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NEO Consulting Pty Ltd

Geotechnical and Acid Sulfate Soil Investigation Report

31-37 Phillips Street, Raymond Terrace, NSW

NR163_GI & ASSA
19 June 2024

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1. Introduction

1.1 Background

This report details the results of a Geotechnical Investigation and Acid Sulfate Soil Assessment (GI & ASSA) carried out for the proposed construction of general housing at 31-37 Phillip Street, Raymond Terrace, NSW, 2324. The GI was undertaken by NR Engineering Consultants (NR) at the request of Mr Nick Caltabiano of NEO Consulting Pty Ltd (the Client).

This GI report has been prepared to provide advice and recommendations to assist in design of foundations for the proposed re-development at 31-37 Phillips Street, Raymond Terrace, NSW.

1.2 Proposed Development

The following documents were supplied by the client for preparation of this GI report:

- A Request for Quotation (RFQ) via an email dated 7 May 2024 to provide quotation for a Geotechnical Report and Acid Sulfate Assessment, and
- Architectural drawings prepared by Stanton Dahl Architects, rev P3, dated 14 May 2024.
- Survey Drawing Prepared by Parker Scanlon

Based on the provided documents, NR understands that the proposed development involves demolition of existing structures, and construction of general housing consisting of four double storey buildings (Hume A, Hume B, LAHC A and LAHC B) which would be on-grade structures. Minor cut and fill is required for levelling the site after demolition.

1.3 Objectives

The objectives of the GI and ASSA were to assess the existing site surface and subsurface conditions at four boreholes and seven Dynamic Cone Penetration test locations, and to provide geotechnical advice and recommendations addressing the following:

- Dilapidation Surveys,
- Building foundation options, including,
    - Design parameters.
    - Earthquake loading factor in accordance with AS1170.4:2007.
- The requirement for additional geotechnical works.

1.4 Scope of Works

The scope of works for the GI and ASSA included:

- Preparation of a Work Health and Safety Plan,
- Review of relevant geological maps for the project area,

- Site walkover inspection by a geotechnical engineer to assess topographical features and site the conditions,
- Four boreholes with auger drilling fitted on UTE as shown in **Plate 1**,
- Seven Dynamic Cone Penetrometer (DCP) tests (as shown in **Plate 1**) were carried out from ground surface in accordance with AS1289.6.3.2 – 1997, "Determination of the penetration resistance of a soil – 9kg Dynamic Cone Penetrometer" to estimate near surface soil conditions and confirm depths to bedrock. The termination depths encountered at DCP test locations are tabulated below in **Table 1-1:**

Table 1-1 Summary of Termination Depths in BHs/DCP Tests

Building	Test No.	Location	Termination Depth (m, BEGL)	Comments
Hume A	DCP1	As shown in Plate 1	4.90	Terminated on Loose Sand
	BH1	As shown in Plate 1	6.00	Terminated in Sand
Hume B	DCP2	As shown in Plate 1	5.10	Terminated on medium dense Sand
	DCP3	As shown in Plate 1	5.90	Terminated on very dense Sand
	BH4	As shown in Plate 1	4.00	Terminated in Sand
LAHC A	DCP4	As shown in Plate 1	3.40	Terminated on dense Sand
	DCP5	As shown in Plate 1	3.30	Terminated on dense Sand
	BH2	As shown in Plate 1	4.00	Terminated in Sand
LAHC B	DCP6	As shown in Plate 1	2.00	Refusal on Extremely Weathered Material (hard clay)
	DCP7	As shown in Plate 1	1.83	Refusal on Extremely Weathered Material (hard clay)
	BH3	As shown in Plate 1	4.20	Refused on Low Strength Bedrock

- Measurements of groundwater seepage/levels, where possible, after withdrawal of the DCP rods and boreholes, and
- Preparation of this GI report.

A NR Geotechnical Engineer was present on site to set out the BH/DCP test locations, carry out the field testing, log the subsurface conditions and record groundwater levels.

Plate 1: BH/DCP Test Location Plan

1.5 Constraints

The GI was limited by the intent of the investigation and the type of the equipment used. The discussions and advice presented in this report are intended to assist in the preparation of initial designs for the proposed development. Further geotechnical inspections should be carried out prior and during construction, respectively, to confirm the geotechnical and groundwater models and the design parameters provided in this report.

2. Site Description

2.1 Site Description and Identification

The site identification detail and associated information are presented in **Table 2-1** below**.**

Table 2-1 Summary of Site Information

Information	Detail
Street Address	31-37 Phillips Street, Raymond Terrace, NSW
Lot and Deposited Plan (DP) Identification	Lot 130 DP31774 Lot 129 DP31774 Lot 151 DP31774
Local Government Authority	Port Stephens Council
Site Description	The site is located on the high north side of Phillip Street and west of Windsor Street which are formed with a bitumen pavement, with kerb adjacent to the site. The site consists of three lots (Nos. 31, 35 & 37) and currently occupied by three single storey fibro houses with metal roofs. The existing houses have grassy front and backyards with concrete strip driveways leading backyard car parking. Some site views of the front yards, existing site houses and the backyards are shown below in **Plates 2 to 4.**
Site Area	The total area of the site is approximately 1776.8 m^2 (including all lots) based on Survey Drawing.

Plate 2: A view of existing site house and front yard of No. 31, looking north

Plate 3: A view of rear of site house and backyard of No. 31, looking south

Plate 4: A view of existing site house and front yard of No. 35, looking north

Plate 5: A view of backyard of No. 35, looking west

Plate 6: A view of existing site house and front yard of No. 37, looking north-west

Plate 7: A view of T Section, existing site house and front yard of No. 37, looking north

Plate 8: A view of rear of site house and backyard of No. 37, looking east

2.2 Regional Setting

The site topography and geological information for the locality is summarised in **Table 2-2** below**.**

Table 2-2 Topographic and Geological Information

Attribute	Description
Topography	The site is located within flat topography.
Regional Geology	Information on regional sub-surface conditions, referenced from the Minview Seamless Geology Map indicates the site is underlain by Mulbring Siltstone (Pmtm), which typically comprises of Medium- to dark-grey siltstone, minor claystone, sporadic thin cherty beds (resistant), rare thin sandstone and limestone beds, sporadic marine fossils. An excerpt of the geological map is shown below in **Plate 9**.

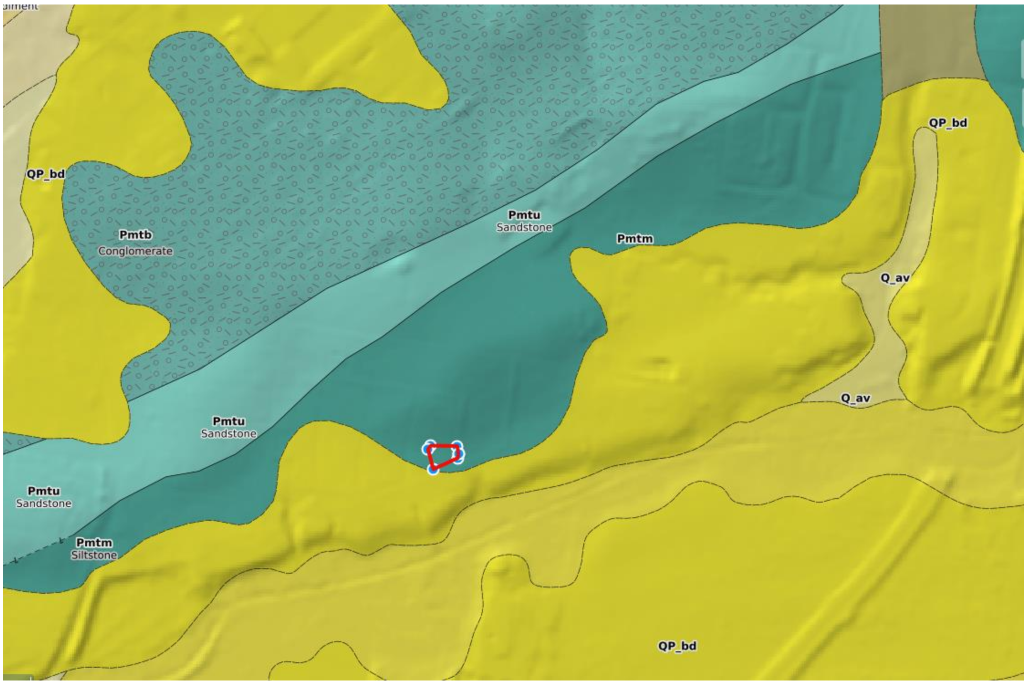


Plate 9: Geological Map, excerpt from Mineview Map

2.3 Acid Sulfate Soil

Based on NSW Planning Portal Spatial Viewer, the site falls under acid sulfate soil Class 4 as shown in **Plate 10**.

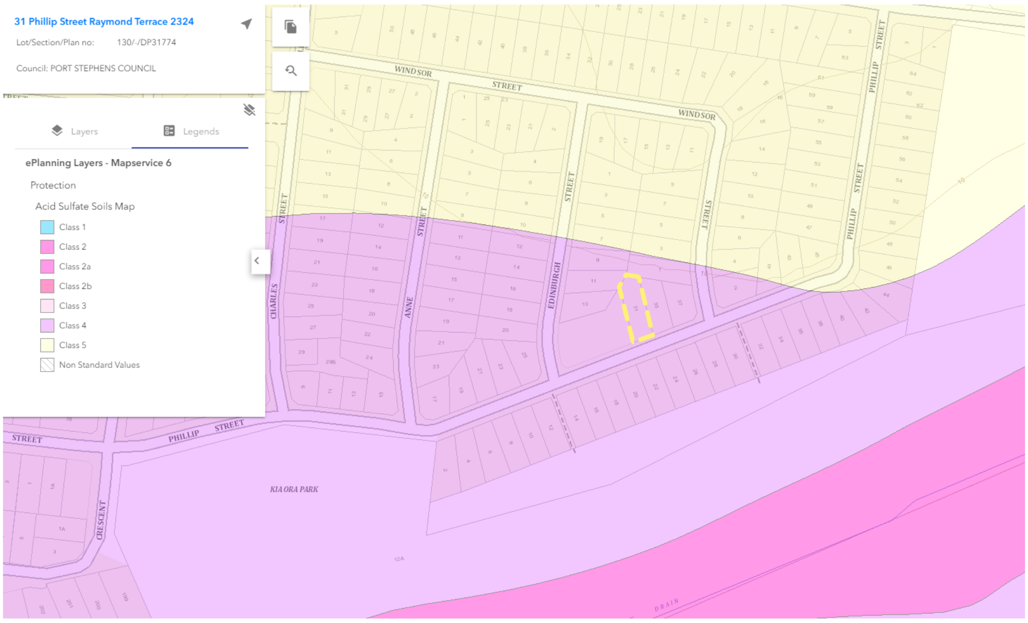


Plate 10: Acid Sulfate Soil Map, snipped from NSW Planning Portal Spatial Viewer

The proposed development involves the construction of slab on grade or foundation piers. The construction works in the form of foundation piles is expected to proceed more than 2m below existing ground level therefore acid sulfate assessment is required for the proposed development as per Acid Sulfate Soil Management Advisory Committee (ASSMAC) guidelines published in 1998.

3. Investigation Results

3.1 Stratigraphy

For the development of a site-specific geotechnical model, the observed stratigraphy during the GI has been grouped into five lithological units. A summary of the subsurface conditions across the site, interpreted from the geotechnical investigation results, is presented in **Table 3-1** below. More detailed descriptions of subsurface conditions at each borehole location are shown on the borehole logs presented in **Appendix A**. The details of the methods of soil classifications, explanatory notes and abbreviations adopted on the borehole logs are also presented in **Appendix A**.

