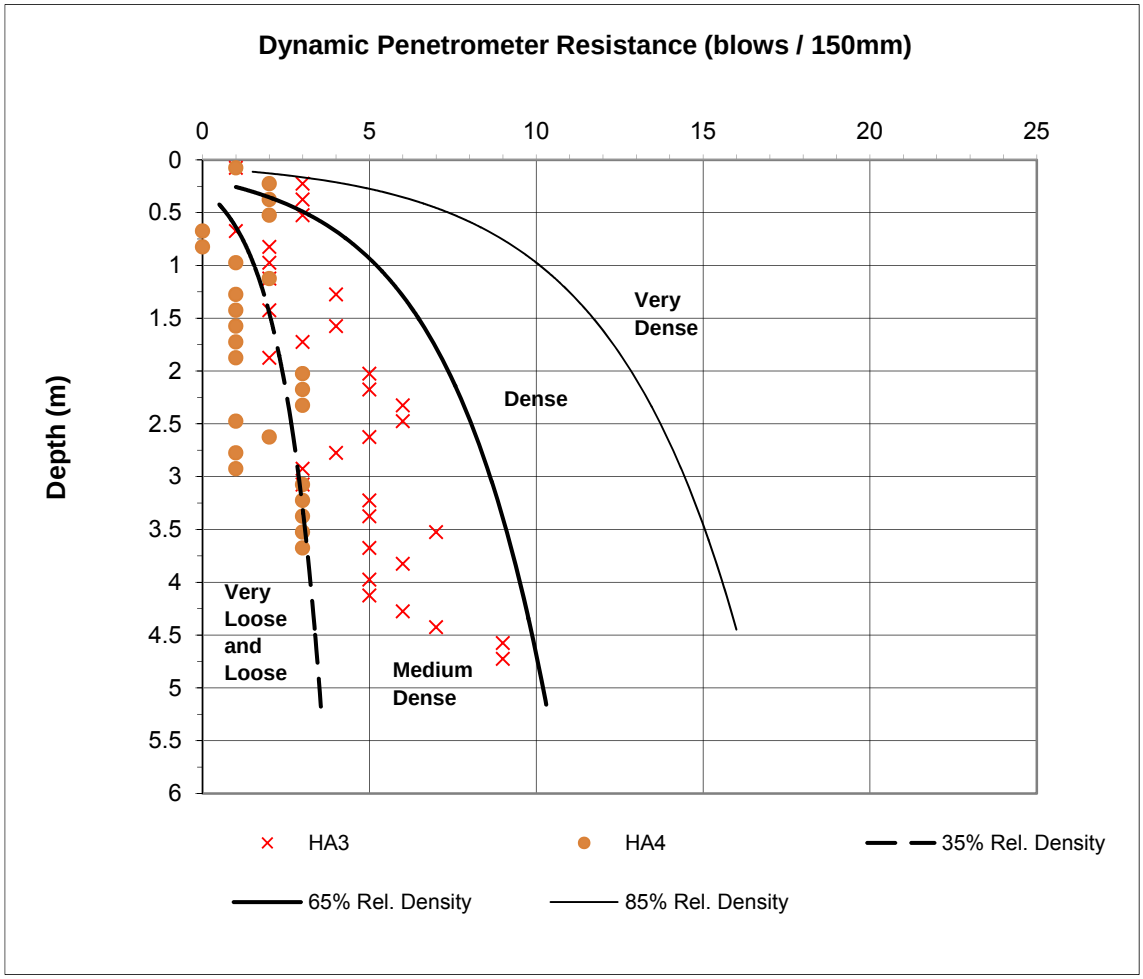


Figure 8 *Plot of dynamic penetrometer resistance test carried out from the top of the sand dunes at the location of hand augers HA3 & HA4 (density curves from Ref [5])*

The subsurface conditions encountered in the boreholes and hand augers drilled to the north of the dunes site can generally be summarised as follows:

- Topsoil (encountered in HA1, HA2, HA5, and BH7) comprising silty sand, fine to medium grained, grey, to a depth of 0.3m in the hand augers and 0.8m in BH7; overlying
- Aeolian sand, quartzose, fine to medium grained, encountered in all test holes to depths in excess of 12m in BH6 and BH7.

Dynamic penetrometer test results carried out at the location of HA 1, 2 & 5 are plotted on **Figure 9.**

With reference to **Figure 9** the density of the near surface sands is variable but generally medium dense (ie relative density index between 35% to 65%) or better below a depth of 0.7m.

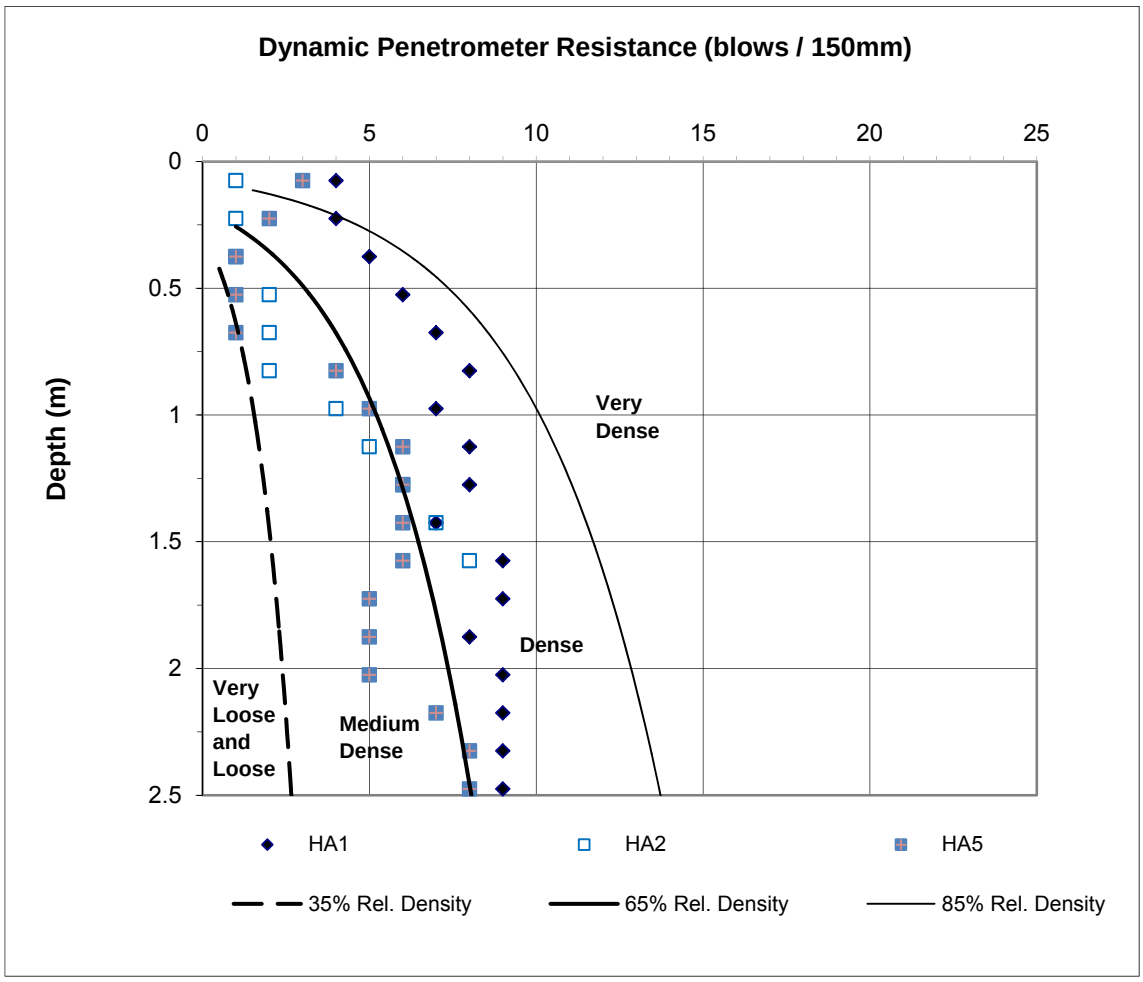


Figure 9 *Plot of dynamic penetrometer resistance at the location of hand augers HA1, HA2 & HA5 (density curves from Ref [5])*

The results of the Standard penetration testing (SPT) in BH6 & 7 are plotted on **Figure 10.** The results indicate that the sands are loose to medium dense in the upper zone and medium dense with depth.

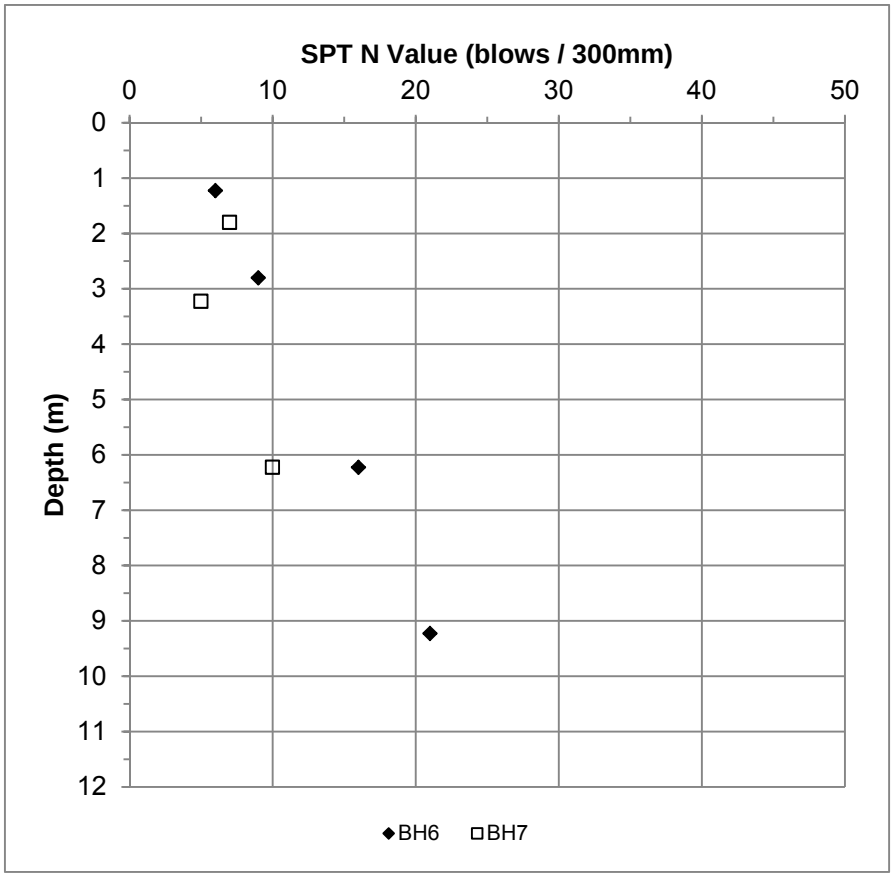


Figure 10 *Summary of SPT testing in BH6 and BH7*

5.1.2 GROUNDWATER LEVELS

The test locations have not been surveyed and all groundwater measurements are relative to the existing ground surface level. On 5 February 2018 groundwater was measured in PZ1 (in BH7) and PZ2 (in BH6) at depths of 7.45m and 6.30m below ground level respectively. With reference to **Drawing 2** in **Appendix A** the depths corresponded to a groundwater level of approximately 2m AHD.

The automatic down-hole data logger installed in BH7/PZ1 commenced taking readings on the 5 February 2018 and the data was downloaded on 28 February 2018 after some rainfall. The water level in PZ1 is recorded in **Figure 11** along with rainfall data from the Nelson Bay (Nelson Head) weather station approximately 12km away.

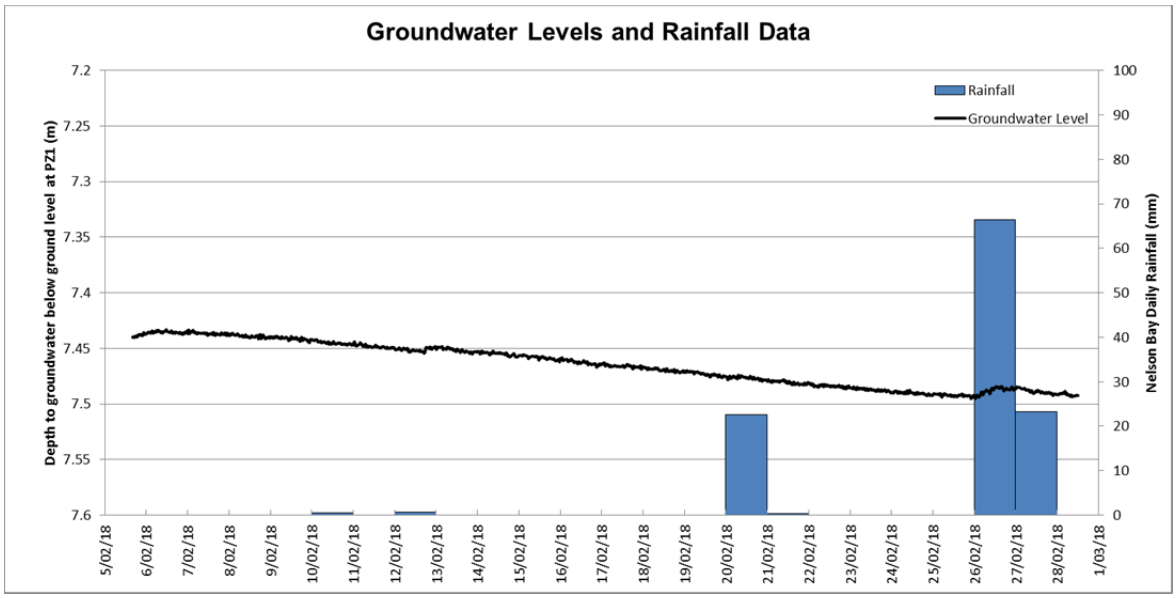


Figure 11 *Continuous groundwater measurements throughout February 2018.*

The depth to groundwater has steadily decreased by a total of approximately 50mm across the 23 days recorded. After significant rainfall on 26 February the groundwater level rose by 10mm however returned the next day to the downward trend.

5.1.3 INFILTRATION TEST RESULTS

Double ring infiltrometer testing was undertaken at four (4) locations (INF1 to INF4) across the site. Infiltrometer rings were driven 100mm into the surface of the soil layer. The sites of the test were soaked with water for an approximate 30 minute period of time to establish saturated soil conditions before the testing was conducted.