Table 3-1 Summary of Subsurface Conditions

Unit Material [2]	Approximate Depth to top of Unit (m BEGL) [1]	Observed Thickness (m)	Comments
Unit 1: Topsoil/Fill	Surface	0.10 to 0.30	Topsoil – silty sand, grey, with roots, moist to wet
Unit 2: Marine Sand [5]	0.10 to 0.30	1.90 to 5.70 [3]	Medium Dense to dense, becoming very dense at depth, poorly graded, fine to medium grained, sand. Very Loose to Loose layers were encountered at depths from 1.2m to 4.6m in DCP2 and DCP3, and from 3.5m to termination depth of 4.9m BEGL. Marine Sand layer was noticed in all boreholes and DCP tests. However, north-eastern part of the site has encountered marine soil overlying extremely weathered material and siltstone/sandstone bedrock.
Unit 3: Hard Clay (extremely Weathered material)	2.00 [4]	3.8 [4]	Extremely weathered material, silty clay observed in borehole BH3, DCP6 and DCP7 only.
Unit 4: ELS to VLS Siltstone/ Sandstone Bedrock	3.80 [4]	4.2 [4]	Extremely Low strength (ELS) to Very Low Strength (VLS) Siltstone/Sandstone bedrock. observed in borehole BH3, DCP6 and DCP7 only.
Unit 5: LS Siltstone/ Sandstone Bedrock	4.20 [4]	- [4]	Low strength (LS) Siltstone /Sandstone bedrock. Observed in borehole BH3, DCP6 and DCP7 only.

1 Approximate depth and level at the time of our investigation. Depths and levels may vary across the site.
2 For more detailed descriptions of the subsurface conditions, reference should be made to the borehole logs attached to **Appendix A.**
3 Observed up to termination depth in all DCP tests.
4 These units observed in borehole BH3, DCP6 and DCP7 only.
5 Unit 2 is subdivided into four sub-units as tabulated in **Table 5-1**

3.2 Groundwater Observations

Some seepage was observed in BH2 at 1m depth BEGL but NR understands that was from the recent rains prior to our investigation.

Groundwater was observed during augering of the borehole BH1 at depth between 5m and 6.0m BEGL as the sand recovered from this depth was wet. However, if it is mandatory to accurately determine the depth of groundwater or any condition imposed by Council, a monitoring wells are required to be installed for long term groundwater monitoring.

4. Laboratory Test Results

Soil samples collected from the boreholes were sent to NATA accredited laboratory for chemical testing (SGS Environmental Services Sydney).

pH Testing

Non-oxidised (pH_F) and oxidised (pH_{FOX}) pH testing was conducted on fifteen representative samples from four sampling locations (BH1 to BH4). Laboratory results for pH_F ranged from 4.5 – 6.3, indicating that the soils are limited in acidity, and a general absence of actual ASS.

Results for the Oxidised samples (pH_{FOX}) ranged between 3.9 – 6.1, indicating neither a positive or negative acid generating ability and some indicates little or no drop in pH which means sPOCAS tests required to confirm potential acid sulfate soils and sulfur trail should be used. The results are summarised in **Table 4-1**.

Various natural constituents other than sulphide (e.g. organic matter, iron and manganese minerals) can also react with peroxide, leading to the generation of acid. Such constituents may be present in the examined soils (Sullivan *et al.*, 2018; ASSMAC, 1998; NSW EPA, 1995). Therefore, quantitative laboratory analyses of soil were required to confirm the presence of acid sulfate soils and oxidisable sulphides.

Table 4-1 Summary of Laboratory Test Results (pH_F and pHFOX)

Borehole	Soil	Depth (m BEGL)	pH_F	pH_{FOX}	Reaction Rate
BH1	Sand	0.5 – 1.0	6.0	3.9	1
BH1	Sand	1.5 – 2.0	5.5	4.9	1
BH1	Sand	2.5 – 3.0	5.8	5.3	1
BH1	Sand	3.5 – 4.0	5.8	6.1	1
BH2	Sand	0.5 – 1.0	5.8	4.3	1
BH2	Sand	1.5 – 2.0	5.7	5.1	1
BH2	Sand	2.5 – 3.0	5.0	5.3	1
BH2	Sand	3.5 – 4.0	5.4	5.6	1
BH3	Sand	0.5 – 1.0	6.1	5.0	1
BH3	Sand	1.5 – 2.0	5.0	4.4	1
BH3	Clay	2.5 – 3.0	4.5	3.9	1
BH4	Sand	0.5 – 1.0	5.5	4.2	1
BH4	Sand	1.5 – 2.0	5.7	5.3	1
BH4	Sand	2.5 – 3.0	6.3	5.8	1
BH4	Sand	3.5 – 4.0	5.9	5.6	1

SPOCAS Suite

Four samples (one from each borehole) were selected for SPOCAS analysis as indicated in **Table 4-2.**

Table 4-2 Summary of Laboratory Test Results (sPOCAS)

Borehole	Depth (m)	Soil	pH KCl	TAA (moles H+/tonne)	TPA (moles H+/tonne)	TSA (moles H+/tonne)	SPOS (as %S)	a-Net Acidity (moles H^+/tonne)	Liming rate (kg CaCO3/t)
BH1	2.5 – 3.0	Sand	5.7	<5	7.0	<5	0.016	10	NA
BH2	3.5 – 4.0	Sand	5.9	<5	<5	<5	<0.005	5	NA
BH3	2.5 – 3.0	Clay	4.2	67	80	12	0.20	120	9.3
BH4	1.5 – 2.0	Sand	5.3	10	7.0	<5	0.025	16	NA

The sulfur trail of SPOCAS analysis (S_{POS}) gives a measure of the maximum oxidisable sulfur present in a soil sample.

Action criteria for sand and clays are stated for 1 to 1,000 tonnes or more than 1,000 tonnes) in Table 4.4 of Acid Sulfate Soil Manual by NSW Acid Sulfate Soil Management Advisory Committee (ASSMAC).

NR considered that if foundations excavation is required, the disturbance would not increase more than 1,000 tonnes. One S_{POS} and Titratable peroxide acidity (TPA) results were reported above the action criteria (0.10%S) and 62moles H+/tonnes which is a clay sample. SPOS, Titratable peroxide acidity (TPA) and titratable sulfidic activity (TSA) concentrations were reported below the action criteria for Sands in all other three samples.

Based on the action criteria S_{POS} and TPA concentrations in the dataset, the reflective TPA concentrations of one out four samples is likely indicative of sulfur acidity.

It should be noted that works in the soils that exceeds the action criteria would only need to prepare an acid sulfate soil management plan.

The full set of laboratory results analysis sheets is included in **Appendix: B**.

5. Comments and Recommendations

5.1 Geotechnical Assessment

The site investigation identified the presence of topsoil/fill of thickness (0.10m to 0.30m) across the tested locations. The fill is underlain by “marine soil” poorly graded, fine to medium grained sand to the depths varying from 2.0m to 6.0m BEGL. The marine sand layer is extending further 6.0m BEGL and the thickness is unknown in BH1, BH2 and BH4.

The results from the DCP tests are summarised below:

Table 5-1 Summary of Unit 2 (divided into 4 sub-units)

	Depth (m BEGL)						
Building Unit	**Hume A**	**Hume B**		**LAHC A**		**LAHC B**	
Unit 2	**DCP1**	**DCP2**	**DCP3**	**DCP4**	**DCP5**	**DCP6**	**DCP7**
Unit 2a Medium Dense Sand	Surface to 3.6m	0.3m to 1.1m	0.3m to 1.1m	0.3m to 1.2m	0.3m to 1.2m	0.1m to 0.5m	0.1m to 1.7m DCP terminated @ 1.83m
Unit 2b Very loose to loose Sand	3.6m to 4.8m DCP terminated @4.9m	1.1m to 4.6m	1.1m to 4.6m	1.2m to 1.4m	1.2m to 1.4m	0.5m to 0.9m	
Unit 2c Medium Dense to Dense Sand		4.6m to 5.0 DCP terminated @ 5.1m	4.6m to 5.8m	1.4m to 3.4m DCP terminated @ 3.4m	1.4m to 3.3m DCP terminated @ 3.3m	0.9m to 1.50m DCP terminated @2.0m	
Unit 2d Very Dense Sand			>5.8m DCP terminated @ 5.9m				

The marine sand (Unit 2) is characterised as medium dense to dense sand becoming very dense sand at depths with very loose to loose layers as tabulated above.

Unit 3 and Unit 4, extremely weathered material and siltstone/sandstone bedrock, were encountered in borehole BH3 and DCP6 and DCP7 locations which is completed at the north-eastern end of the site.

The recommendations and conclusions in this report are based on an investigation utilising only surface observations and drilling tools. This test equipment provides limited data from isolated test points across the entire site with limited investigated depth of 4m to 6m, therefore some variation to the interpreted sub-surface conditions is possible, especially between test locations. The results of the investigation provide a reasonable basis for the analysis and subsequent design of the proposed works.

5.2 Design & Construction Recommendations

Design and the construction recommendations are provided below:

5.2.1 Demolition Consideration and Dilapidation Survey

Due to presence of sand on this site, care should be taken during demolition, particularly the concrete pavement, to avoid damaging neighbouring structures and infrastructures. Demolition of concrete slabs, pavement and floor slabs may require breaking into smaller size prior to disposal offsite. We recommend that saw cut slots be provided near adjoining buildings to reduce the risk of vibrations being transferred to nearby structures and infrastructures. If possible, the concrete slabs should be removed using hydraulic equipment rather than impact hammers. Dilapidation reports can assist to ensure if there are any damages during demolition due to vibrations. The reports would provide a record of existing conditions prior to commencement of the work. A copy of each report should be provided to the adjoining property owner who should be asked to confirm that it represents a fair assessment of existing conditions. The reports should be carefully reviewed prior to demolition and construction.

5.2.2 Site Classification

The fill (clayey sand/silty clay) was encountered at the tested locations of the site to a depth of <0.3m depth BEGL. The thickness of fill is very small therefore not considered in the site classification.

In the proposed building area, very loose to loose sand was encountered to depths of 1.1m to 4.6m. Because of the presence of loose sand, the site is designated as a Class 'P' in its current state, in accordance with the Australian Standard AS 2870-2011. Reference should also be made to AS2870 for design, construction, performance criteria and maintenance precautions on **Class P** site.

Considering deep foundation, for piles foundations placed on medium dense sand (Unit 2c), very dense sand (Unit 2d) or bedrock (Unit 4), the site can be classified as “A”.

5.2.3 Earthquake Classification

Site sub-soil classification as per Structural design actions AS1170.4 – 2007, Part 4: Earthquake actions in Australia is C_e Shallow Soils.

5.2.4 Footings

Based on investigation data, the ground condition across the site is variable. We recommend that all footings be founded in materials of similar strength to minimise the risk of differential settlements. NR understands that four separate buildings will be constructed, the below foundation options can be considered based on the ground condition of the site.

Raft slabs may be suited to uniform slab conditions and building loads. Further detailed evaluation of expected performance including the evaluation of allowable bearing pressures and settlements would be required once design loads, founding level, and column layout are better known. For preliminarily appraisal, a raft slab may be assessed using an allowable bearing capacity of 100kPa.

In the case of a piled stiffened raft slab, the piles are designed to their ultimate capacity and act as settlement reducers to the stiffened raft slab.

The subgrade preparation below any raft slabs will be important in the final performance of the raft. Detailed analysis of a piled raft would be required to estimate the settlements and the contact pressures below the raft. Further discussion regarding sub-grade preparation is provided below in **Section 5.3**.

It is also recommended that a 150mm thick layer of good quality granular material such as recycled concrete or crushed rock be placed and compacted over the prepared surface, particularly at heavily loaded areas. Construction of this layer helps to improve the uniformity of the subgrade compaction of the in-situ sands, and 'smooth-out' deflections across the base of the slab.

Alternatively, the proposed development may be supported on deep foundations, such as piles, founded into lower medium dense to dense sands, Unit 2c, expected at 5m BEGL within **Buildings Hume A** and **Hume C** and shallower depths of 1.4m within **Building LAHC A**. However, **Building LAHC B** area indicates presence of shallow bedrock within 4m depths.

The load carrying capacity of piles in sands is dependent on the pile diameter, the depth of pile embedment, the method of pile installation, the density profile of the sands adjacent to the shaft and below its base and the presence of weaker layers. Piles should be designed by an experienced design engineer. The founding layer/stratum below the pile base must be thick enough to prevent failure by punching shear.

As a preliminary guide, we estimate that concrete CFA piles of 450mm diameter may be designed for a maximum allowable end bearing capacity of 250kPa when embedded two times the pile diameter into medium dense sands.

Where bedrock is present within north-eastern area of the site, foundation piers in very low to low strength siltstone/sandstone bedrock (class V) can be designed based on allowable end bearing of 700kPa.

Another alternative could be steel screw piles, which could have working end bearing pressures similar to the grout injected pile solution. However, the working bearing pressure is dependent on the pile diameter and embedment depth as well as the strength/stiffness of the pile and its helix. These piles have relatively limited lateral load capacity. Also it is important that steel screw piles can penetrate to achieve an adequate embedment into the proposed founding strata; screw piles may have difficulty in penetrating the medium dense to dense sands. The contribution to the pile capacity from the shaft resistance for screw piles should be ignored due to installation disturbance. Advice should be sought from the specialist contractors on their proprietary system and on corrosion provisions.

These parameters are for indicative purposes only, and once the footing designs have been finalised, we recommend that this be reviewed by the Geotechnical Engineer. Settlements must be considered by the designer.

If the raft slabs are adopted, NR recommends completing additional investigation in the form cone penetration testing (CPTs) along the western and southern end of the site after the demolition of the existing structures to establish the continuous profile across the site.

5.3 Earthworks

Earthworks' recommendations provided in this report should be complemented by reference to AS3798.

5.3.1 Subgrade Preparation

For areas where filling is required, the existing uncontrolled fill must be fully removed and replaced with engineered fill as recommended below.

1. Remove the top layer of fill, and stockpile this separately. Such excavation may need to be carried out with the excavation sides battered at an angle of no steeper than 1 Vertical to 1.5 Horizontal. The new fill must be 'keyed-in' the sides of these batters.
2. The remaining existing fill should be fully excavated down to surface of the residual clay and replaced with engineered fill.
3. The exposed subgrade at the base of the excavation should be proof rolled with a smooth drum roller (say 8 tonne) used in static or non-vibratory mode of operation. Caution is required when proof rolling near existing structures, infrastructures and/or retaining walls. The purpose of the proof rolling is to detect any soft or heaving areas, and to allow for some further improvement in strength or compaction.
4. The final pass should be undertaken in the presence of a geo-technician or geotechnical engineer, to detect any unstable or soft subgrade areas, and to allow for some further improvement in compaction.
5. If dry conditions prevail at the time of construction, then any exposed clayey fill subgrade may become desiccated or have shrinkage cracks prior to pouring any concrete slabs. If this occurs, the subgrade must be watered and rolled until the cracks disappear.
6. Unstable subgrade detected during proof rolling should be locally excavated down to a sound base and replaced with engineered fill or further advice should be sought. Any fill placed to raise site levels should also be engineered fill.

5.3.2 Engineered Fill Specifications

Any fill used to backfill unstable subgrade areas, raise surface levels or backfill service trenches should be engineered fill. Materials preferred for use as engineered fill are well-graded granular materials, such as ripped or crushed sandstone, free of deleterious substances and having a maximum particle size not exceeding 75 mm. such fill should be compacted in layers not greater than 200 mm loose thickness, to a minimum density of 98% of SMDD.

The existing clays excavated from cut areas may be reused as engineered fill, provided unsuitable ('over-wet' and 'oversized') material and any deleterious material is removed. The fill for earthworks platforms should be compacted in layers of not greater than 200mm loose thickness to a density strictly between 98% and 102% of SMDD, and within 2% of Standard Optimum Moisture Content (SOMC). Some moisture conditioning would possibly be required as the in-situ moisture content of the clay fill was shown by laboratory testing to be dry of SOMC in areas.

We recommend that the engineered fill layers extend a horizontal distance of at least 1m beyond the design geometry. The roller must extend over the edge of each placed layer in order to seal the batter surface. On completion of filling, the excess under-compacted edge fill should be trimmed back to the design geometry.

The 'tying in' of engineered fill to temporary cut batter slopes can be achieved by locally benching the cut slopes in no greater than 0.4m high steps. This can be carried out progressively as the height of engineered fill increases.

For backfilling confined excavations such as service trenches, a similar compaction to engineered fill should be adhered to, but if light compaction equipment is used then the layer thickness should be limited to 100mm loose thickness.

5.3.3 Density Testing

Density tests should be regularly carried out on the fill to confirm the above specifications are achieved. The frequency of density testing should be at least one test per layer per material type per 2500 m^2 or 1 test per $500m^3$ distributed reasonably evenly throughout full depth and area or 3 tests per lot, whichever requires the most tests. We recommend that Level 2 control of fill compaction, as defined in AS3798-2007, be adhered to on this site. Preferably, the geotechnical inspection and testing authority (GITA) should be engaged directly on behalf of the client and not by the earthwork's subcontractor.

5.3.4 Site Drainage

During construction of the fill, platform runoff should be enhanced by providing suitable falls to reduce ponding of water on the surface of the fill. Ponding of water may lead to softening of the fill and subsequent delays in the earthworks program. A poorly drained subgrade may become untrafficable when wet. We recommend that if soil softening occurs, the subgrade be over-excavated to below the affected soil, and then replaced with engineered fill as specified above.

6. PASS Management Plan

6.1 Avoidance Strategies

The cheapest option is to avoid the disturbance of ASS/PASS, as they remain inert while in anaerobic and/or anoxic conditions.

6.2 Soil Neutralisation

Where the disturbance of the PASS is unavoidable, neutralisation of the excavated soils with Calcium Carbonate ($CaCO_3$) in the form of finely crushed limestone or 'Aglime' is required. The volume of lime required is calculated based on the acidity of the soil and its total oxidisable sulphur content along with the neutralising value (NV) of the agent and volume of soil disturbed. (Tables 6.1 and 6.2 in ASS Manual- 1998, and provided in **Table 4-2** in this report). Neutralising material should be applied to counteract the ASS and PASS at a 'safety factor' of 1.5 to 2.0.

6.3 Neutralising acidic dewatering effluent

The rate of application of these products for treating acid water should be calculated to avoid the possibility of 'overshooting' (i.e. making water too alkaline). As such testing of the collected seepage waters will be necessary to confirm treatment rates. The optimum water conditions are pH 6.5-8.5 and total acidity <40mg/L. The treatment material 'Aglime' (CaCo3 – pH 8.5 to 9.0) is the cheapest neutralising agent and generally not harmful to plants, livestock, humans and most aquatic species. The quantity of alkaline neutralising agent needed must be determined by laboratory assessment of the total acidity of water.

A staged treatment plan is provided below for use on all PASS soils excavated on this site.

1. A bunded area of sufficient size to hold and treat all excavated soil to be treated will be required. This area needs to be lined with two layers of plastic sheeting to ensure no leakage at overlaps. Hay bales should be provided around the bunded area with the plastic extended over the hay bales to create a sealed containment zone. A low point should be created to one side of the bunded area for collection of seepage water that drains from the soils. This water will also require treatment therefore it will need to be retained. Plastic sheeting should also be used to cover the treatment area following placement of the soils to ensure no additional water enters during rainfall events.
2. The soils should then be treated with natural lime via mechanical mixing at

regular intervals during excavation. Based on the results of the sPOCAS testing it is considered that a value of 8.7 kg of lime per tonne of soil to be treated will be required.

If pier drilling is proposed then mixing of the non-acid sulphate soils from surface with the PASS soils below 1m depth will be expected to occur during drilling of each pier. This may result in a lower value of lime being suitable, however this would need to be confirmed via onsite testing during the pier drilling process. If this further testing is not undertaken then the above recommended liming rate should be maintained

3. Testing of several samples of the mixed and treated soils, along with the separate drainage water, must be undertaken at approximately 3-day intervals after excavation to assess the treatment effectiveness. This will determine if the treatment is working and any required modifications to the plan. The field testing must continue until the treated soils can be determined as neutral (pH ≥ 6 and ≤ 8) at which time they may be classified as General Solid Waste and used as fill onsite or disposed off site.

It is recommended that any footings do not extend to within 0.20m of the surface of the water table, as this will lower the bearing capacity of the subsoil due to loosening and bring difficulties in construction. It may also disturb the Potential Acid Sulfate Soils (PASS). An experienced structural engineer should be consulted for the footing design.

The recommendations and conclusions in this report are based on an investigation utilizing only surface observations and single auger borehole. This test equipment provides limited data from a small, isolated test point. Therefore, some minor variation to the interpreted sur-surface conditions is possible, especially between test locations

6.4 Conclusions

The site is classified as being within an Acid Sulphate Soils Class 4 Zone. The laboratory test results indicate that the soils have a ‘Low’ Reaction Rate, whilst several of the oxidised pH values were >4. Therefore assuming the proposed works involve excavation for foundation piers up to 4m to 5m and site contains Potential Acid Sulfate Soils. As such, according to the Acid Sulphate Soils Management Advisory Committee (ASSMAC), a management plan presented above can be followed during construction.

7. FURTHER GEOTECHNICAL REQUIREMENTS

To allow certification at the completion of the project it will be necessary for NR Engineering Consultants to:

- Due to variation across the site, NR recommends completing additional CPTs or boreholes across the site to establish more accurate soil profile and establish the bedrock along western and southern end.
- Review and approve the structural design drawings for compliance with the recommendations of this report prior to construction,
- Inspect all new footings and earthworks to confirm compliance to design assumptions with respect to allowable bearing pressure, base cleanness and stability prior to the placement of steel or concrete,

The client and builder should make themselves familiar with the requirements spelled out in this report for inspections during the construction phase. NR Engineering Consultants cannot complete the certification if it has not been called to site to undertake the required inspections.

8. Statement of Limitations

This report has been prepared for the exclusive use of NEO Consulting Pty Ltd who is the only intended beneficiary of NR's work. The scope of the inspections carried out for the purpose of this report is limited to those agreed with NEO Consulting Pty Ltd

No other party should rely on the document without the prior written consent of NR, and NR undertakes no duty, or accepts any responsibility or liability, to any third party who purports to rely upon this document without NR's approval.

NR has used a degree of care and skill ordinarily exercised in similar investigations by reputable members of the geotechnical industry in Australia as at the date of this document. No other warranty, expressed or implied, is made or intended. Each section of this report must be read in conjunction with the whole of this report, including its appendices and attachments.

The conclusions presented in this report are based on a limited investigation of conditions, with specific sampling locations chosen to be as representative as possible under the given circumstances.

NR's professional opinions are reasonable and based on its professional judgment, experience, training and results from analytical data. NR may also have relied upon information provided by the Client and other third parties to prepare this document, some of which may not have been verified by NR.

NR's professional opinions contained in this document are subject to modification if additional information is obtained through further investigation, observations, or validation testing and analysis during remedial activities. In some cases, further testing and analysis may be required, which may result in a further report with different conclusions.

References

AS1289.6.3.1:2004, Methods of Testing Soils for Engineering Purposes, Standards Australia.

AS1726:2017, Geotechnical Site Investigations, Standards Australia.