Two tests were undertaken at each testing location using a 1.5L Marriotte tube. The double ring infiltrometer test reports are presented in **Appendix C** and are summarised in **Table 2**.

Table 2 *Summary of In Situ Infiltration Rate Testing*

Borehole	Depth of test (m)	Soil Type	Test Method	Average Infiltration Rate (m/s)
INF1	0.1	SAND, fine to medium grained	Double Ring Infiltrometer – Constant Head	5.0×10^{-4}
INF2	0.1	SAND, fine to medium grained	Double Ring Infiltrometer – Constant Head	4.0×10^{-4}
INF3	0.1	SAND, fine to medium grained	Double Ring Infiltrometer – Constant Head	4.2×10^{-4}
INF4	0.1	SAND, fine to medium grained	Double Ring Infiltrometer – Constant Head	4.1×10^{-4}

The measured infiltration rates as shown in **Table 2** indicate that the sand clean at the site has an approximate surface infiltration rate of 4.0×10^{-4} to 5.0×10^{-4}m/s.

The Hazen formula for permeability along with particle size distribution results suggests the dune sand has permeability of between 2×10^{-4} and 6×10^{-4}m/s.

5.2 LABORATORY TEST RESULTS

5.2.1 PARTICLE SIZE DISTRIBUTION TESTING RESULTS

Laboratory testing results are attached in **Appendix C** and are plotted and summarised in **Figure 12** and **Table 3** respectively.

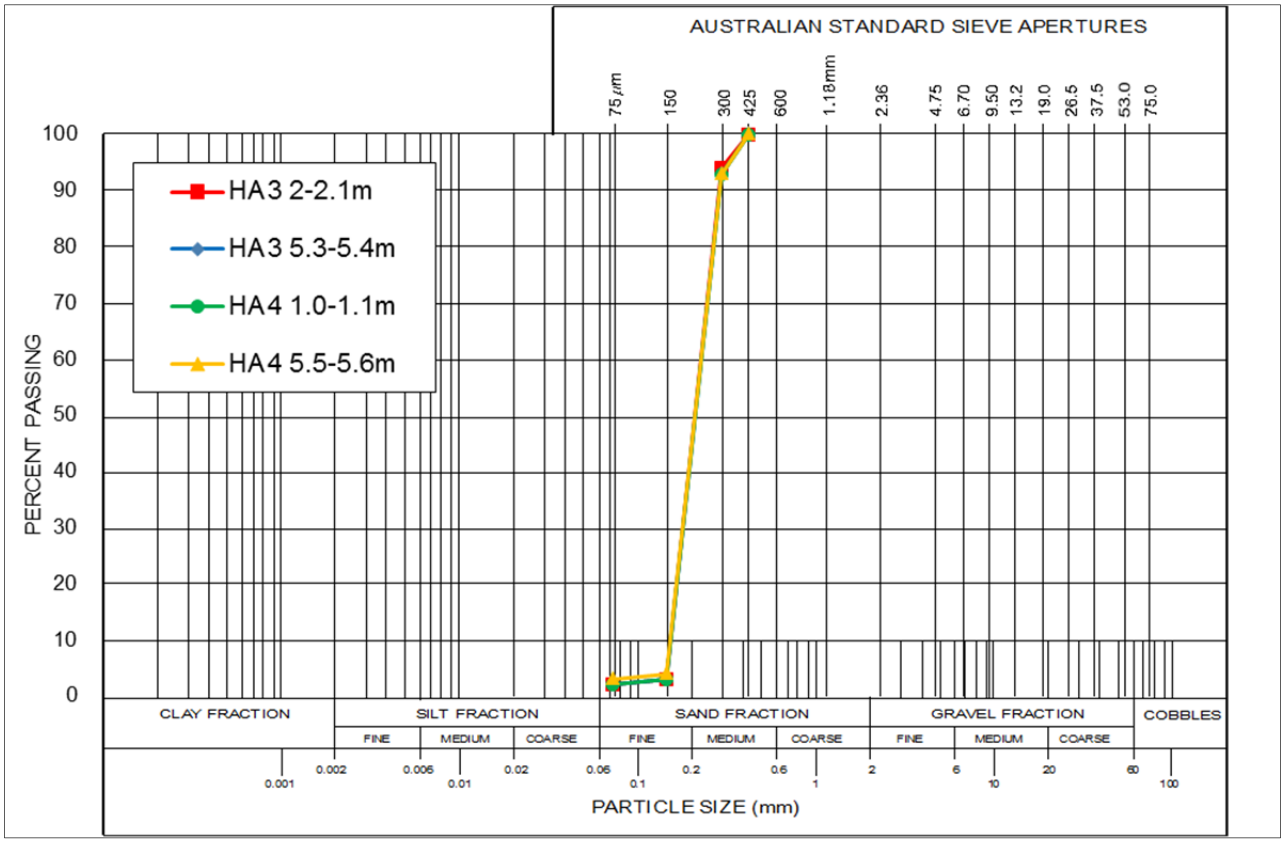


Figure 12 *Particle Size Distribution Test Results*

Table 3 *Summary of Particle Size Distribution Testing Results*

Borehole	Depth (m)	Soil Type	Particle Size Distribution		
			% Silt and Clay	% Sand	% Gravel
HA3	2.0-2.1	Aeolian SAND	2	98	0
HA3	5.3-5.4	Aeolian SAND	2	98	0
HA4	1.0-1.1	Aeolian SAND	2	98	0

HA4	5.5-5.6	Aeolian SAND	3	97	0

The particle size distribution results indicate that the fine to medium grained dune sand is uniform in grain size with approximately ninety percent of the sand having a grain size between 0.15 and 0.30mm.

5.2.2 ACID SULFATE TEST RESULTS

The results of the acid sulfate screening testing on the samples of sand taken from the bores are shown on **Table 4**.

Table 4 *Summary of ASS screening test results*

	UNITS (m)	HA3 4.0-4.1	HA3 5.0-5.1	HA3 5.9-6.0	HA4 4.0-4.1	HA4 5.0-5.1	HA4 5.9-6.0	BH6 4.0-4.1	BH6 6-6.45	BH6 9-9.45
pH_F	pH unit	7.63	7.54	7.79	8.17	6.82	8.08	7.09	6.89	6.97
pH_{FOX}	pH unit	6.12	6.16	6.30	6.22	5.72	6.12	5.60	5.89	5.88
$pH_F - pH_{FOX}$	pH unit	1.51	1.38	1.49	1.95	1.1	1.96	1.49	1	1.09
Reaction Rate	-	1	1	1	1	1	1	1	1	1

pH_F - pH

pH_{FOX} – pH after oxidation

Reaction Rate Rate: 0 = No Reaction, 1 = Slight, 2 = Moderate, 3 = High, 4 = Very Vigorous

The screening test results indicate that the pH of the soils tested was greater than 4 and as such soils are not actual acid sulfate soils.

The screening testing indicate a drop on oxidation of greater then 1pH unit on oxidation but the resulting pH after oxidation is greater than 5 pH units and the reaction rate is slight indicating limited acid generation potential that the soils are unlikely to be potential acid sulfate soils. To confirm the limited acid potential of the sands four (4) chromium reducible sulphur analysis were carried out. The results are presented in **Appendix D**.

In summary, the % chromium reducible sulphur varied from 0.005% to 0.008% well below the trigger criteria of 0.03%S for a potential acid sulfate soil (PASS).

6 ADVICE ON REQUESTED SEARS

6.1 GROUNDWATER LEVELS

Groundwater monitoring has been ongoing for a limited period of time following a relatively dry period.

Available information on the maximum groundwater fluctuations likely in the sand beds included the following:

- Anna Bay Public School Bore 3 (discussed in section 2.3.3) indicates maximum groundwater surface level fluctuations over the years of monitoring presented (2002 to 2015) of 2.5m.

- The HW groundwater monitoring data for BL215A and SK9593b (monitoring wells closest to the site) indicates a maximum groundwater surface level fluctuation over the years monitored of approximately 2.8m.
- Ref [3], Figure 11 graphs groundwater levels between 1976 and 1987 for 2 long term monitoring wells in the Tomago sand beds which indicate maximum fluctuations of 2.5 to 3m for the period monitored.
- Ref [3] reports the monitoring of 7 wells at Salt Ash between July 2008 and October 2011 which fluctuated with climatic conditions typically from 1.0 to 1.7mAHD. The report considers the Hunter Water groundwater monitoring wells and modelling to include consideration of the effect of the heavy rainfall periods during 1990 and 2007 and reports a transient groundwater model run over the period from January 1997 to August 2011. The data and model indicate that the highest groundwater levels in the north Stockton aquifer were recorder in May to August 1999. Accordingly, the report finds that the August 1999 groundwater levels represent the maximum groundwater level. Modelling and the groundwater monitoring observation wells indicate a maximum fluctuation in groundwater level of 3.2m.

Based on the above groundwater surface level fluctuations (and the current relatively dry weather conditions) it is considered that the level of the groundwater surface may rise up to 3.5m above the current water depth as indicated in BH6/PZ2. Accordingly, it is expected that the highest probable water level would be 2.8m below the ground level at BH6/PZ2 in the proximity of the proposed sand mine operational area.

6.2 SURFACE WATER INFILTRATION TESTING

The results of the surface water infiltration testing are presented in Section 4.1.3. The test results yielded infiltration rates which varied from 4 to 5 $x10^{-4}$m/sec.

The results are considered to be typical or representative values of infiltration rates for the clean, fine to medium grained sands at the site.

6.3 ACID SULFATE TESTING

Based on the results of the ASS testing, the sand mining operations are not expected to encounter actual acid sulfate (AAS) nor potential acid sulfate soils (PASS).

6.4 BATTER STABILITY AND SITE EARTHWORKS

6.4.1 ANGLE OF REPOSE OF THE DUNE SAND

The angle of repose of a sand batter is a measure of the shear strength friction angle of the sand in its loose state. With reference to **Figure 8** it may be seen that at least parts of the dune sand are composed of loose sand. Accordingly, it is considered that the angle of repose of the batter provides a good estimate of the shear strength friction angle of the sand.

The angle of repose was measured using a hand held inclinometer on an excavated sand dune to the south of the electricity power easement at site on 30 January 2018. The sand dune slope face was assessed to be at its critical angle of repose as disturbance of the batter surface caused surface flow and raveling on the batter. The measured angle of repose was approximately 30-33 degrees.

Based on the above and previous experience with similar materials the following Parameters have been adopted for stability assessment:

- Friction Angle (ϕ) – 33^o
- Cohesion – 0
- Density (γ) – 19kN/m^3

6.4.2 BATTER STABILITY ANALYSIS FOR SHORT-TERM APPLICATIONS

It is understood that it is proposed to extract sand from the face of the dune system with an approximate height of 8m by excavator.

It is expected that the batter face in moist sand will be steeper than 1.5H:1V (35^o) for short periods of time due to the capillary suction of the moisture between the sand particles imparting an additional shear strength by way of apparent cohesion.

In this state the batter is susceptible to a sudden collapse onto anything that is at the toe of the batter.

It is therefore suggested that when the sand mine is not actively loading out that the face should be battered down to an angle of no greater than 1.5H: 1V.

6.4.1 BATTER STABILITY ANALYSIS FOR LONG-TERM APPLICATIONS

It is understood that a stable batter slope is required for long term remediation of the sand mine batters on site at the boundary. In practical terms it is difficult to rehabilitate batter slopes in excess of 2H:1V.

A 2H:1V sand batter would have a factor of safety of 1.3 against sand raveling down the batter surface face. Due to the trivial nature of the movement a factor of safety of 1.3 is considered acceptable for this type of movement.

The factor of safety against mass rotational slumping of a 2H:1V batter slope extending behind the batter crest has been analyzed using commercially available stability program SlopeW and the parameters discussed in Section 5.4.1. The result is shown on **Figure 13**.

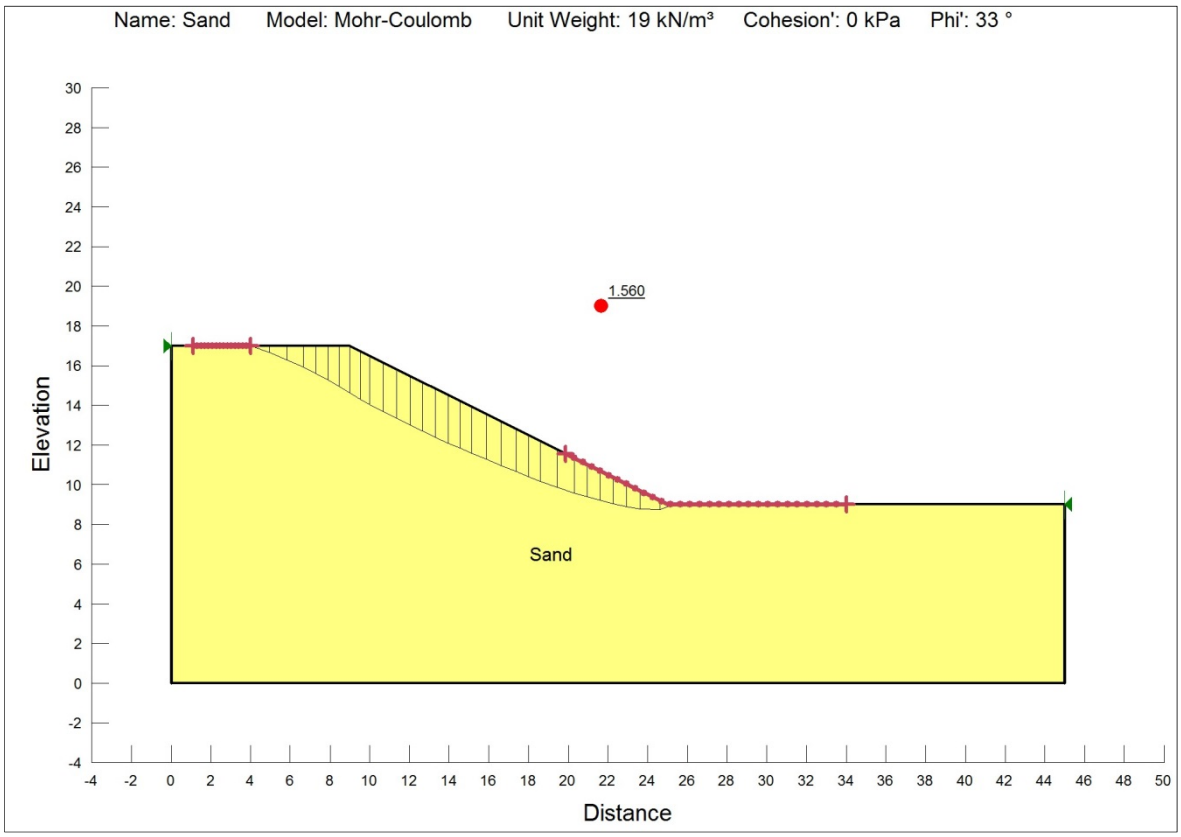


Figure 13 *Plot of Factor of safety against mass rotational slumping of 2H:1V batter slope*

The factor of safety against mass rotational slumping of a 2H:1V batter slope is in excess of 1.5 and this is considered acceptable for the proposed situation.

Based on the above it is suggested that from a geotechnical perspective a maximum batter slope of 2H:1V be adopted for the final landform batter.

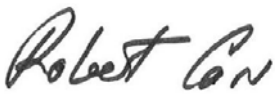
7 LIMITATIONS

This report has been prepared for Tattersall Lander Pty Ltd in accordance with the agreement with RCA Australia (RCA). The services performed by RCA have been conducted in a manner consistent with that generally exercised by members of its profession and consulting practice.

This report has been prepared for the sole use of Tattersall Lander Pty Ltd for the specific purpose and the specific development described in the report. The report may not contain sufficient information for purposes or developments other than that described in the report or for parties other than Tattersall Lander Pty Ltd. This report shall only be presented in full and may not be used to support objectives other than those stated in the report without permission.

The information in this report is considered accurate at the date of issue with regard to the current conditions of the site. The conclusions drawn in the report are based on interpolation between boreholes or test pits. Conditions can vary between test locations that cannot be explicitly defined or inferred by investigation.

Yours faithfully
RCA AUSTRALIA



Jason Haines
Geotechnical Engineer

Robert Carr
Principal Geotechnical Engineer

REFERENCES

[1] Colquhoun G.P., Phillips, G., Hughes, K.S, Deyssing L., Fitzherbert, J.A., & Troedson, A.L. 2015. New South Wales Zone 56 Seamless Geology, version 1 [Digital Dataset], Geological Survey of New South Wales, Maitland.

[2] Roy P.S. & Boyd R. 1996 Quarterly Geology of South East Australia: a Tectonically Stable, Wave-Dominated, Sediment-Deficient Margin, Field Guide to the Central New South Wales Coast, November 1996, International Geological Correlation Project #367.

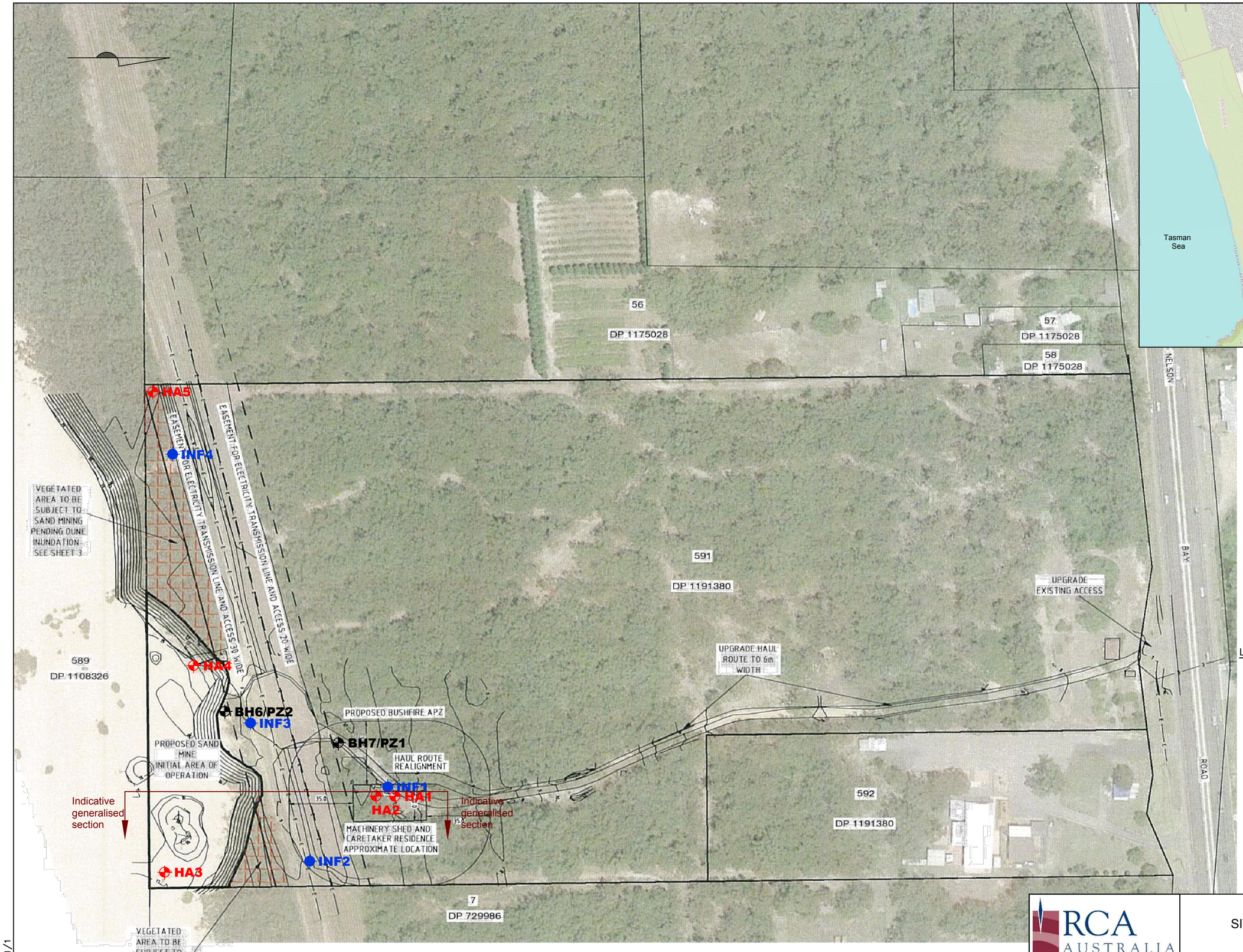
[3] Report titled *RAAF Williamtown Groundwater Modelling for AECOM Services Pty Ltd* by Heritage Computing Pty Ltd TAS Hydro Simulations, Project No:AEC002, Ref HC2016/09d dated June 2016.

[4] Report titled *Determination of Maximum Predicted Groundwater Level and Maximum Extraction Level at Lot 218 and 220, Salt Ash,* prepared for Mackas Sand Pty Ltd by Umwelt Environmental Consultants November 2011.

[5] Fityus S., *Calibration of the Blunt Tipped Dynamic Penetrometer for Silica Sands*, Proc of the first International Conference on Site Characterisation, ISC'98/Atlanta/ Georgia USA, 19-22April 1998.

Appendix A

Drawings



Locality Plan
N.T.S.

LEGEND

- Approximate hand auger borehole location
- Approximate borehole/piezometer location
- Approximate double ring infiltration test location

NOTE: Drawing adapted from plan (PDF) supplied by Tattersall Lander Pty Ltd
Job No. 217111, Dwg: Overall Layout

0 20 40 60 80 100
metres

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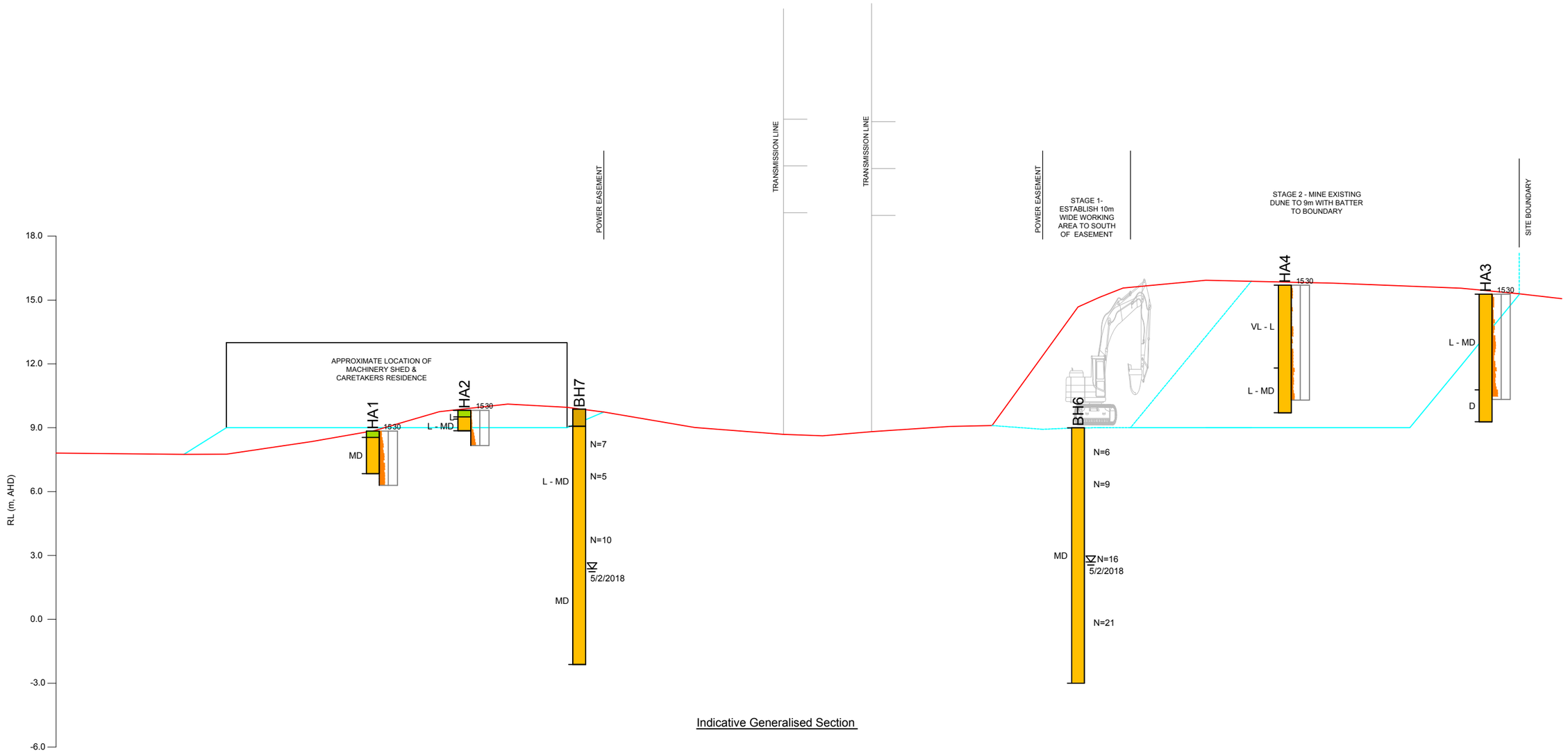
SITE AND TEST LOCATION PLAN
4226 NELSON BAY ROAD
ANNA BAY

CLIENT	Tattersall Lander Pty Ltd			RCA Ref	13280-201/2
DRAWN BY	JH	SCALE	~1 : 2000 (A3)	DRAWING No 1	REV 0
APPROVED BY	RJC	DATE	21/08/2018	OFFICE	NEWCASTLE

CDT–DWG–A3H–001/1



Indicative Generalised Section

LEGEND

- TOPSOIL
- TOPSOIL/AEOLIAN
- AEOLIAN

BOREHOLE ID

Soil consistency/ Density — xx — N=00 SPT N value R=SPT refusal

Pocket penetrometer (kPa) — PP= — Groundwater level

Rock Weathering — xx — xx Estimated Rock Strength

DCP ID

15 30 DCP - blow counts per 100mm interval

DCP Test results

NOTE: Reproduced from drawing supplied by Tattersall Lander
Ref No. 21800004, Sheet 4

Test holes not surveyed. Bores positioned in levels to match ground surface on section. Test holes projected onto section

SCALE

Horizontal = 1 : 500 (A3)
Vertical = 1 : 200 (A3)

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INDICATIVE GENERALISED SECTION
4226 NELSON BAY ROAD
ANNA BAY

CLIENT	Tattersall Lander Pty Ltd			RCA Ref	13280-201/1
DRAWN BY	JH	SCALE	As Shown (A3)	DRAWING No 2	REV 0
APPROVED BY	RJC	DATE	21/08/2018	OFFICE	NEWCASTLE

CDT-DWG-A3H-001/1

Appendix B

Borehole and Hand Auger Borehole Logs

Piezometer Diagrams

Explanatory Notes

GEOTECHNICAL HAND AUGER
HA1

SHEET 1 OF 1

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 13280
CLIENT: Tattersall Lander Pty Ltd
PROJECT: Geotechnical Investigation
LOCATION: 4226 Nelson Bay Road, Anna Bay

DATE: 30/01/2018
SURFACE RL:
COORDS:
EXCAVATION METHOD: Hand Auger with Sand Attachment

Borehole Information					Field Material Information					
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
Not Encountered	4					SM	TOPSOIL, Silty SAND, fine to medium grained, grey	D		TOPSOIL PSP method used for Dynamic Penetrometer
	4		0.20m D 0.30m							
	5			0.30		SP	SAND, fine to medium grained, grey, poorly graded, trace of silt	M	MD	AEOLIAN
	6			0.5						
	7		0.70m D 0.80m				Becoming mottled pale yellow-white and grey at 0.6m			Small root at 0.6m
	6									
	7			1.0						Small root at 0.9m
	8						Becoming red-brown mottled grey at 1.0m			
	8		1.30m D 1.40m							
	7									
	9			1.5						
	9		1.80m							
	8		D 2.00m							
	9			2.00			HAND AUGER HA1 TERMINATED AT 2.00 m			
	9									
	9			2.5						
	9									
				3.0						
				3.5						
				4.0						
				4.5						