AS2870, Residential Slabs and Footings, Standards Australia.

AS3600:2009, Concrete Structures, Standards Australia.

AS3798-2007, Guidelines on Earthworks for Commercial and Residential Developments, Standards Australia.

AS 1170.4-2007, Structural design for earthquakes, Standards Australia

AS4678:2002, Earth retaining Structures, Standards Australia.

Excavation Work Code of Practice – January 2020 – WorkCover NSW.

Geological Series sheet (9130), 1: 100,000, Geological Map Sydney, Geological Survey

Abbreviations

AHD	Australian Height Datum
AS	Australian Standard
BEGL	Below Existing Ground Level
BEL	Bulk Excavation Level
BH	Borehole
DCP	Dynamic Cone Penetration Test
DBYD	Dial Before You Dig
DP	Deposited Plan
NR	NR Engineering Consultants
GI	Geotechnical Investigation
GME	Groundwater Monitoring Event
RL	Reduced Level

Appendix A – BH/DCP Logs And Explanatory Notes

SOIL LOG

CLIENT: NEO Consulting Pty Ltd **DATE:** 24/05/2024 **BORE No.:** BH1

PROJECT: Geotchnical Investigation **PROJECT No.:** NR163 **SHEET:** 1 of 2

LOCATION: 31-37 Phillip Street, Raymond Terrace, N **SURFACE LEVEL:** EGL

Depth (m)	Description of Strata PRIMARY SOIL - strength/density, colour, grainsize/plasticity, moisture, soil type incl. secondary constituents, other remarks	Sampling Type	Sampling Depth (m)	In Situ Testing Type	Results	
0.00						
	GRASSY LAWN			DCP1		
0.10	Top Soil/Fill- grey, moist, silty Sand.					
	Fine to medium grained, grey, poorly graded Sand.					
			0.50			
		S1				
1.00			1.00			
	from 1.5m, brown		1.50			
		S2				
2.00			2.00			
			2.50			
		S3				
3.00			3.00			
			3.50			
		S4				
4.00			4.00			
5.00						

RIG: UTE Rig DRILLER: Jacob LOGGED: NJ

METHOD: Auger

GROUND WATER OBSERVATIONS: Groundwater expected at between 5.0m to 6.0m

REMARKS: EGL - Existing Ground Level CHECKED: NJ

SOIL LOG

CLIENT: NEO Consulting Pty Ltd **DATE:** 24/05/2024 **BORE No.:** BH1

PROJECT: Geotchnical Investigation **PROJECT No.:** NR163 **SHEET:** 2 of 2

LOCATION: 31-37 Phillip Street, Raymond Terrace, N **SURFACE LEVEL:** EGL

Depth (m)	Description of Strata PRIMARY SOIL - strength/density, colour, grainsize/plasticity, moisture, soil type incl. secondary constituents, other remarks	Sampling		In Situ Testing	
		Type	Depth (m)	Type	Results
5.00	Fine to medium grained, brown, poorly graded Sand.				
6.00	**Augering terminated at 6.0m depth on Sand**				
7.00					
8.00					
9.00					
10.00					

RIG: UTE Rig DRILLER: Jacob LOGGED: NJ

METHOD: Auger

GROUND WATER OBSERVATIONS: Groundwater expected at between 5.0m to 6.0m

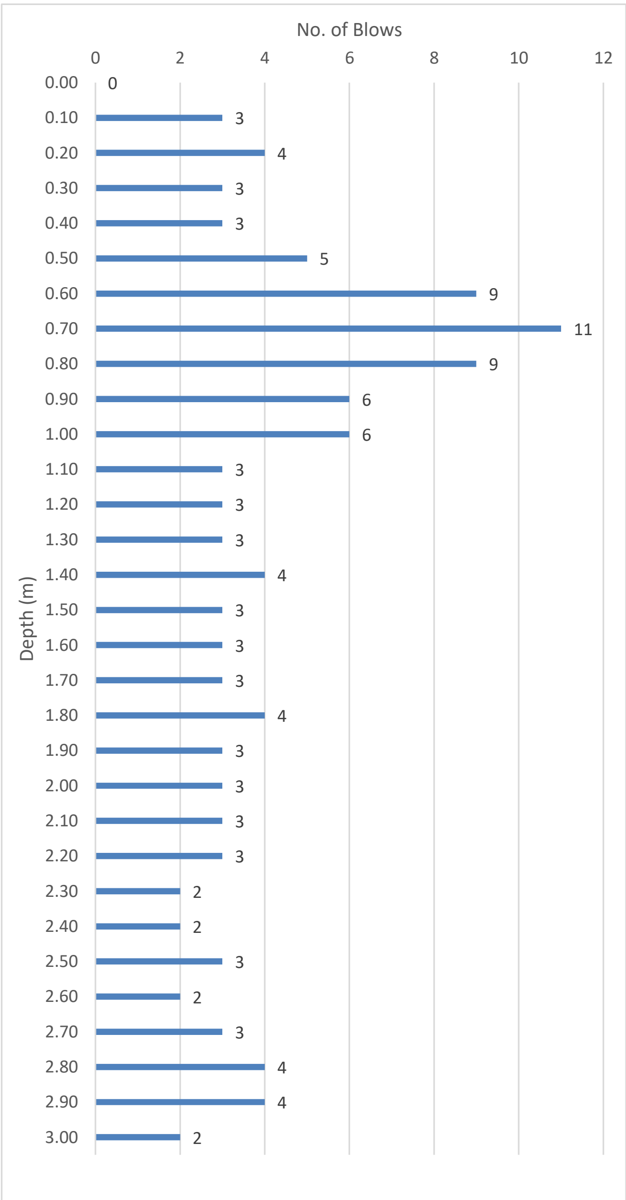
REMARKS: EGL - Existing Ground Level CHECKED: NJ

DYNAMIC PENETROMETER TEST SHEET

CLIENT: NEO Consulting Pty Ltd
DATE: 24/05/2024
PROJECT: Geotchnical Investigation
PROJECT No.: NR163
LOCATION: 31-37 Phillip Street, Raymond Terrace, NSW, 2324
SHEET: 1 of 2

Depth (m)	Test Location DCP1
0.00	-
0.10	3
0.20	4
0.30	3
0.40	3
0.50	5
0.60	9
0.70	11
0.80	9
0.90	6
1.00	6
1.10	3
1.20	3
1.30	3
1.40	4
1.50	3
1.60	3
1.70	3
1.80	4
1.90	3
2.00	3
2.10	3
2.20	3
2.30	2
2.40	2
2.50	3
2.60	2
2.70	3
2.80	4
2.90	4
3.00	2

Penetration vs Depth



TEST METHOD: AS 1289. F3.2, CONE PENETROMETER PENETROMETER

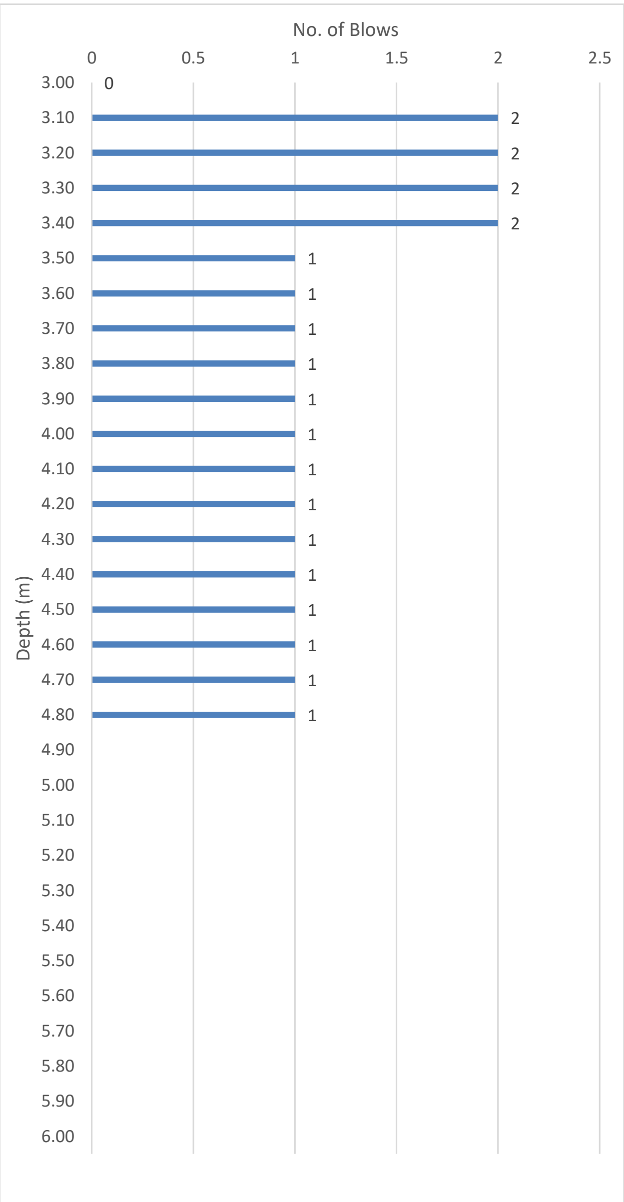
REMARKS:
(HB) Test hammer bouncing upon refusal on solid object
-- No test undertaken at this level due to prior excavation of soils

DYNAMIC PENETROMETER TEST SHEET

CLIENT:	NEO Consulting Pty Ltd	**DATE:**	24/05/2024
PROJECT:	Geotchnical Investigation	**PROJECT No.:**	NR163
LOCATION:	31-37 Phillip Street, Raymond Terrace, NSW, 2324	**SHEET:**	2 of 2

Depth (m)	Test Location DCP1
3.00	-
3.10	2
3.20	2
3.30	2
3.40	2
3.50	1
3.60	1
3.70	1
3.80	1
3.90	1
4.00	1
4.10	1
4.20	1
4.30	1
4.40	1
4.50	1
4.60	1
4.70	1
4.80	1
4.90	Terminated @ 4.9m
5.00	on very loose sand
5.10	
5.20	
5.30	
5.40	
5.50	
5.60	
5.70	
5.80	
5.90	
6.00	

Penetration vs Depth



TEST METHOD: AS 1289. F3.2, CONE PENETROMETER PENETROMETER

REMARKS:

(HB) Test hammer bouncing upon refusal on solid object

-- No test undertaken at this level due to prior excavation of soils

DCP cone was moist on retrieval indicates water seepage water.

SOIL LOG

CLIENT: NEO Consulting Pty Ltd **DATE:** 24/05/2024 **BORE No.:** BH4

PROJECT: Geotchnical Investigation **PROJECT No.:** NR163 **SHEET:** 1 of 1

LOCATION: 31-37 Phillip Street, Raymond Terrace, N **SURFACE LEVEL:** EGL

Depth (m)	Description of Strata PRIMARY SOIL - strength/density, colour, grainsize/plasticity, moisture, soil type incl. secondary constituents, other remarks	Sampling		In Situ Testing	
		Type	Depth (m)	Type	Results
0.00	GRASSY LAWN			DCP2/DCP3	
0.10	Top Soil/Fill- grey, moist, silty Sand.				
	Fine to medium grained, grey, poorly graded Sand, moist		0.50		
		S1			
1.00	from 1m, wet.		1.00		
	from 1.5m, brown, moist		1.50		
		S2			
2.00			2.00		
			2.50		
		S3			
3.00			3.00		
			3.50		
		S4			
4.00	**Augering terminated at 4.0m depth on Sand**		4.00		
5.00					

RIG: UTE Rig DRILLER: Jacob LOGGED: NJ

METHOD: Auger

GROUND WATER OBSERVATIONS: seepage water at 1.0m due to recent rain. Groundwater is expected at 5m to 6m.

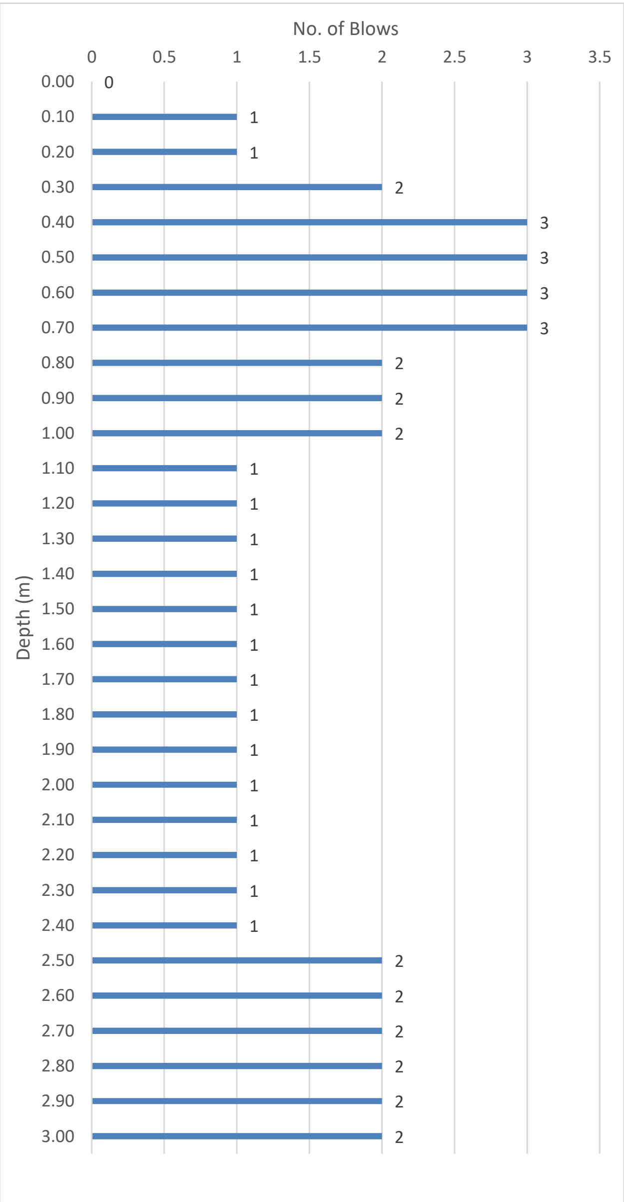
REMARKS: EGL - Existing Ground Level CHECKED: NJ

DYNAMIC PENETROMETER TEST SHEET

CLIENT:	NEO Consulting Pty Ltd	**DATE:**	24/05/2024
PROJECT:	Geotchnical Investigation	**PROJECT No.:**	NR163
LOCATION:	31-37 Phillip Street, Raymond Terrace, NSW, 2324	**SHEET:**	1 of 2

Depth (m)	Test Location DCP2
0.00	-
0.10	1
0.20	1
0.30	2
0.40	3
0.50	3
0.60	3
0.70	3
0.80	2
0.90	2
1.00	2
1.10	1
1.20	1
1.30	1
1.40	1
1.50	1
1.60	1
1.70	1
1.80	1
1.90	1
2.00	1
2.10	1
2.20	1
2.30	1
2.40	1
2.50	2
2.60	2
2.70	2
2.80	2
2.90	2
3.00	2

Penetration vs Depth



TEST METHOD: AS 1289. F3.2, CONE PENETROMETER PENETROMETER

REMARKS:

(HB) Test hammer bouncing upon refusal on solid object

-- No test undertaken at this level due to prior excavation of soils

DYNAMIC PENETROMETER TEST SHEET

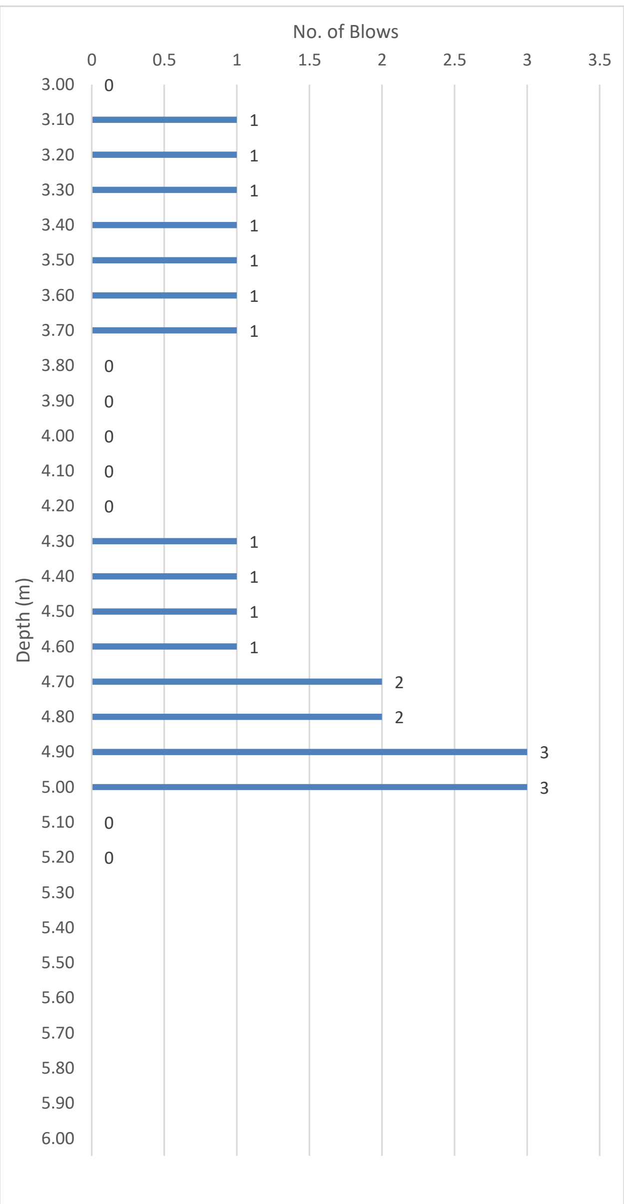
CLIENT: NEO Consulting Pty Ltd **DATE:** 24/05/2024

PROJECT: Geotchnical Investigation **PROJECT No.:** NR163

LOCATION: 31-37 Phillip Street, Raymond Terrace, NSW, 2324 **SHEET:** 2 of 2

Depth (m)	Test Location DCP2
3.00	-
3.10	1
3.20	1
3.30	1
3.40	1
3.50	1
3.60	1
3.70	1
3.80	HW
3.90	HW
4.00	HW
4.10	HW
4.20	HW
4.30	1
4.40	1
4.50	1
4.60	1
4.70	2
4.80	2
4.90	3
5.00	3
5.10	Terminated @ 5.1m
5.20	on medium dense sand
5.30	
5.40	
5.50	
5.60	
5.70	
5.80	
5.90	
6.00	

Penetration vs Depth



TEST METHOD: AS 1289. F3.2, CONE PENETROMETER PENETROMETER

REMARKS:

(HB) Test hammer bouncing upon refusal on solid object

-- No test undertaken at this level due to prior excavation of soils

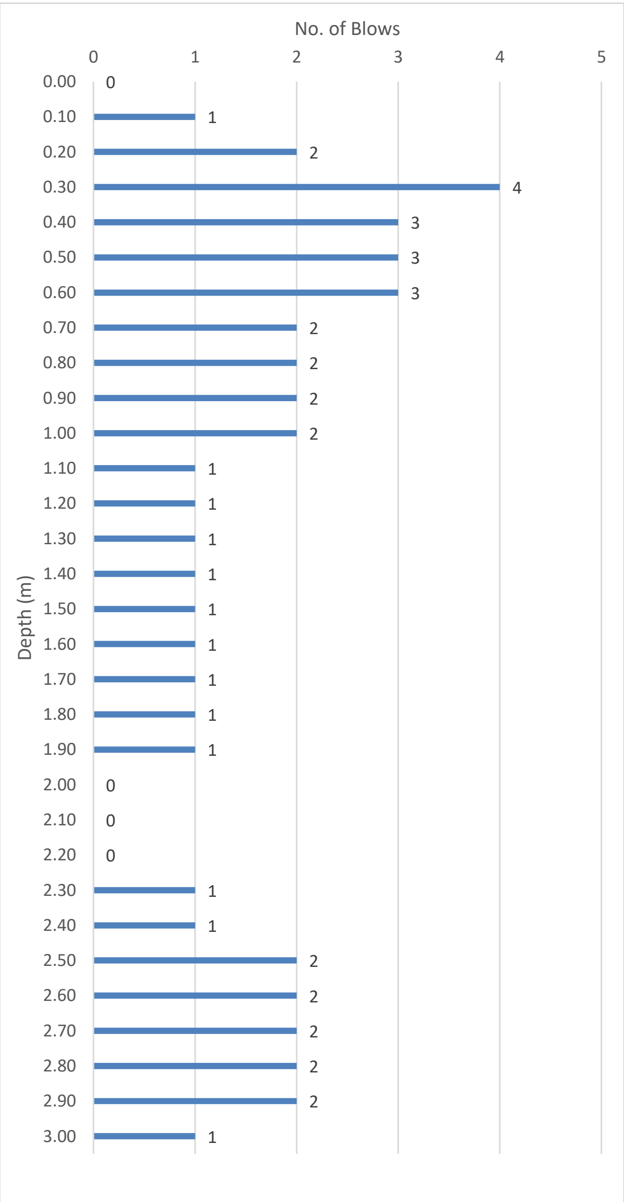
DCP cone was wet on retrieval indicates water seepage water.

DYNAMIC PENETROMETER TEST SHEET

CLIENT:	NEO Consulting Pty Ltd	**DATE:**	24/05/2024
PROJECT:	Geotchnical Investigation	**PROJECT No.:**	NR163
LOCATION:	31-37 Phillip Street, Raymond Terrace, NSW, 2324	**SHEET:**	1 of 2

Depth (m)	Test Location DCP3
0.00	-
0.10	1
0.20	2
0.30	4
0.40	3
0.50	3
0.60	3
0.70	2
0.80	2
0.90	2
1.00	2
1.10	1
1.20	1
1.30	1
1.40	1
1.50	1
1.60	1
1.70	1
1.80	1
1.90	1
2.00	HW
2.10	HW
2.20	HW
2.30	1
2.40	1
2.50	2
2.60	2
2.70	2
2.80	2
2.90	2
3.00	1