LOGGED: JH | CHECKED: RJC | DATE: 05/03/2018

GEOTECHNICAL HAND AUGER
HA2

SHEET 1 OF 1

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 13280
CLIENT: Tattersall Lander Pty Ltd
PROJECT: Geotechnical Investigation
LOCATION: 4226 Nelson Bay Road, Anna Bay

DATE: 30/01/2018
SURFACE RL:
COORDS:
EXCAVATION METHOD: Hand Auger with Sand Attachment

Borehole Information					Field Material Information					
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
Not Encountered	1					SM	TOPSOIL, Silty SAND, fine to medium grained, grey			TOPSOIL PSP method used for Dynamic Penetrometer
	1		0.20m D 0.30m							
	1			0.30		SP	SAND, fine to medium grained, grey, poorly graded, trace of silt	D	L L - MD	AEOLIAN Sand very dry - water added at 0.5m
	2		0.60m D 0.70m	0.5						
	2									
	2			0.95						
	4			1.0			HAND AUGER HA2 TERMINATED AT 0.95 m Hand auger refusal on ~50mm tree root			
	5									
	6									
	7			1.5						
	8									
				2.0						
				2.5						
				3.0						
				3.5						
				4.0						
				4.5						

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GEOTECHNICAL HAND AUGER
HA3

RCA AUSTRALIA
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PROJECT No: 13280
CLIENT: Tattersall Lander Pty Ltd
PROJECT: Geotechnical Investigation
LOCATION: 4226 Nelson Bay Road, Anna Bay

DATE: 30/01/2018
SURFACE RL:
COORDS:
EXCAVATION METHOD: Hand Auger with Sand Attachment

Borehole Information					Field Material Information					
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
Not Encountered	1 3 3 3 1 2 2 2 4 2 4 3 2 5 5 6 6 5 4 3 3 5 5 7 5 6 5 5 6 7 9 9		1.00m D 1.20m 2.00m D 2.10m 3.00m D 3.10m 4.00m D 4.10m 5.00m	0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5		SP	SAND, fine to medium grained, pale yellow-white, poorly graded Becoming pale yellow-white mottled with grey at 2.0m Becoming pale yellow-white at 3.2m	D M	L - MD D	AEOLIAN PSP method used for Dynamic Penetrometer

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GEOTECHNICAL HAND AUGER
HA3

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 13280
CLIENT: Tattersall Lander Pty Ltd
PROJECT: Geotechnical Investigation
LOCATION: 4226 Nelson Bay Road, Anna Bay

DATE: 30/01/2018
SURFACE RL:
COORDS:
EXCAVATION METHOD: Hand Auger with Sand Attachment

Borehole Information					Field Material Information					
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
Not Encountered			D 5.10m 5.30m D 5.40m 5.90m D 6.00m	5.5 6.00		SP	SAND, fine to medium grained, pale yellow-white, poorly graded	M	D	AEOLIAN
							HAND AUGER HA3 TERMINATED AT 6.00 m			
				6.5 7.0 7.5 8.0 8.5 9.0 9.5						

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GEOTECHNICAL HAND AUGER
HA4

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 13280
CLIENT: Tattersall Lander Pty Ltd
PROJECT: Geotechnical Investigation
LOCATION: 4226 Nelson Bay Road, Anna Bay

DATE: 30/01/2018
SURFACE RL:
COORDS:
EXCAVATION METHOD: Hand Auger with Sand Attachment

Borehole Information					Field Material Information					
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
Not Encountered	1 2 2 2 0 0 1 2 1 1 1 1 1 3 3 3 1 2 1 1 3 3 3 3 3 3 5 4 3 4 4 3 3 4		1.00m D 1.10m 2.00m D 2.10m 3.00m D 3.10m 4.00m D 4.10m 5.00m	0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5		SP	SAND, fine to medium grained, pale yellow-white, poorly graded	D M	VL - L L - MD	AEOLIAN PSP method used for Dynamic Penetrometer

LOGGED: JH | CHECKED: RJC | DATE: 05/03/2018

GEOTECHNICAL HAND AUGER
HA4

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 13280
CLIENT: Tattersall Lander Pty Ltd
PROJECT: Geotechnical Investigation
LOCATION: 4226 Nelson Bay Road, Anna Bay

DATE: 30/01/2018
SURFACE RL:
COORDS:
EXCAVATION METHOD: Hand Auger with Sand Attachment

Borehole Information					Field Material Information					
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
Not Encountered	4 5 5		D 5.10m 5.50m D 5.60m 5.90m D 6.00m	5.5 6.00		SP	SAND, fine to medium grained, pale yellow-white, poorly graded	M	L - MD	AEOLIAN Decomposing tree branches from 5.51m
							HAND AUGER HA4 TERMINATED AT 6.00 m			
				6.5 7.0 7.5 8.0 8.5 9.0 9.5						

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GEOTECHNICAL HAND AUGER
HA5

SHEET 1 OF 1

RCA AUSTRALIA
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PROJECT No: 13280
CLIENT: Tattersall Lander Pty Ltd
PROJECT: Geotechnical Investigation
LOCATION: 4226 Nelson Bay Road, Anna Bay

DATE: 30/01/2018
SURFACE RL:
COORDS:
EXCAVATION METHOD: Hand Auger with Sand Attachment

Borehole Information					Field Material Information					
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
Not Encountered	3			0.0		SM	TOPSOIL, Silty SAND, fine to medium grained, grey-black, poorly graded	D		TOPSOIL PSP method used for Dynamic Penetrometer
	2		0.20m D 0.30m							
	1			0.30		SP	SAND, fine to medium grained, grey, trace of silt, poorly graded		L	AEOLIAN
	1			0.5						Water added at 0.5m
	1		0.70m D 0.80m				Becoming pale grey at 0.7m		D	
	4							M		
	5			1.0			Becoming brown at 0.9m			Lots of roots from 0.9m to 1.2m
	6		1.20m D 1.30m							
	6									
	6			1.50			HAND AUGER HA5 TERMINATED AT 1.50 m			
	6			2.0						
	5									
	5									
	5									
	7			2.5						
	8									
	8			3.0						
				3.5						
				4.0						
				4.5						

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GEOTECHNICAL BOREHOLE LOG

BH6

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GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 13280
CLIENT: Tattersall Lander Pty Ltd
PROJECT: Geotechnical Investigation
LOCATION: 4226 Nelson Bay Road, Anna Bay

DATE COMMENCED: 23/01/2018
DATE COMPLETED: 23/01/2018
SURFACE RL:
COORDS:
DRILL MODEL: Track Mounted Hanjin 8D

Borehole Information					Field Material Information					
METHOD	WATER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
Hollow Flight Auger			0.10m D 0.20m	0		SP	SAND, fine to medium grained, pale yellow-white, poorly graded	D M	MD	AEOLIAN
			0.40m D 0.50m	0.5			Becoming grey-black, with a trace of silt at 0.4m			
		1.00m	1.00m	1.0			Becoming pale grey, without a trace of silt at 1.0m			
		SPT 3, 3, 3 N=6	D							
		1.45m	1.45m	1.5			Becoming mottled pale yellow-white, red and brown at 1.4m			
		2.50m	2.50m	2.5						
		SPT 3, 4, 5 N=9	D							
		2.95m	2.95m	3.0						
				3.5			Becoming pale yellow-white at 3.8m			
			4.00m D 4.10m	4.0						
				4.5						

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GEOTECHNICAL BOREHOLE LOG

BH6

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 13280
CLIENT: Tattersall Lander Pty Ltd
PROJECT: Geotechnical Investigation
LOCATION: 4226 Nelson Bay Road, Anna Bay

DATE COMMENCED: 23/01/2018
DATE COMPLETED: 23/01/2018
SURFACE RL:
COORDS:
DRILL MODEL: Track Mounted Hanjin 8D

Borehole Information					Field Material Information					
METHOD	WATER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
Hollow Flight Auger	23/01/18 ▽ 05/02/18	6.00m	6.00m	5.5		SP	SAND, fine to medium grained, pale yellow-white, poorly graded	M	MD	AEOLIAN
		SPT 4, 8, 8 N=16	D	6.0				W		
		6.45m	6.45m	6.5						
				7.0						
				7.5						
				8.0						
				8.5						
		9.00m	9.00m	9.0						
		SPT 7, 10, 11 N=21	D							
		9.45m	9.45m	9.5						

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GEOTECHNICAL BOREHOLE LOG

BH6

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 13280
CLIENT: Tattersall Lander Pty Ltd
PROJECT: Geotechnical Investigation
LOCATION: 4226 Nelson Bay Road, Anna Bay

DATE COMMENCED: 23/01/2018
DATE COMPLETED: 23/01/2018
SURFACE RL:
COORDS:
DRILL MODEL: Track Mounted Hanjin 8D

Borehole Information					Field Material Information					
METHOD	WATER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
Hollow Flight Auger						SP	SAND, fine to medium grained, pale yellow-white, poorly graded	W	MD	AEOLIAN
				10.5						
				11.0						
				11.5						
				12.00			BOREHOLE BH6 TERMINATED AT 12.00 m			
				12.5						
				13.0						
				13.5						
				14.0						
				14.5						

LOGGED: JH | CHECKED: RJC | DATE: 05/03/2018

GEOTECHNICAL BOREHOLE LOG

BH7

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 13280
CLIENT: Tattersall Lander Pty Ltd
PROJECT: Geotechnical Investigation
LOCATION: 4226 Nelson Bay Road, Anna Bay

DATE COMMENCED: 23/01/2018
DATE COMPLETED: 23/01/2018
SURFACE RL:
COORDS:
DRILL MODEL: Track mounted Hanjin 8D

Borehole Information					Field Material Information					
METHOD	WATER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
Hollow Flight Auger				0.5		SP-SM	TOPSOIL, SAND, fine to medium grained, grey, with silt	D		TOPSOIL / AEOLIAN
				0.80		SP	SAND, fine to medium grained, red-brown, poorly graded		L - MD	AEOLIAN
		1.50m	1.50m	1.0						
		SPT 4, 3, 4 N=7	D	1.5			Becoming pale yellow-white at 1.8m			
		1.95m	1.95m	2.0						
				2.5				M		
		3.00m	3.00m	3.0						
		SPT 3, 2, 3 N=5	D	3.5						
		3.45m	3.45m	4.0						
				4.5						

LOGGED: JH | CHECKED: RJC | DATE: 05/03/2018

GEOTECHNICAL BOREHOLE LOG

BH7

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 13280
CLIENT: Tattersall Lander Pty Ltd
PROJECT: Geotechnical Investigation
LOCATION: 4226 Nelson Bay Road, Anna Bay

DATE COMMENCED: 23/01/2018
DATE COMPLETED: 23/01/2018
SURFACE RL:
COORDS:
DRILL MODEL: Track mounted Hanjin 8D

Borehole Information					Field Material Information					
METHOD	WATER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
Hollow Flight Auger	23/01/18 05/02/18	6.00m SPT 3, 4, 6 N=10 6.45m	6.00m D 6.45m 8.80m D 8.90m	5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0 9.5		SP	SAND, fine to medium grained, red-brown, poorly graded	M W	L - MD MD	AEOLIAN

LOGGED: JH | CHECKED: RJC | DATE: 05/03/2018

GEOTECHNICAL BOREHOLE LOG

BH7

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

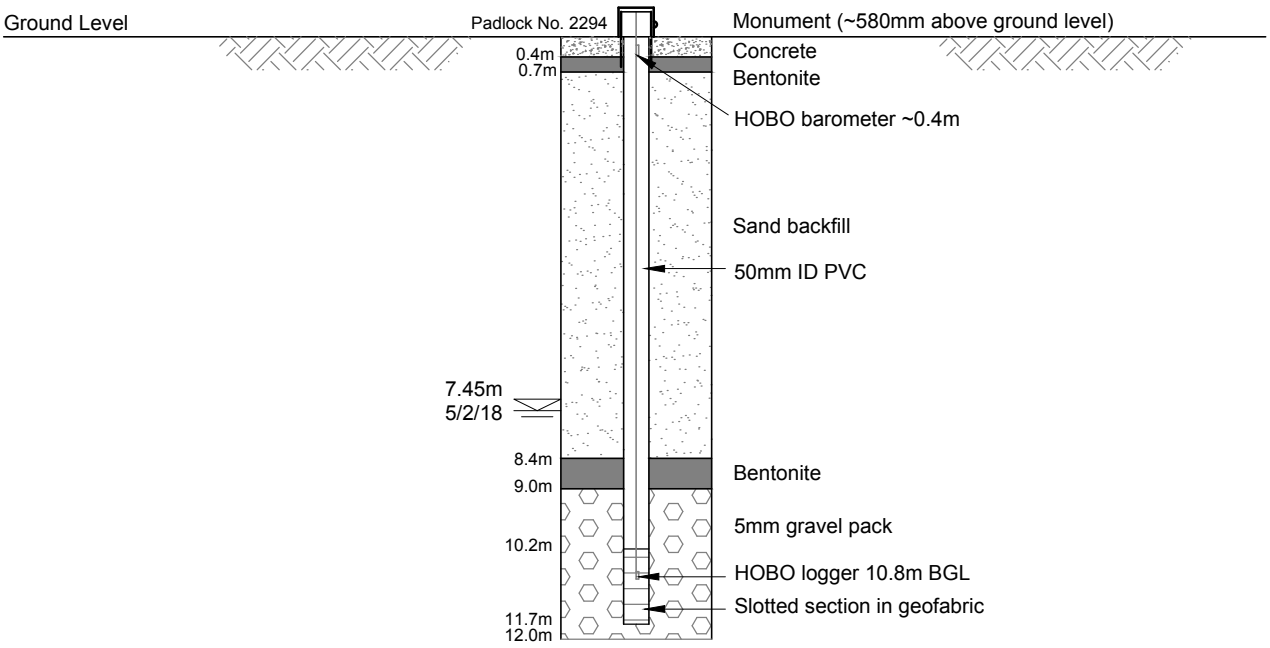
PROJECT No: 13280
CLIENT: Tattersall Lander Pty Ltd
PROJECT: Geotechnical Investigation
LOCATION: 4226 Nelson Bay Road, Anna Bay

DATE COMMENCED: 23/01/2018
DATE COMPLETED: 23/01/2018
SURFACE RL:
COORDS:
DRILL MODEL: Track mounted Hanjin 8D