Penetration vs Depth



TEST METHOD: AS 1289. F3.2, CONE PENETROMETER PENETROMETER

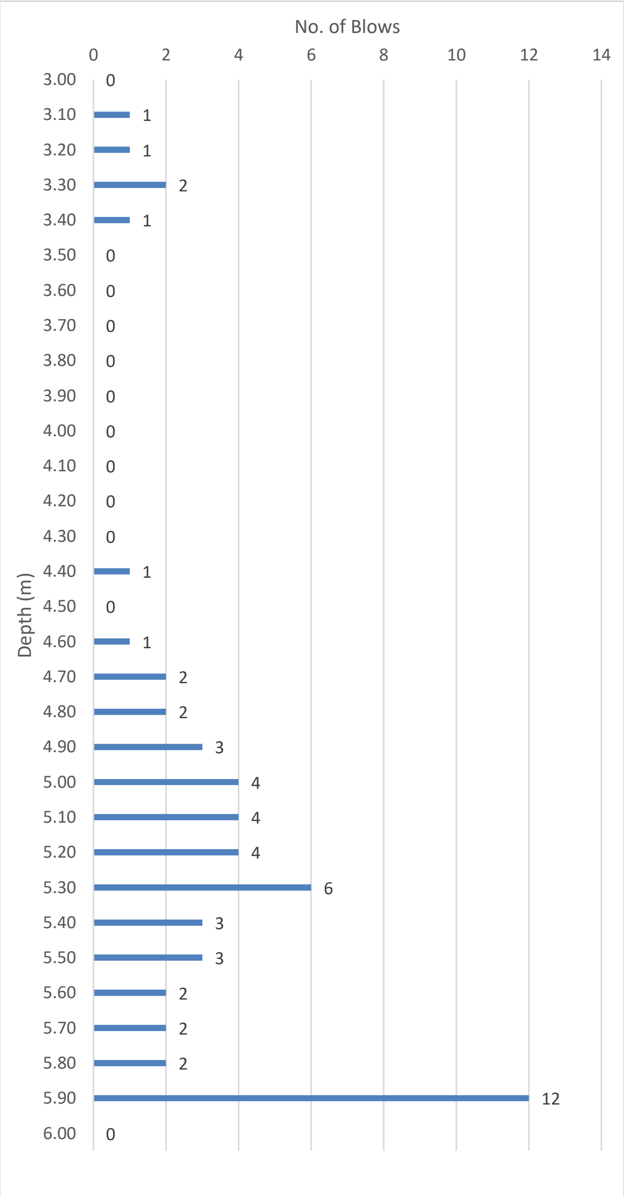
REMARKS:
(HB) Test hammer bouncing upon refusal on solid object
-- No test undertaken at this level due to prior excavation of soils

DYNAMIC PENETROMETER TEST SHEET

CLIENT:	NEO Consulting Pty Ltd	**DATE:**	24/05/2024
PROJECT:	Geotchnical Investigation	**PROJECT No.:**	NR163
LOCATION:	31-37 Phillip Street, Raymond Terrace, NSW, 2324	**SHEET:**	2 of 2

Depth (m)	Test Location DCP3
3.00	-
3.10	1
3.20	1
3.30	2
3.40	1
3.50	HW
3.60	HW
3.70	HW
3.80	HW
3.90	HW
4.00	HW
4.10	HW
4.20	HW
4.30	HW
4.40	1
4.50	HW
4.60	1
4.70	2
4.80	2
4.90	3
5.00	4
5.10	4
5.20	4
5.30	6
5.40	3
5.50	3
5.60	2
5.70	2
5.80	2
5.90	12
6.00	Terminated @ 5.90m

Penetration vs Depth



TEST METHOD: AS 1289. F3.2, CONE PENETROMETER PENETROMETER

REMARKS:

(HB) Test hammer bouncing upon refusal on solid object

-- No test undertaken at this level due to prior excavation of soils

DCP cone was wet on retrieval indicates water seepage water.

SOIL LOG

CLIENT: NEO Consulting Pty Ltd **DATE:** 24/05/2024 **BORE No.:** BH2

PROJECT: Geotchnical Investigation **PROJECT No.:** NR163 **SHEET:** 1 of 1

LOCATION: 31-37 Phillip Street, Raymond Terrace, N **SURFACE LEVEL:** EGL

Depth (m)	Description of Strata PRIMARY SOIL - strength/density, colour, grainsize/plasticity, moisture, soil type incl. secondary constituents, other remarks	Sampling		In Situ Testing	
		Type	Depth (m)	Type	Results
0.00	GRASSY LAWN			DCP4/DCP5	
0.10	Top Soil/Fill- grey, moist, silty Sand.				
	Fine to medium grained, grey, poorly graded Sand.				
		S1	0.50		
1.00			1.00		
	from 1.5m, brown	S2	1.50		
2.00			2.00		
		S3	2.50		
3.00			3.00		
	with some shells	S4	3.50		
4.00			4.00		
	Augering terminated at 4.0m depth on Sand				
5.00					

RIG: UTE Rig DRILLER: Jacob LOGGED: NJ

METHOD: Auger

GROUND WATER OBSERVATIONS: not observed

REMARKS: EGL - Existing Ground Level CHECKED: NJ

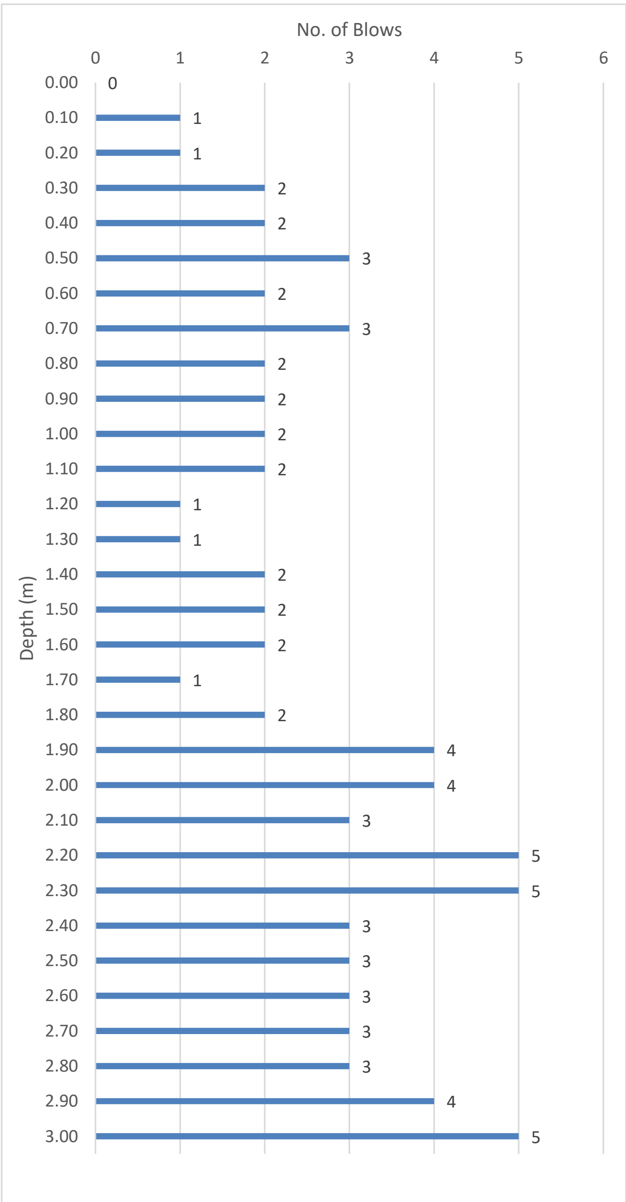
ENGINEERING CONSULTANTS

DYNAMIC PENETROMETER TEST SHEET

CLIENT:	NEO Consulting Pty Ltd	**DATE:**	24/05/2024
PROJECT:	Geotchnical Investigation	**PROJECT No.:**	NR163
LOCATION:	31-37 Phillip Street, Raymond Terrace, NSW, 2324	**SHEET:**	1 of 2

Depth (m)	Test Location DCP4
0.00	-
0.10	1
0.20	1
0.30	2
0.40	2
0.50	3
0.60	2
0.70	3
0.80	2
0.90	2
1.00	2
1.10	2
1.20	1
1.30	1
1.40	2
1.50	2
1.60	2
1.70	1
1.80	2
1.90	4
2.00	4
2.10	3
2.20	5
2.30	5
2.40	3
2.50	3
2.60	3
2.70	3
2.80	3
2.90	4
3.00	5

Penetration vs Depth



TEST METHOD: AS 1289. F3.2, CONE PENETROMETER PENETROMETER

REMARKS:

(HB) Test hammer bouncing upon refusal on solid object

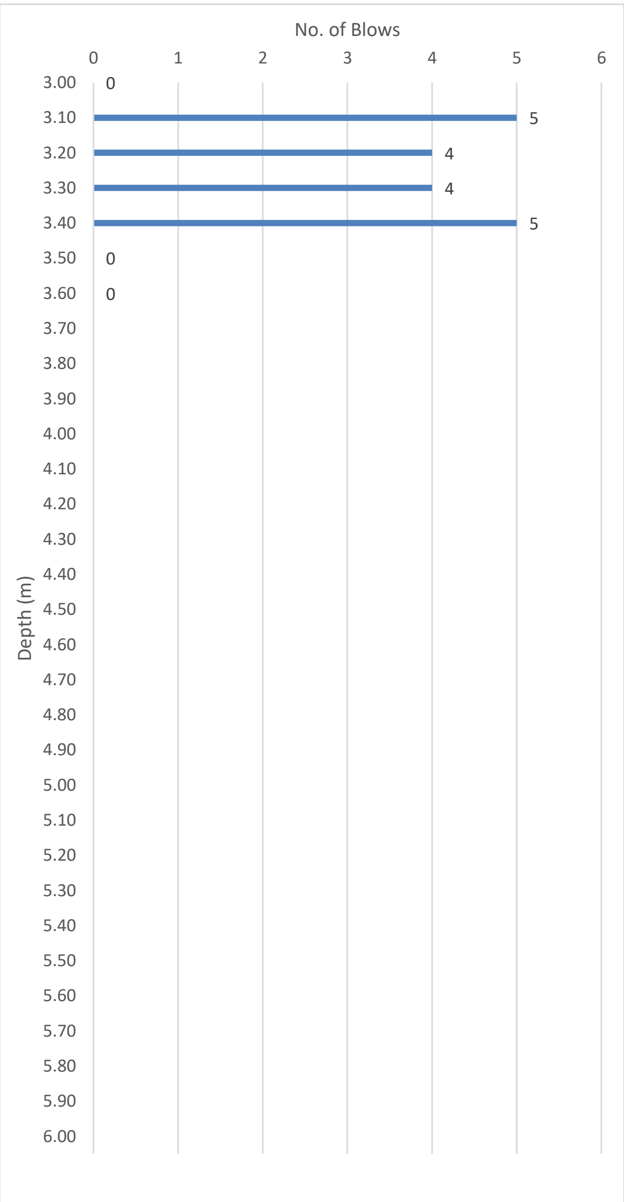
-- No test undertaken at this level due to prior excavation of soils

DYNAMIC PENETROMETER TEST SHEET

CLIENT: NEO Consulting Pty Ltd
DATE: 24/05/2024
PROJECT: Geotchnical Investigation
PROJECT No.: NR163
LOCATION: 31-37 Phillip Street, Raymond Terrace, NSW, 2324
SHEET: 2 of 2

Depth (m)	Test Location DCP4
3.00	-
3.10	5
3.20	4
3.30	4
3.40	5
3.50	Terminated @ 3.4m
3.60	on dense sand
3.70	
3.80	
3.90	
4.00	
4.10	
4.20	
4.30	
4.40	
4.50	
4.60	
4.70	
4.80	
4.90	
5.00	
5.10	
5.20	
5.30	
5.40	
5.50	
5.60	
5.70	
5.80	
5.90	
6.00	

Penetration vs Depth



TEST METHOD: AS 1289. F3.2, CONE PENETROMETER PENETROMETER

REMARKS:

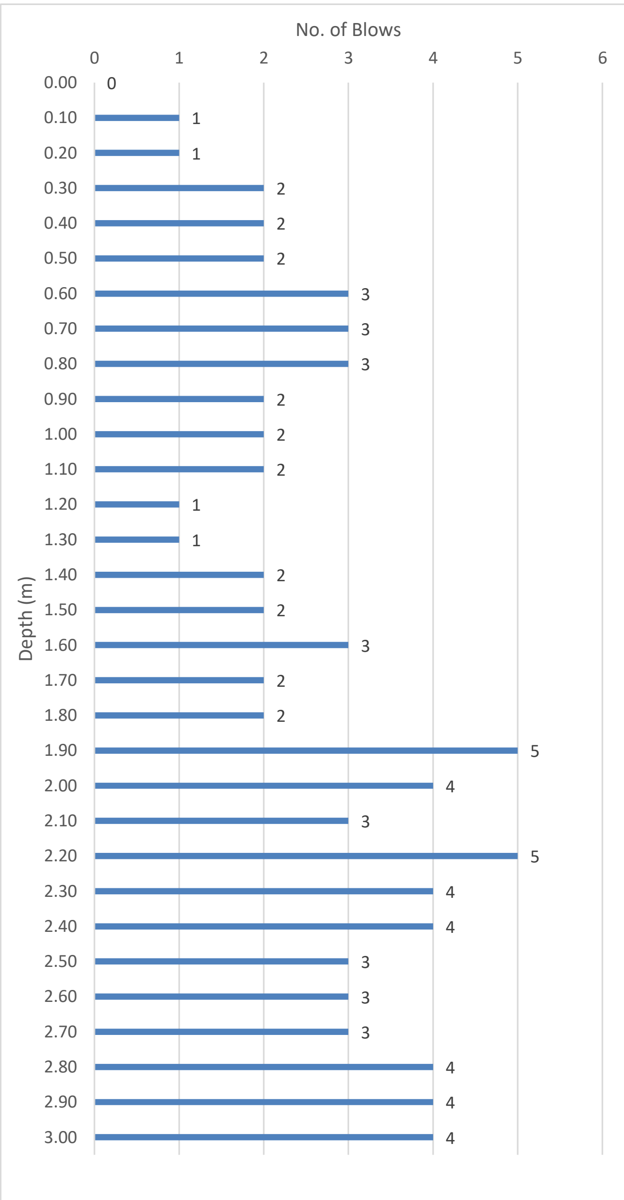
(HB) Test hammer bouncing upon refusal on solid object
-- No test undertaken at this level due to prior excavation of soils
DCP cone was moist on retrieval indicates water seepage water.

DYNAMIC PENETROMETER TEST SHEET

CLIENT:	NEO Consulting Pty Ltd	**DATE:**	24/05/2024
PROJECT:	Geotchnical Investigation	**PROJECT No.:**	NR163
LOCATION:	31-37 Phillip Street, Raymond Terrace, NSW, 2324	**SHEET:**	1 of 2

Depth (m)	Test Location DCP5
0.00	-
0.10	1
0.20	1
0.30	2
0.40	2
0.50	2
0.60	3
0.70	3
0.80	3
0.90	2
1.00	2
1.10	2
1.20	1
1.30	1
1.40	2
1.50	2
1.60	3
1.70	2
1.80	2
1.90	5
2.00	4
2.10	3
2.20	5
2.30	4
2.40	4
2.50	3
2.60	3
2.70	3
2.80	4
2.90	4
3.00	4

Penetration vs Depth



TEST METHOD: AS 1289. F3.2, CONE PENETROMETER PENETROMETER

REMARKS:

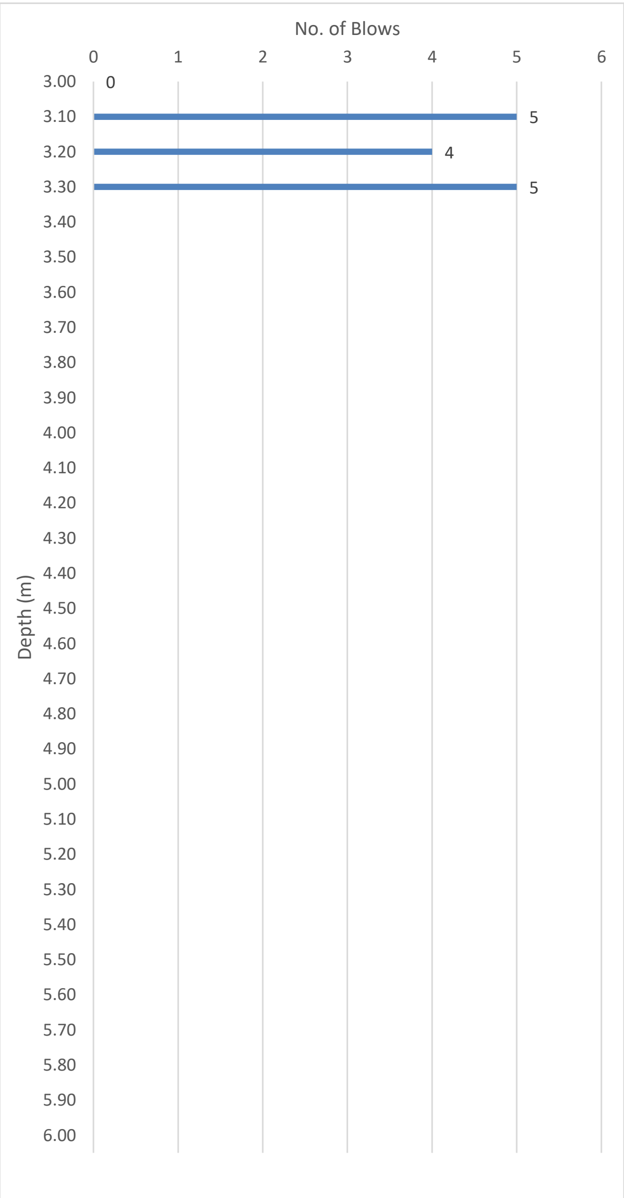
(HB)	Test hammer bouncing upon refusal on solid object
--	No test undertaken at this level due to prior excavation of soils

DYNAMIC PENETROMETER TEST SHEET

CLIENT:	NEO Consulting Pty Ltd	**DATE:**	24/05/2024
PROJECT:	Geotchnical Investigation	**PROJECT No.:**	NR163
LOCATION:	31-37 Phillip Street, Raymond Terrace, NSW, 2324	**SHEET:**	2 of 2

Depth (m)	Test Location DCP5
3.00	-
3.10	5
3.20	4
3.30	5
3.40	Terminated @ 3.3m
3.50	on dense sand
3.60	
3.70	
3.80	
3.90	
4.00	
4.10	
4.20	
4.30	
4.40	
4.50	
4.60	
4.70	
4.80	
4.90	
5.00	
5.10	
5.20	
5.30	
5.40	
5.50	
5.60	
5.70	
5.80	
5.90	
6.00	

Penetration vs Depth



TEST METHOD: AS 1289. F3.2, CONE PENETROMETER PENETROMETER

REMARKS:

(HB)	Test hammer bouncing upon refusal on solid object
--	No test undertaken at this level due to prior excavation of soils
	DCP cone was moist on retrieval indicates water seepage water.

SOIL LOG

CLIENT: NEO Consulting Pty Ltd **DATE:** 24/05/2024 **BORE No.:** BH3

PROJECT: Geotchnical Investigation **PROJECT No.:** NR163 **SHEET:** 1 of 1

LOCATION: 31-37 Phillip Street, Raymond Terrace, N **SURFACE LEVEL:** EGL

Depth (m)	Description of Strata PRIMARY SOIL - strength/density, colour, grainsize/plasticity, moisture, soil type incl. secondary constituents, other remarks	Sampling Type	Sampling Depth (m)	In Situ Testing Type	Results
0.00	Fill- grey, moist, silty Sand.			DCP6/DCP7	
0.20	Fine grained, grey, silty Sand.				
		S1	0.50 – 1.00		
1.00					
	from 1.5m, brown, clayey sand/sandy clay	S2	1.50 – 2.00		
2.00	from 2m: Silty Clay (extemely weathered material)				
		S3	2.50 – 3.00		
3.00					
		S4	3.50 – 4.00		
3.80	Siltstone/Sandstone, extremely low to very low strength, extremely weathered.				
4.00					
4.20	**Augering terminated at 4.2m depth on Low Strength Silstone/Sandstone Bedrock**				
5.00					

RIG: UTE Rig DRILLER: Jacob LOGGED: NJ

METHOD: Auger

GROUND WATER OBSERVATIONS: not observed

REMARKS: EGL - Existing Ground Level CHECKED: NJ

DYNAMIC PENETROMETER TEST SHEET

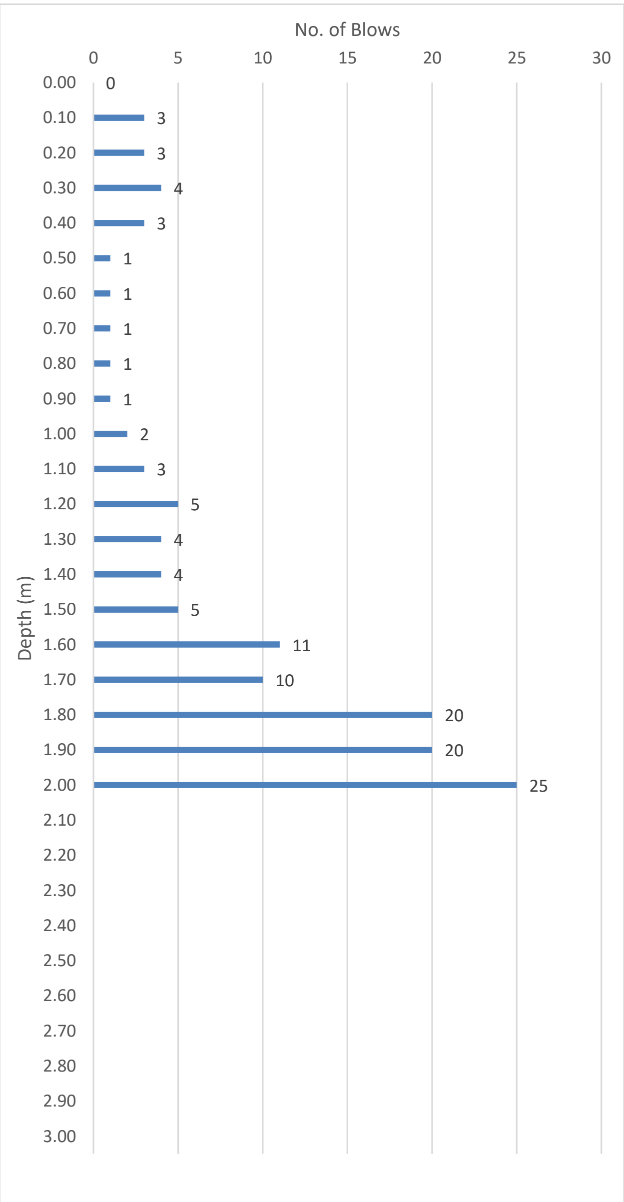
CLIENT: NEO Consulting Pty Ltd **DATE:** 24/05/2024

PROJECT: Geotchnical Investigation **PROJECT No.:** NR163

LOCATION: 31-37 Phillip Street, Raymond Terrace, NSW, 2324 **SHEET:** 1 of 1

Depth (m)	Test Location DCP6
0.00	-
0.10	3
0.20	3
0.30	4
0.40	3
0.50	1
0.60	1
0.70	1
0.80	1
0.90	1
1.00	2
1.10	3
1.20	5
1.30	4
1.40	4
1.50	5
1.60	11
1.70	10
1.80	20
1.90	20
2.00	25
2.10	Terminated @ 2.0m
2.20	on hard Clay/Extremely
2.30	weathered material
2.40	
2.50	
2.60	
2.70	
2.80	
2.90	
3.00	

Penetration vs Depth



TEST METHOD: AS 1289. F3.2, CONE PENETROMETER PENETROMETER

REMARKS:

(HB) Test hammer bouncing upon refusal on solid object

-- No test undertaken at this level due to prior excavation of soils

DCP cone was slightly moist on retrieval.