Borehole Information					Field Material Information					
METHOD	WATER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
Hollow Flight Auger						SP	SAND, fine to medium grained, red-brown, poorly graded	W	MD	AEOLIAN
				10.5						
				11.0						
				11.5						
				12.00			BOREHOLE BH7 TERMINATED AT 12.00 m			
				12.5						
				13.0						
				13.5						
				14.0						
				14.5						

LOGGED: JH | CHECKED: RJC | DATE: 05/03/2018

PZ1



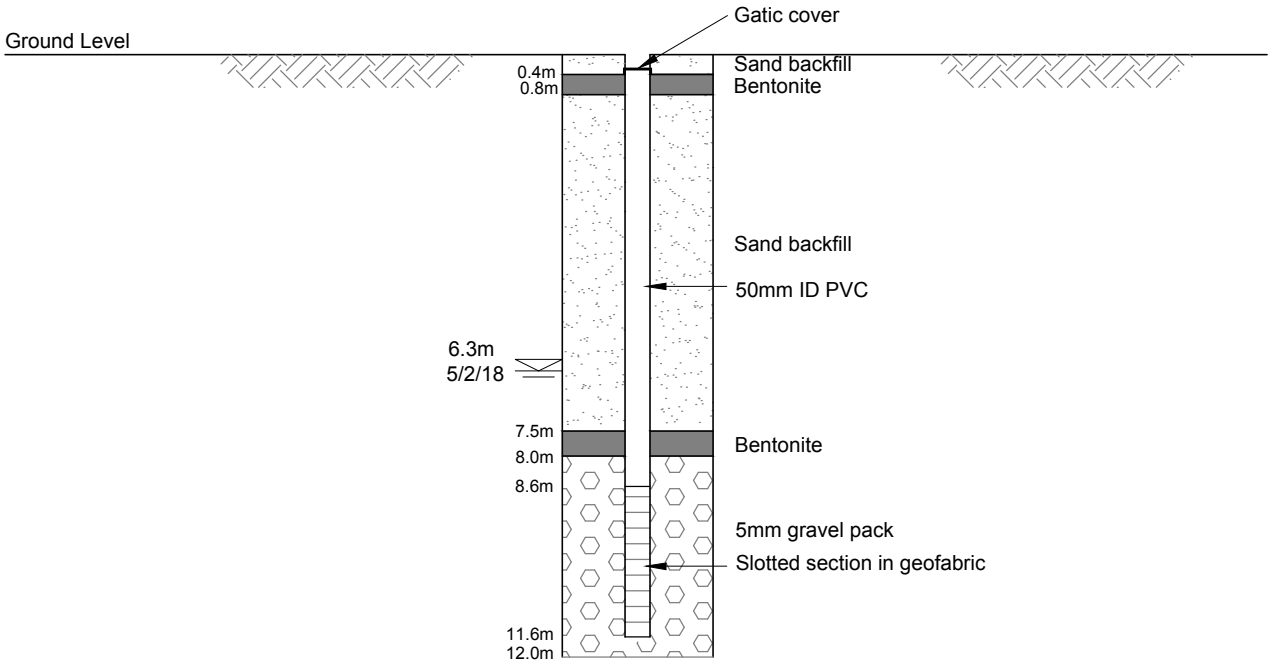
RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

STANDPIPE PIEZOMETER
CONSTRUCTION DETAILS
4226 NELSON BAY ROAD
ANNA BAY

CLIENT	Tattersall Lander Pty Ltd						
DRAWN BY	JH	SCALE	N.T.S.	RCA Ref	13280-201/2		OFFICE
APPROVED BY	RJC	DATE	21/08/2018	DRAWING No	PZ1	Rev 0	NEWCASTLE

CDT-DWG-A4V-001/1

PZ2



RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

STANDPIPE PIEZOMETER
CONSTRUCTION DETAILS
4226 NELSON BAY ROAD
ANNA BAY

CLIENT	Tattersall Lander Pty Ltd						
DRAWN BY	JH	SCALE	N.T.S.	RCA Ref	13280-201/2		OFFICE
APPROVED BY	RJC	DATE	21/08/2018	DRAWING No	PZ2	Rev 0	NEWCASTLE

CDT-DWG-A4V-001/1

Explanatory Notes – Soil Description

In engineering terms soil includes every type of uncemented or partially cemented material found in the ground. In practice if the material can be remoulded by hand in its field condition or in water it is described as a soil. The dominant soil constituent is given in capital letters with secondary textures in lower case. The dominant feature is assessed from *AS 1726:2017 – Geotechnical Site Investigations* and a soil symbol is used to define a soil layer.

METHOD

Method	Description
AD/T	Auger Drilling with tungsten carbide bit
AD/V	Auger Drilling with V Bit
AS	Auger Screwing
AT	Air Track
BH	Backhoe
CT	Cable Tool Rig
DB	Washbore Drag Bit
DT	Diatube
E	Excavator
EH	Excavator with Hammer
HA	Hand Auger
H	Diamond Core-63mm diameter
N	Natural Exposure
NMLC	Diamond Core-52mm diameter
N	Diamond Core-47mm diameter
Percussion	Percussion Drilling
PT	Push Tube
RR	Rock Roller
V	Vacuum Excavation
WS	Washbore
	Existing Excavation

WATER

Water level at date shown

Seepage

NOT ENCOUNTERED: The borehole/test pit was dry soon after excavation. Inflow may have been observed and the borehole/test pit been left open for a longer period.

NOT OBSERVED: The observation of groundwater was not possible due to drilling water surface seepage or cave in of the borehole/test pit.

SAMPLING

Sample	Description
B	Bulk Disturbed Sample
D	Disturbed Sample
SPT	Standard Penetration Test
U50	Undisturbed Sample - 50mm diameter
U75	Undisturbed Sample - 75mm diameter
ES	Soil Sample Environmental
EW	Water Sample Environmental
G	Gas Sample

SOIL CLASSIFICATION

The appropriate symbols are selected based on the result of visual examination field tests and available laboratory test results such as particle size analysis liquid limit and plasticity index.

Group Symbol	Description
GW	Well graded gravel
GP	Poorly graded gravel
GM	Silty gravel
GC	Clayey gravel
SW	Well graded sand
SP	Poorly graded sand
SM	Silty sand
SC	Clayey sand
ML	Silt of low plasticity
CL	Clay of low plasticity
OL	Organic soil of low plasticity
CI	Clay of medium plasticity
MH	Silt of high plasticity
CH	Clay of high plasticity
OH	Organic soil of high plasticity
Pt	Peat highly organic soil

MOISTURE CONDITION

For coarse grained soils the following terms are used

Dry - Non-cohesive and free-running

Moist - Soil feels cool darkened in colour
- Soil tends to stick together

Wet - Soil feels cool darkened in colour
- Soil tends to stick together free water forms when handling

For fine grained soils the following moisture content (w) terms are used

w < PL - Moist dry of plastic limit

w ≈ PL - Moist near plastic limit.

w > PL - Moist wet of plastic limit.

w ≈ LL - Wet near liquid limit.

w > LL - Wet wet of liquid limit

PLASTICITY

Soil plasticity is a measure of the range of water content over which a soil exhibits plastic properties. The classification of the degree of plasticity in terms of the Liquid Limit (LL) is as follows.

Description of Plasticity	Range of Liquid Limit for Silt	Range of Liquid Limit for Clay
Non-plastic	Not applicable	Not applicable
Low plasticity	≤50	≤35
Medium plasticity	Not applicable	>35 and ≤50
High plasticity	>50	>50

COHESIVE SOILS – CONSISTENCY

The consistency of a cohesive soil is defined by descriptive terminology such as very soft soft firm stiff very stiff and hard. These terms are assessed by the shear strength of the soil as observed visually by hand penetrometer dynamic cone penetrometer or vane shear values and by resistance to deformation to hand moulding.

A hand penetrometer may be used in the field or the laboratory to provide an approximate assessment of the unconfined compressive strength (UCS) of cohesive soils. Undrained shear strength $c_u \approx 0.5$ UCS. Undrained shear strength values are recorded in kPa as follows

Strength	Symbol	Indicative Undrained Shear Strength, c_u (kPa)
Very Soft	VS	≤12
Soft	S	>12 and ≤25
Firm	F	>25 and ≤50
Stiff	St	>50 and ≤100
Very Stiff	VSt	>100 and ≤200
Hard	H	>200
Friable	Fr	

COHESIONLESS SOILS – RELATIVE DENSITY

Relative density terms such as very loose loose medium dense dense and very dense are used to describe silty and sandy material and these are usually based on resistance to drilling penetration. Standard Penetration Test (SPT) N values or Perth Sand Penetrometer resistance.

Term	Symbol	Density Index
Very Loose	VL	0 to 15
Loose	L	15 to 35
Medium Dense	MD	35 to 65
Dense	D	65 to 85
Very Dense	VD	>85

SOIL PARTICLE SIZE DESCRIPTIVE TERMS

Fraction	Name	Subdivision	Size (mm)
Oversize	Boulders		>200
	Cobbles		63 to 200
Coarse grained soil	Gravel	Coarse	19 to 63
		Medium	6.7 to 19
		Fine	2.36 to 6.7
	Sand	Coarse	0.6 to 2.36
		Medium	0.21 to 0.6
		Fine	0.075 to 0.21
Fine grained soil	Silt		0.002 to 0.075
	Clay		<0.002

Explanatory Notes - Rock Description

METHOD

Refer to soil description s□eet.

WATER

Refer to soil description s□eet.

ROCK QUALITY

T□e defect spacing is s□o□n □□ere applicable and t□e Rock □uality Designation (R□D) and Total Core Recovery (TCR) for eac□ core run is given □□ere□

$$TCR = \frac{\text{Lengt□ of core recovered}}{\text{Lengt□ of core run}} \times 100$$

$$R□D = \frac{\text{Sum of a□ial lengt□ of sound core pieces □100mm long}}{\text{Lengt□ of core run}} \times 100$$

ROCK MATERIAL WEATHERING

Rock material □eat□ering is described using t□e abbreviations and definitions used in *AS1726:2017– Geotechnical Site Investigations*.

Term		Abbreviation		Definition
Residual Soil		RS		Material is □eat□ered to suc□ an e□tent t□at it □as soil properties. Mass structure and material te□ture and fabric of original rock are no longer visible□ but t□e soil □as not been significantly transported.
E□tremely □eat□ered		□W		Material is □eat□ered to suc□ an e□tent t□at it □as soil properties. Mass structure and material te□ture and fabric of original rock are still visible.
Hig□ly Weat□ered	Distinctly Weat□ered	HW	DW	T□e □□ole of t□e rock material is discoloured□ usually by iron staining or bleac□ing to t□e e□tent t□at t□e colour of t□e original rock is not recognisable. Rock strengt□ is significantly c□anged by □eat□ering. Some primary minerals □ave □eat□ered to clay minerals. Porosity may be increased by leac□ing or may be decreased due to deposition of □eat□ering products in pores.
Moderately Weat□ered	Distinctly Weat□ered	MW	DW	T□e □□ole of t□e rock material is discoloured□ usually by iron staining or bleac□ing to t□e e□tent t□at t□e colour of t□e original rock is not recognisable□but s□o□s little or no c□ange of strengt□ from fres□ rock.
Slig□tly Weat□ered		SW		Rock is partially discoloured □it□ staining or bleac□ing along □oints but s□o□s little or no c□ange of strengt□ from fres□ rock.
□res□		□R		Rock s□o□s no sign of decomposition of individual minerals or colour c□anges.

W□ere it is not practicable to distinguis□ bet□een □Hig□ly Weat□ered□ and □Moderately Weat□ered□rock t□e term □Distinctly Weat□ered□may be used. □Distinctly Weat□ered□is defined as follo□s□Rock strengt□ usually c□anged by □eat□ering. T□e rock may be □ig□ly discoloured□ usually by iron staining. Porosity may be increased by leac□ing□or may be decreased due to deposition of □eat□ering products in t□e pores□ T□ere is some c□ange in rock strengt□.

ROCK MATERIAL STRENGTH

Rock strengt□ is described using *AS1726:2017– Geotechnical Site Investigations* and *ISRM – Commission on Standardisation of Laboratory and Field Tests, 'Suggested method of determining the Uniaxial Compressive Strength of Rock materials and the Point Load Index'* as follo□s□

Term	Abbreviation	Uniaxial Compressive Strength (MPa)	Point Load Index Is_{50} (MPa)
Very Lo□	VL	0.6 to 2	0.03 to 0.1
Lo□	L	2 to 6	0.1 to 0.3
Medium	M	6 to 20	0.3 to 1
Hig□	H	20 to 60	1 to 3
Very Hig□	VH	60 to 200	3 to 10
E□tremely Hig□	EH	□200	□10

◀ Diametral Point Load Inde□ test.

▼ A□ial Point Load Inde□ test.

DEFECT SPACING/BEDDING THICKNESS

Depending on t□e pro□ect□may be eit□er described as mean perpendicular spacing □it□in a set of defects or bedding□or as t□e spacing bet□een all defects □it□in t□e rock mass.

Term	Defect Spacing	Bedding
E□tremely closely spaced	□6 mm	T□inly laminated
	6 to 20 mm	Laminated
Very closely spaced	20 to 60 mm	Very t□in
Closely spaced	0.06 to 0.2 m	T□in
Moderately □idely spaced	0.2 to 0.6 m	Medium
Widely spaced	0.6 to 2.0 m	T□ick
Very □idely spaced	□2 m	Very t□ick

DEFECT DESCRIPTION

Type	Definition
JT	Joint
BP	Bedding Parting
CO	Contact
CS	Clay Seam
CZ	Crus□ Zone
D□	Dyke
DZ	Decomposed Zone
□C	□racture
□Z	□racture Zone
□L	□oliation
□LT	□ault
VN	Vein
SM	Seam
IS	Infilled Seam
SZ	S□ear Zone

Planarity	Roughness
PR □Planar	VR □Very Roug□
CU □Curved	R□ □Roug□
U □Undulating	S □Smoot□
ST □Stepped	POL □Polis□ed
IR □Irregular	SL □Slickensided

Symbol	Coating or Infill
CA	Calcite
Clay	Clay
CN	Clean
□e	Iron o□ide
□T	C□lorite
□□	□uart□
□	Carbonaceous
SN	Stain
VNR	Veneer

T□e inclinations of defects are measured from perpendicular to t□e core a□is.

Appendix C

Double Ring Infiltrometer Test Results

DOUBLE RING INFILTROMETER TEST

CLIENT: Tattersall Lander Pty Ltd
PROJECT: Geotec□nical Investigation
LOCATION: 4226 Nelson Bay Road□Anna Bay

DATE: 5/02/2018
RCA REF: 13280

SOIL DESCRIPTION: SAND

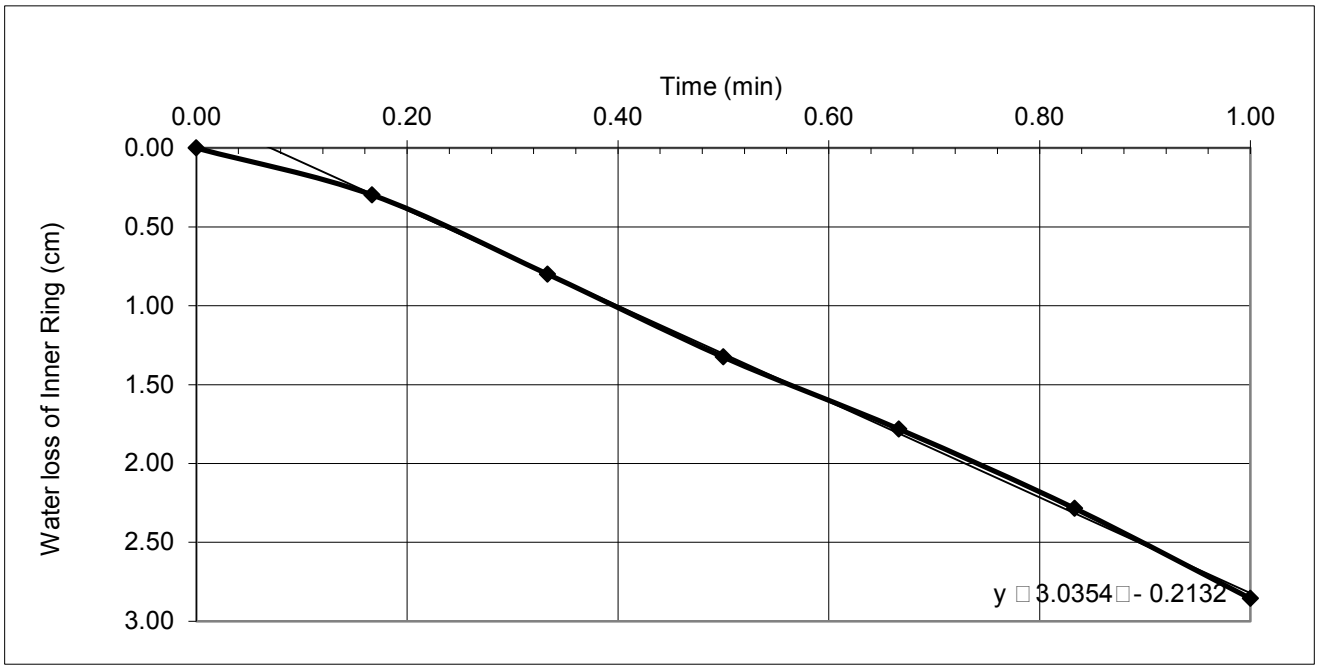
TEST METHOD: Constant Head

BORE DETAILS

Test No□	IN□1a	
Dept□□	10	cm
Dept□ of □ater in rings□	20	cm
Internal diameter of inner ring□	24	cm
Internal diameter of outer ring□	38.5	cm
Area of inner ring□	452	cm^2
Area of annular space bet□een rings□	712	cm^2
Internal diameter of Mariotte tube□	3.75	cm
E□ternal diameter of air inlet tube□	0.95	cm
Area of □ater in Mariotte tube□	10.3	cm^2

Soil Moisture at Time of Test: Wet

RESULTS			
Time	**Elapsed time (min)**	**Water level in Mariotte tube (cm)**	**Water loss from inner ring (cm)**
4□35□00 PM	0.00	143.0	0.00
4□35□10 PM	0.17	130.0	0.30
4□35□20 PM	0.33	108.0	0.80
4□35□30 PM	0.50	85.0	1.33
4□35□40 PM	0.67	65.0	1.78
4□35□50 PM	0.83	43.0	2.28
4□36□00 PM	1.00	18.0	2.86



CALCULATED INFILTRATION RATE **3.04E+00 cm / min**
5.1E-04 m / sec

RCA Australia	**Tested by: JH**	**Date: 6/2/18**
	Checked by:	**Date:**

DOUBLE RING INFILTROMETER TEST

CLIENT: Tattersall Lander Pty Ltd
PROJECT: Geotec□nical Investigation
LOCATION: 4226 Nelson Bay Road□Anna Bay

DATE: 5/02/2018
RCA REF: 13280

SOIL DESCRIPTION: SAND

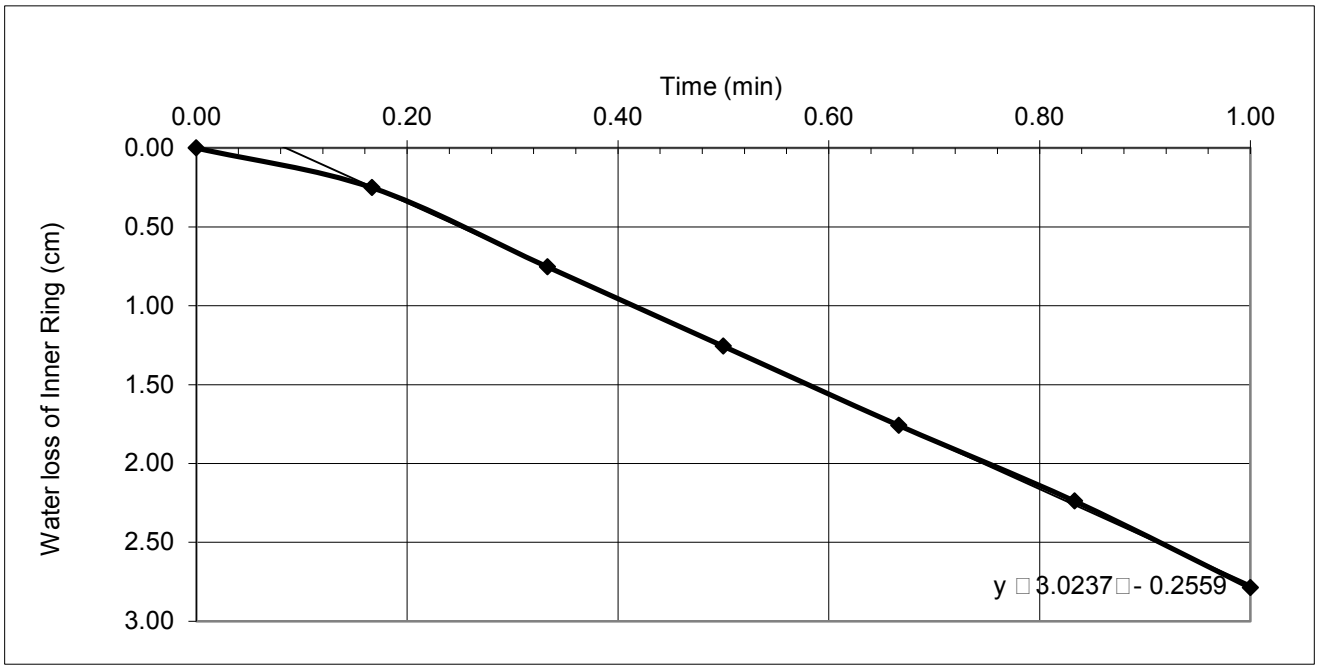
TEST METHOD: Constant Head

BORE DETAILS

Test No□	IN□1b	
Dept□□	10	cm
Dept□of □ater in rings□	20	cm
Internal diameter of inner ring□	24	cm
Internal diameter of outer ring□	38.5	cm
Area of inner ring□	452	cm^2
Area of annular space bet□een rings□	712	cm^2
Internal diameter of Mariotte tube□	3.75	cm
E□ternal diameter of air inlet tube□	0.95	cm
Area of □ater in Mariotte tube□	10.3	cm^2

Soil Moisture at Time of Test: Wet

RESULTS			
Time	**Elapsed time (min)**	**Water level in Mariotte tube (cm)**	**Water loss from inner ring (cm)**
4□48□00 PM	0.00	124.0	0.00
4□48□10 PM	0.17	113.0	0.25
4□48□20 PM	0.33	91.0	0.75
4□48□30 PM	0.50	69.0	1.26
4□48□40 PM	0.67	47.0	1.76
4□48□50 PM	0.83	26.0	2.24
4□49□00 PM	1.00	2.0	2.79



CALCULATED INFILTRATION RATE **3.02E+00 cm / min**
5.0E-04 m / sec

RCA Australia	**Tested by: JH**	**Date: 6/2/18**
	Checked by: RJC	**Date:**

DOUBLE RING INFILTROMETER TEST

CLIENT: Tattersall Lander Pty Ltd
PROJECT: Geotec□nical Investigation
LOCATION: 4226 Nelson Bay Road□Anna Bay

DATE: 5/02/2018
RCA REF: 13280

SOIL DESCRIPTION: SAND

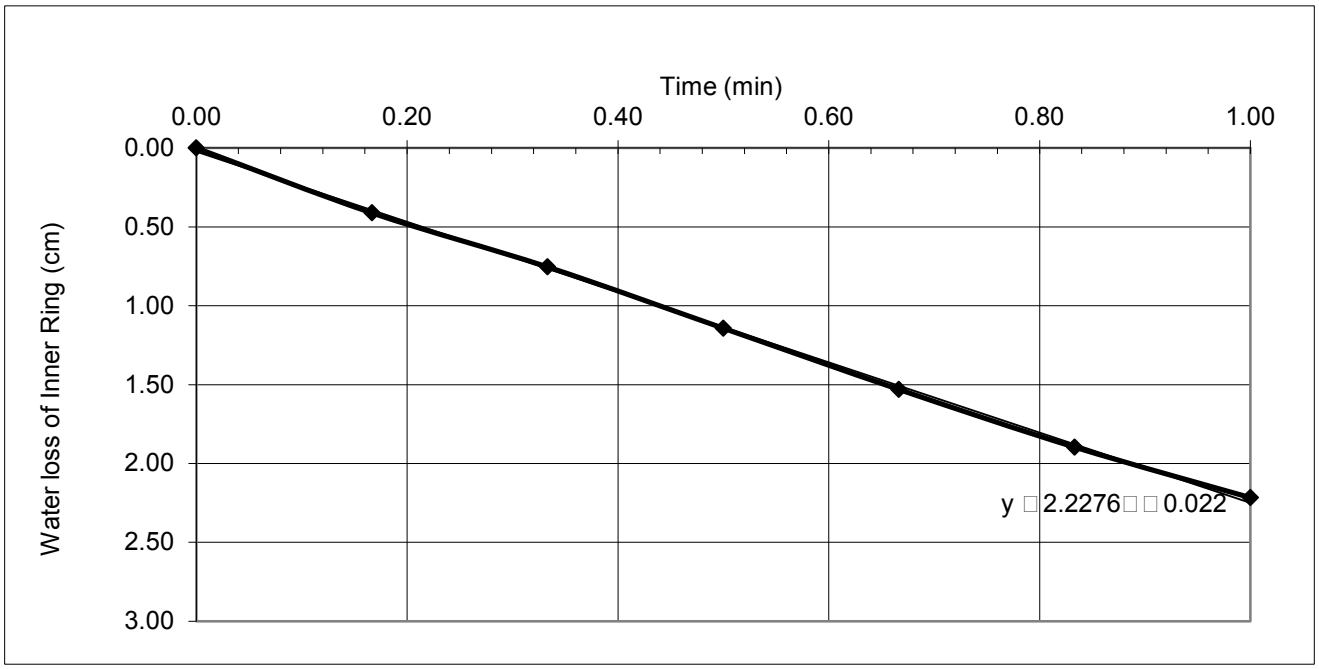
TEST METHOD: Constant Head

BORE DETAILS

Test No□	IN□2a
Dept□□	10 cm
Dept□ of □ater in rings□	25 cm
Internal diameter of inner ring□	24 cm
Internal diameter of outer ring□	38.5 cm
Area of inner ring□	452 cm^2
Area of annular space bet□een rings□	712 cm^2
Internal diameter of Mariotte tube□	3.75 cm
E□ternal diameter of air inlet tube□	0.95 cm
Area of □ater in Mariotte tube□	10.3 cm^2

Soil Moisture at Time of Test: Wet

RESULTS			
Time	**Elapsed time (min)**	**Water level in Mariotte tube (cm)**	**Water loss from inner ring (cm)**
5□27□00 PM	0.00	124.0	0.00
5□27□10 PM	0.17	106.0	0.41
5□27□20 PM	0.33	91.0	0.75
5□27□30 PM	0.50	74.0	1.14
5□27□40 PM	0.67	57.0	1.53
5□27□50 PM	0.83	41.0	1.90
5□28□00 PM	1.00	27.0	2.22



CALCULATED INFILTRATION RATE **2.22E+00 cm / min**
3.7E-04 m / sec

RCA Australia	**Tested by: JH**	**Date: 6/2/18**
	Checked by: RJC	**Date:**

DOUBLE RING INFILTROMETER TEST

CLIENT: Tattersall Lander Pty Ltd
PROJECT: Geotec□nical Investigation
LOCATION: 4226 Nelson Bay Road□Anna Bay

DATE: 5/02/2018
RCA REF: 13280

SOIL DESCRIPTION: SAND

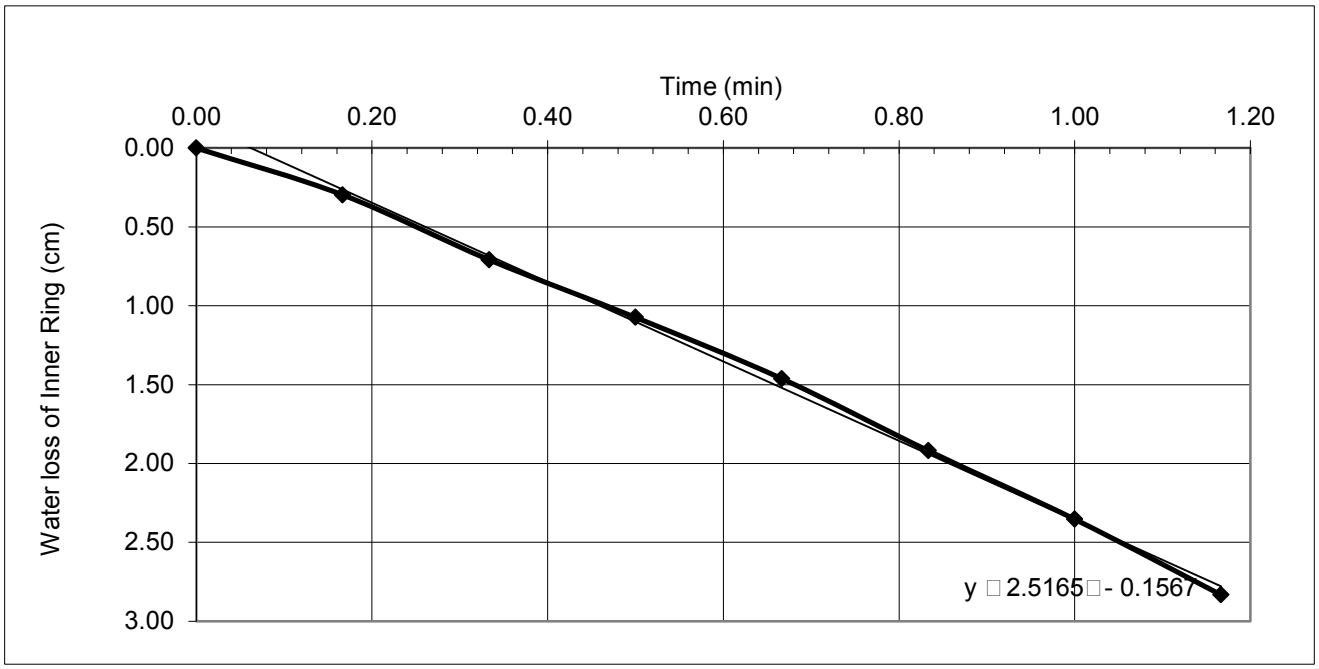
TEST METHOD: Constant Head

BORE DETAILS

Test No□	IN□2b	
Dept□□	10	cm
Dept□ of □ater in rings□	25	cm
Internal diameter of inner ring□	24	cm
Internal diameter of outer ring□	38.5	cm
Area of inner ring□	452	cm^2
Area of annular space bet□een rings□	712	cm^2
Internal diameter of Mariotte tube□	3.75	cm
E□ternal diameter of air inlet tube□	0.95	cm
Area of □ater in Mariotte tube□	10.3	cm^2

Soil Moisture at Time of Test: Wet

RESULTS			
Time	**Elapsed time (min)**	**Water level in Mariotte tube (cm)**	**Water loss from inner ring (cm)**
5□35□00 PM	0.00	133.0	0.00
5□35□10 PM	0.17	120.0	0.30
5□35□20 PM	0.33	102.0	0.71
5□35□30 PM	0.50	86.0	1.07
5□35□40 PM	0.67	69.0	1.46
5□35□50 PM	0.83	49.0	1.92
5□36□00 PM	1.00	30.0	2.35
5□36□10 PM	1.17	9.0	2.83



CALCULATED INFILTRATION RATE **2.51E+00 cm / min**
4.2E-04 m / sec

RCA Australia	**Tested by: JH**	**Date: 6/2/18**
	Checked by: RJC	**Date:**

DOUBLE RING INFILTROMETER TEST

CLIENT: Tattersall Lander Pty Ltd
PROJECT: Geotec□nical Investigation
LOCATION: 4226 Nelson Bay Road□Anna Bay

DATE: 5/02/2018
RCA REF: 13280

SOIL DESCRIPTION: SAND

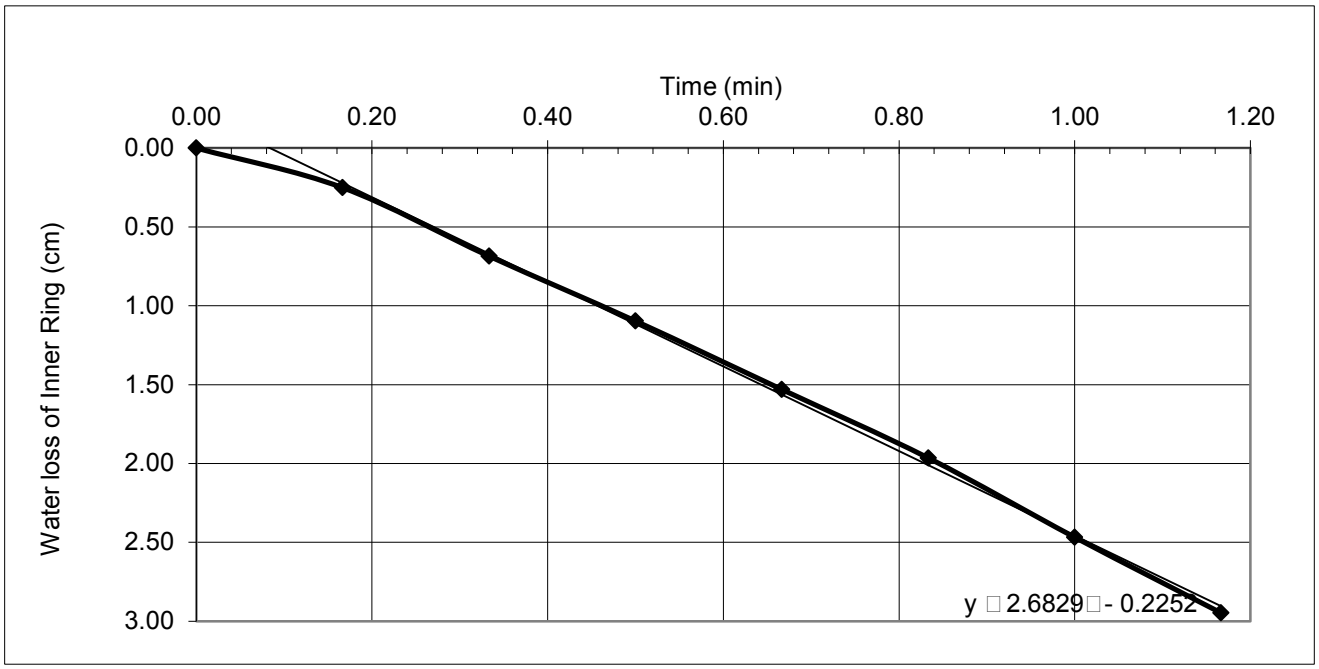
TEST METHOD: Constant Head

BORE DETAILS

Test No□	IN□3a	
Dept□□	10	cm
Dept□ of □ater in rings□	20	cm
Internal diameter of inner ring□	24	cm
Internal diameter of outer ring□	38.5	cm
Area of inner ring□	452	cm^2
Area of annular space bet□een rings□	712	cm^2
Internal diameter of Mariotte tube□	3.75	cm
E□ternal diameter of air inlet tube□	0.95	cm
Area of □ater in Mariotte tube□	10.3	cm^2

Soil Moisture at Time of Test: Wet

RESULTS			
Time	**Elapsed time (min)**	**Water level in Mariotte tube (cm)**	**Water loss from inner ring (cm)**
5□58□00 PM	0.00	138.0	0.00
5□58□10 PM	0.17	127.0	0.25
5□58□20 PM	0.33	108.0	0.69
5□58□30 PM	0.50	90.0	1.10
5□58□40 PM	0.67	71.0	1.53
5□58□50 PM	0.83	52.0	1.96
5□59□00 PM	1.00	30.0	2.47
5□59□10 PM	1.17	9.0	2.95



CALCULATED INFILTRATION RATE **2.68E+00 cm / min**
4.5E-04 m / sec

RCA Australia	**Tested by: JH**	**Date: 6/2/18**
	Checked by: RJC	**Date:**

DOUBLE RING INFILTROMETER TEST

CLIENT: Tattersall Lander Pty Ltd
PROJECT: Geotec□nical Investigation
LOCATION: 4226 Nelson Bay Road□Anna Bay

DATE: 5/02/2018
RCA REF: 13280

SOIL DESCRIPTION: SAND

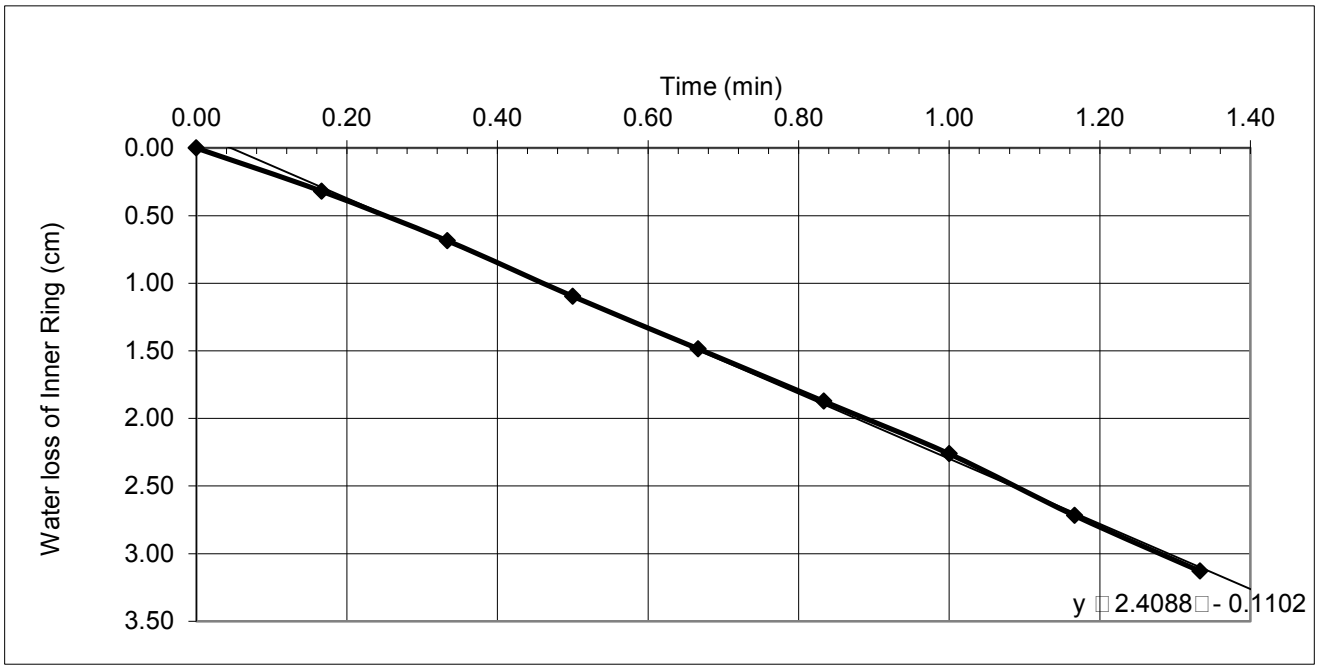
TEST METHOD: Constant Head

BORE DETAILS

Test No□	IN□3b
Dept□□	10 cm
Dept□ of □ater in rings□	20 cm
Internal diameter of inner ring□	24 cm
Internal diameter of outer ring□	38.5 cm
Area of inner ring□	452 cm^2
Area of annular space bet□een rings□	712 cm^2
Internal diameter of Mariotte tube□	3.75 cm
E□ternal diameter of air inlet tube□	0.95 cm
Area of □ater in Mariotte tube□	10.3 cm^2

Soil Moisture at Time of Test: Wet

RESULTS			
Time	**Elapsed time (min)**	**Water level in Mariotte tube (cm)**	**Water loss from inner ring (cm)**
6□05□00 PM	0.00	137.0	0.00
6□05□10 PM	0.17	123.0	0.32
6□05□20 PM	0.33	107.0	0.69
6□05□30 PM	0.50	89.0	1.10
6□05□40 PM	0.67	72.0	1.49
6□05□50 PM	0.83	55.0	1.87
6□06□00 PM	1.00	38.0	2.26
6□06□10 PM	1.17	18.0	2.72
6□06□20 PM	1.33	0.0	3.13



CALCULATED INFILTRATION RATE **2.41E+00 cm / min**
4.0E-04 m / sec

RCA Australia	**Tested by: JH**	**Date: 6/2/18**
	Checked by: RJC	**Date:**

DOUBLE RING INFILTROMETER TEST

CLIENT: Tattersall Lander Pty Ltd
PROJECT: Geotec□nical Investigation
LOCATION: 4226 Nelson Bay Road□Anna Bay

DATE: 12/02/2018
RCA REF: 13280

SOIL DESCRIPTION: SAND

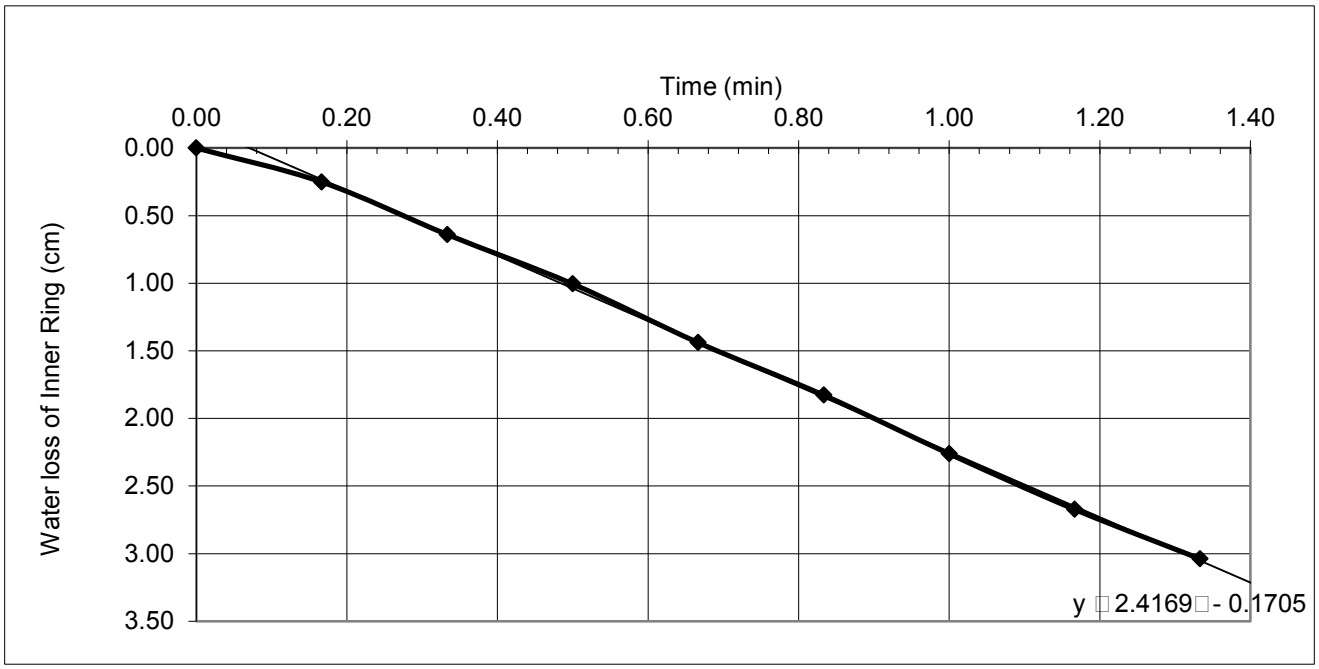
TEST METHOD: Constant Head

BORE DETAILS

Test No□	IN□4a	
Dept□□	10	cm
Dept□ of □ater in rings□	30	cm
Internal diameter of inner ring□	24	cm
Internal diameter of outer ring□	38.5	cm
Area of inner ring□	452	cm^2
Area of annular space bet□een rings□	712	cm^2
Internal diameter of Mariotte tube□	3.75	cm
E□ternal diameter of air inlet tube□	0.95	cm
Area of □ater in Mariotte tube□	10.3	cm^2

Soil Moisture at Time of Test: Wet

RESULTS			
Time	**Elapsed time (min)**	**Water level in Mariotte tube (cm)**	**Water loss from inner ring (cm)**
5□35□00 PM	0.00	143.0	0.00
5□35□10 PM	0.17	132.0	0.25
5□35□20 PM	0.33	115.0	0.64
5□35□30 PM	0.50	99.0	1.01
5□35□40 PM	0.67	80.0	1.44
5□35□50 PM	0.83	63.0	1.83
5□36□00 PM	1.00	44.0	2.26
5□36□10 PM	1.17	26.0	2.67
5□36□20 PM	1.33	10.0	3.04



CALCULATED INFILTRATION RATE **2.42E+00 cm / min**
4.0E-04 m / sec

RCA Australia	**Tested by: JH**	**Date: 12/2/18**
	Checked by: RJC	**Date:**

DOUBLE RING INFILTROMETER TEST

CLIENT: Tattersall Lander Pty Ltd
PROJECT: Geotec□nical Investigation
LOCATION: 4226 Nelson Bay Road□Anna Bay

DATE: 12/02/2018
RCA REF: 13280

SOIL DESCRIPTION: SAND

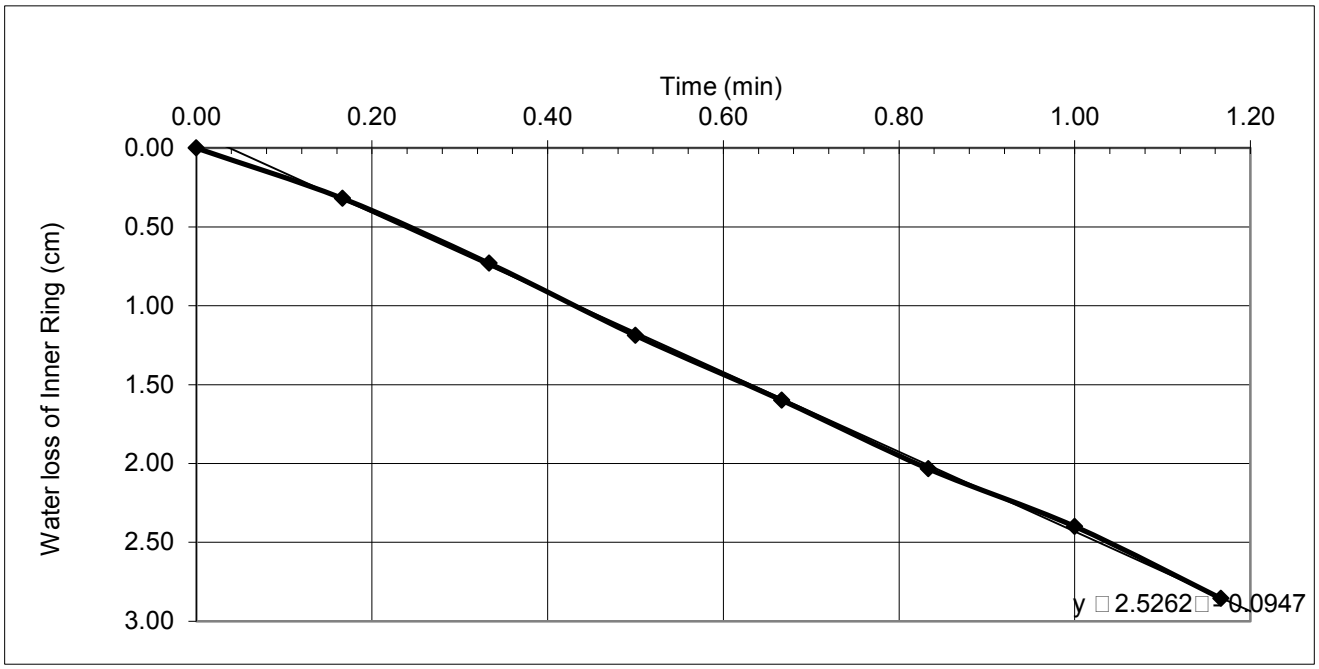
TEST METHOD: Constant Head

BORE DETAILS

Test No□	IN□4b
Dept□□	10 cm
Dept□ of □ater in rings□	35 cm
Internal diameter of inner ring□	24 cm
Internal diameter of outer ring□	38.5 cm
Area of inner ring□	452 cm^2
Area of annular space bet□een rings□	712 cm^2
Internal diameter of Mariotte tube□	3.75 cm
E□ternal diameter of air inlet tube□	0.95 cm
Area of □ater in Mariotte tube□	10.3 cm^2

Soil Moisture at Time of Test: Wet

RESULTS			
Time	**Elapsed time (min)**	**Water level in Mariotte tube (cm)**	**Water loss from inner ring (cm)**
5□45□00 PM	0.00	140.0	0.00
5□45□10 PM	0.17	126.0	0.32
5□45□20 PM	0.33	108.0	0.73
5□45□30 PM	0.50	88.0	1.19
5□45□40 PM	0.67	70.0	1.60
5□45□50 PM	0.83	51.0	2.03
5□46□00 PM	1.00	35.0	2.40
5□46□10 PM	1.17	15.0	2.86



CALCULATED INFILTRATION RATE **2.53E+00 cm / min**
4.2E-04 m / sec

RCA Australia	**Tested by: JH**	**Date: 13/2/18**
	Checked by: RJC	**Date:**

Appendix D

Laboratory Test Results

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES1806843**	Page	: 1 of 2
Client	: **ROBERT CARR & ASSOCIATES P/L**	Laboratory	: Environmental Division Sydney
Contact	: MS LAURA SCHOFIELD	Contact	: Customer Services ES
Address	: PO BOX 175 92 HILL ST CARRINGTON NSW 2294	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: +61 02 49029200	Telephone	: +61-2-8784 8555
Project	: 13280	Date Samples Received	: 06-Mar-2018 15:17
Order number	: ----	Date Analysis Commenced	: 12-Mar-2018
C-O-C number	: ----	Issue Date	: 12-Mar-2018 19:08
Sampler	: ----		
Site	: ANNA BAY		
Quote number	: SYBQ/400/17		
No. of samples received	: 4		
No. of samples analysed	: 4		

ilac-MRA NATA
Accreditation No. 825
Accredited for compliance with ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)				Client sample ID	**BH6 4.0-4.1**	**BH3 5.9-6.0**	**BH4 4.0-4.1**	**BH4 5.9-6.0**	**----**
				Client sampling date / time	23-Jan-2018 00:00	23-Jan-2018 00:00	23-Jan-2018 00:00	23-Jan-2018 00:00	----
Compound	*CAS Number*	*LOR*	*Unit*		**ES1806843-001**	**ES1806843-002**	**ES1806843-003**	**ES1806843-004**	**--------**
					Result	Result	Result	Result	----
EA026 : Chromium Reducible Sulfur									
Chromium Reducible Sulphur	----	0.005	%		**0.008**	**0.007**	**0.005**	**0.007**	**----**

QUALITY CONTROL REPORT

Work Order	: **ES1806843**	Page	: 1 of 3
Client	: **ROBERT CARR & ASSOCIATES P/L**	Laboratory	: Environmental Division Sydney
Contact	: MS LAURA SCHOFIELD	Contact	: Customer Services ES
Address	: PO BOX 175 92 HILL ST CARRINGTON NSW 2294	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: +61 02 49029200	Telephone	: +61-2-8784 8555
Project	: 13280	Date Samples Received	: 06-Mar-2018
Order number	: ----	Date Analysis Commenced	: 12-Mar-2018
C-O-C number	: ----	Issue Date	: 12-Mar-2018
Sampler	: ----		
Site	: ANNA BAY		
Quote number	: SYBQ/400/17		
No. of samples received	: 4		
No. of samples analysed	: 4		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA026 : Chromium Reducible Sulfur (QC Lot: 1484917)									
EB1806061-001	Anonymous	EA026: Chromium Reducible Sulphur	----	0.005	%	0.025	0.026	0.00	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA026 : Chromium Reducible Sulfur (QCLot: 1484917)								
EA026: Chromium Reducible Sulphur	----	0.005	%	<0.005	0.25483 %	84.0	70	130

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) or Matrix Spike Duplicate (MSD) Results are required to be reported.**

ALS Environmental

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **ES1806843**	Page	: 1 of 4
Client	: **ROBERT CARR & ASSOCIATES P/L**	Laboratory	: Environmental Division Sydney
Contact	: MS LAURA SCHOFIELD	Telephone	: +61-2-8784 8555
Project	: 13280	Date Samples Received	: 06-Mar-2018
Site	: ANNA BAY	Issue Date	: 12-Mar-2018
Sampler	: ----	No. of samples received	: 4
Order number	: ----	No. of samples analysed	: 4

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **NO Matrix Spike outliers occur.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **Analysis Holding Time Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

- **Quality Control Sample Frequency Outliers exist - please see following pages for full details.**

Outliers : Analysis Holding Time Compliance

Matrix: **SOIL**

Method / Container / Client Sample ID(s)	Extraction / Preparation			Analysis		
	Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EA026 : Chromium Reducible Sulfur						
Snap Lock Bag						
BH6 4.0-4.1, BH3 5.9-6.0, BH4 4.0-4.1, BH4 5.9-6.0	12-Mar-2018	24-Jan-2018	**47**	----	----	----

Outliers : Frequency of Quality Control Samples

Matrix: **SOIL**

Quality Control Sample Type / Method	Count		Rate (%)		Quality Control Specification
	QC	Regular	Actual	Expected	
Laboratory Duplicates (DUP)					
Chromium Reducible Sulphur	1	11	9.09	10.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA026 : Chromium Reducible Sulfur							
Snap Lock Bag (EA026)							
BH6 4.0-4.1, BH3 5.9-6.0, BH4 4.0-4.1, BH4 5.9-6.0	**23-Jan-2018**	**12-Mar-2018**	24-Jan-2018	×	**12-Mar-2018**	10-Jun-2018	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Chromium Reducible Sulphur	EA026	1	11	**9.09**	**10.00**	×	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Chromium Reducible Sulphur	EA026	1	11	**9.09**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Chromium Reducible Sulphur	EA026	1	11	**9.09**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Chromium Reducible Sulphur	EA026	SOIL	In house: Referenced to Sullivan et al (1998) The CRS method converts reduced inorganic sulfur to H2S by CrCl2 solution ; the evolved H2S is trapped in a zinc acetate solution as ZnS which is quantified by iodometric titration.

Preparation Methods	Method	Matrix	Method Descriptions
Drying at 85 degrees, bagging and labelling (ASS)	EN020PR	SOIL	In house

RCA LABORATORIES
• ENVIRONMENTAL • CONSTRUCTION MATERIALS TESTING

Ph: (02) 4902 9200 Fax: 02 4902 9299
92 Hill Street, Carrington NSW 2294
www.rca.com.au Email: labenviro@rca.com.au

ENV-F103-4

Client Name: RCA
Client Site: Anna Bay.
Contact Name: Laura Schofield
Phone Number: 0403699112
Email Report To: lauras@rca.com.au
Project Manager: Bob Carr

Turnaround Required: ☐ Urgent ☑ Standard (5 Day)
Date Required: Standard
Expected Reporting Date: *(Laboratory Use Only)*

ANALYSIS REQUIRED

Page of

RCA Job Number: 13280

SAMPLE INFORMATION

RCA Laboratories Environmental Sample Number	Client ID / Description	Date	Matrix	Total Samples	EA 026 (Scr (CRS))	Notes: invoice and report to above and administrator@rca.com.au
1	BH6 4.0-4.1	23/1/18	S	1	X	S4 BQ_400_17_RCA
1	BH3 5.9-6.0	23/1/18	S	1	X	
1	BH4 4.0-4.1	23/1/18	S	1	X	
1	BH4 5.9-6.0	23/1/18	S	1	X	

LAB OF ORIGIN: NEWCASTLE

E-MAILED

Environmental Division Sydney
Work Order Reference
ES1806843

Telephone : + 61-2-8784 8555

RELINQUISHED BY		RECEIVED BY		Laboratory use only (circle appropriate)
Name: [illegible]	Date: 6/3/18	Name: [illegible]	Date: 6/3/18	Received in good condition: (Yes) No
Of: RCALE	Time: 12:07	Of: ALS	Time: 3:20pm	Chilled: (Yes) No

Received by: AT ALS 6/3/18 19:30

5.7°C ice