ENGINEERING CONSULTANTS

DYNAMIC PENETROMETER TEST SHEET

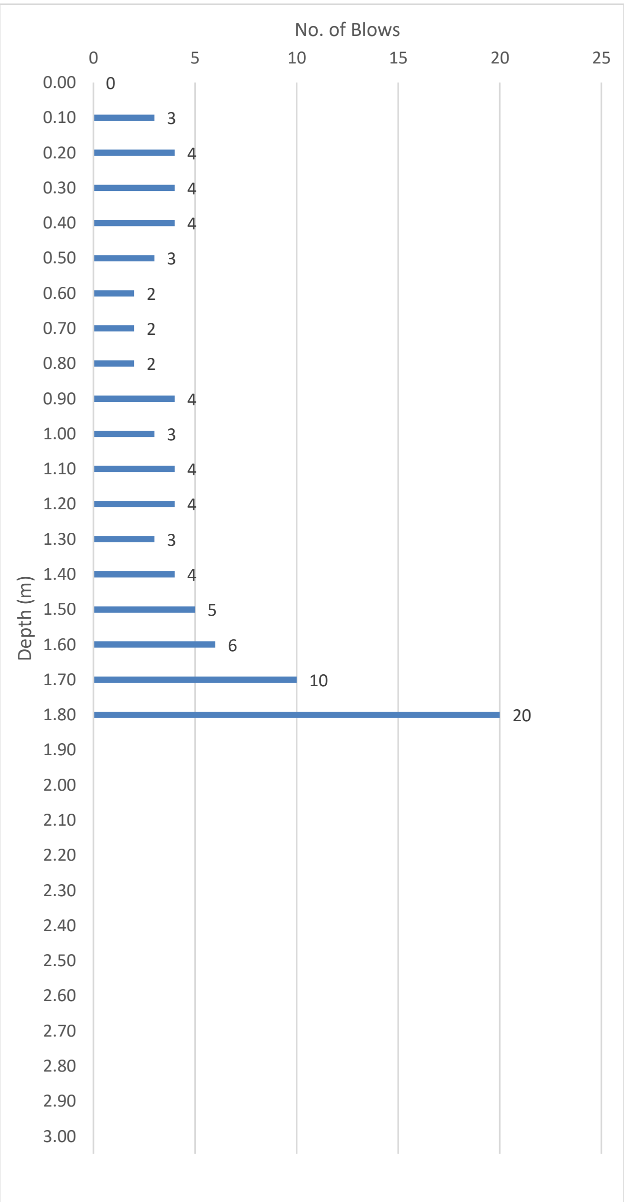
CLIENT: NEO Consulting Pty Ltd **DATE:** 24/05/2024

PROJECT: Geotchnical Investigation **PROJECT No.:** NR163

LOCATION: 31-37 Phillip Street, Raymond Terrace, NSW, 2324 **SHEET:** 1 of 1

Depth (m)	Test Location DCP7
0.00	-
0.10	3
0.20	4
0.30	4
0.40	4
0.50	3
0.60	2
0.70	2
0.80	2
0.90	4
1.00	3
1.10	4
1.20	4
1.30	3
1.40	4
1.50	5
1.60	6
1.70	10
1.80	20
1.90	25/30mm
2.00	Refusal @ 1.83m
2.10	on hard Clay/Extremely
2.20	weathered material
2.30	
2.40	
2.50	
2.60	
2.70	
2.80	
2.90	
3.00	

Penetration vs Depth



TEST METHOD: AS 1289. F3.2, CONE PENETROMETER PENETROMETER

REMARKS:

(HB) Test hammer bouncing upon refusal on solid object

-- No test undertaken at this level due to prior excavation of soils

DCP cone was slightly moist on retrieval.

EXPLANATORY NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT LOGS

DRILLING/EXCAVATION METHOD

HA	Hand Auger	**ADH**	Hollow Auger	**NQ**	Diamond Core - 47 mm
DT	Diatube Coring	**RT**	Rotary Tricone bit	**NMLC**	Diamond Core - 52 mm
NDT	Non-destructive Testing	**RAB**	Rotary Air Blast	**HQ**	Diamond Core - 63 mm
AD*	Auger Drilling	**RC**	Reverse Circulation	**HMLC**	Diamond Core - 63 mm
***V**	V-Bit	**PT**	Push Tube	**EX**	Tracked Hydraulic Excavator
***T**	TC-Bit, e.g. AD/T	**WB**	Wash Boring	**HAND**	Excavated by Hand Methods

PENETRATION RESISTANCE

L	**Low Resistance**	Rapid penetration/ excavation possible with little effort from equipment used.
M	**Medium Resistance**	Penetration/ excavation possible at an acceptable rate with moderate effort from equipment
H	**High Resistance**	Penetration/ excavation is possible but at a slow rate and requires significant effort from equipment used.
R	**Refusal/Practical Refusal**	No further progress possible without risk of damage or unacceptable wear to equipment used.

These assessments are subjective and are dependent on many factors, including equipment power and weight, condition of excavation or drilling tools and experience of the operator.

GEOLOGICAL BOUNDARIES

———————— = Observed Boundary (position known)

– – – – – – – – – – – = Observed Boundary (position approximate)

– –?– –?– –?– – = Boundary (interpreted or inferred)

ROCK CORE RECOVERY

TCR=Total Core Recovery (%)

$$= \frac{\textit{Length of core recovered}}{\textit{Length of core run}} \times 100$$

RQD = Rock Quality Designation (%)

$$= \frac{\sum \textit{Axial lengths of core} > 100mm}{\textit{Length of core run}} \times 100$$

GROUNDWATER/SEEPAGE

Standing Water Level

▷ **Water Seepage**

◁ **Partial water loss**

◀ **Complete Water Loss**

GWNO GROUNDWATER NOT OBSERVED - Observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave-in of the borehole/ test pit.

GWNE GROUNDWATER NOT ENCOUNTERED - Borehole/ test pit was dry soon after excavation. However, groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/ test pit

SAMPLING AND TESTING

SPT	Standard Penetration Test to AS1289.6.3.1-2004
4,7,11 N=18	4,7,11 = Blows per 150mm. N = Blows per 300mm penetration following a 150mm seating drive
30/80mm	Where practical refusal occurs, the blows and penetration for that interval are reported, N is not reported
RW	Penetration occurred under the rod weight only, N<1
HW	Penetration occurred under the hammer and rod weight only, N<1
HB	Hammer double bouncing on anvil, N is not reported
Sampling	
DS	Disturbed Sample
ES	Sample for environmental testing
BDS	Bulk disturbed Sample
WS	Water Sample
U50	Thin walled tube sample - number indicates nominal sample diameter in millimetres
Testing	
FP	Field Permeability test over section noted
FVS	Field Vane Shear test expressed as uncorrected shear strength (sv= peak value, sr= residual value)
PID	Photoionisation Detector reading in ppm
PM	Pressure meter test over section noted
PP	Pocket Penetrometer test expressed as instrument reading in kPa
WPT	Water Pressure tests
DCP	Dynamic Cone Penetrometer test
CPT	Static Cone Penetration test
CPTu	Static Cone Penetration test with pore pressure (u) measurement

NOTES FOR SOIL DESCRITION ON BOREHOLE AND TEST PIT LOGS

SOIL CLASSIFICATION CHART (LABORATORY METHOD)

CRITERIA FOR ASSIGNING GROUP SYMBOLS AN D GROUP NAMES USING LABORATORY TESTS[a]				SOIL CLASSIFICATION	
				GROUP SYMBOL	**GROUP NAME[b]**
COARSE-GRAINED SOILS more than 50% retained on No. 200 sieve	GRAVELS More than 5% of coarse fraction retained on No. 4 sieve	Clean Gravel Less than 5% fines[c]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[e]	GW	Well-graded GRAVEL[f]
			$Cu < 4$ and/or $1 > Cc > 3$[e]	GP	Poorly graded GRAVEL[f]
		Gravels with Fines More than 12% fines[c]	Fines classify as ML or MH	GM	Slity GRAVES [f,g,h]
			Fines classify as CL or CH	GC	Glayey GRAVEL [f,g,h]
	SANDS 50% or more or coarse fraction passes No. 4 sieve.	Clean sands Less than 5% fines[d]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[e]	SW	Well-graded SAND[l]
			Cu <≥ 6 and/or 1 >≤ CC > 3[e]	SP	Poorly graded SAND[l]
		Sands with fines More than 12% fines[d]	Fines classify as ML or MH	SM	Slity SAND[g,h,i]
			Fine classify as CL or CH	SC	Clayey SAND [g,h,i]
FINE-GRAINED 50% or more passes the No. 200 sieve	SILTS AND CLAYS Liquid Limit less than 50%	Inorganic	PI> and plots on or above "A" line [j]	CL	Lean CLAY[k,l,m]
			PL < or plots below "A" line [j]	ML	SILT [k,l,m]
		Organic	$\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$	OL	ORGANIC CLAY [k,l,m,n] ANIC SILT [k,l,m,n]
	SILTS AND CLAYS Liquid Limit 50% or more	Inorganic	PI plots on or above "A" line	CH	Fat CLAY [k,l,m]
			PL plots below "A" line	MH	Elastic SILT [k,l,m]
		Organic	$\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$		ORGANIC CLAY [k,l,m,p] ANIC SILT [k,l,m,p]
Highly organic soils		Primarily organic matter, dark in colour, and organic odour		PT	PEAT

a Based on the material passing the 3-in (75mm) sieve.

b If field sample contained cobbles and/or boulders, add "with cobbles and/or boulders" to group name.

c Gravels with 5 to 12% fines require dual symbols:

- GW-GM well-graded with silt
- GW-GC well-graded with clay
- GP-GM poorly graded gravel with silt
- GP-GC poorly graded gravel with clay

d Sands with 5 to 12% fines require dual symbols:

- GW-GM well-graded with silt
- GW-GC well-graded with clay
- GP-GM poorly graded gravel with silt
- GP-GC poorly graded gravel with clay

e $Cu = D_{60} I D_{10}$ $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

f If soil contains 15% sand, add "with sand" to group name

g If fines classify as CL-ML, use dual symbol GC-GM, SC-SM.

h If fines are organic, add "with organic fines" to group name.

I If soil contains ≥ 15% grave, add "with gravel" to group name.

j If the liquid limit and plasticity index plot in hatched area on plasticity chart, soil is a CL-ML, Silty CLAY.

k If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel", whichever is predominant.

l If soil contains ≥ 30% plus No. 200, predominantly sand, add "sandy" to group name.

m If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

n PI ≥4 and plots on or above "A" line.

o PI < 4 or plots below "A" line.

p PI plots on or above "A" line.

q PI plots below "A" line.

NOTES FOR SOIL DESCRITION ON BOREHOLE AND TEST PIT LOGS

DENSITY EVALUATION OF COARSE-GRAINED SOILS

Standard Penetration Test (SPT) Value (No. of Blows/per 300mm*)	Apparent Density	Density Index
0 –4	Very loose (VL)	≤ 15
>4 – 10	Loose (L)	>15 ≤ 35
>10 – 30	Medium dense (MD)	>35 ≤ 65
>30 – 50	Dense (D)	>65 ≤ 85
>50	Very dense (VD)	>85

* Density index from AS 1289.0.

EVALUATION OF THE CONSISTENCY OF FINE GRAINED SOILS

SPT Blow Count* (blows/300 mm)	Consistency	Unconfined Compressive Strength Kg/cm2	Results of Manuals Manipulation
<2	Very soft (VS)	≤ 0.25	Specimen (height = twice the diameter) sags under its own weight; extrudes between fingers when squeezed.
>2-4	Soft (S)	>0.25 – 0.5	Specimen can be pinched in two between the thumb and forefinger; remoulded by light finger pressure.
>4-8	Medium stiff (MSt)	>0.5 – 1.0	Can be imprinted easily with fingers; remoulded by strong finger pressure.
>8-15	Stiff (St)	>1.0 – 2.0	Can be imprinted with considerable pressure from fingers or indented by thumbnail.
>15-30	Very stiff (VSt)	>2.0 – 4.0	Can barely be imprinted by pressure from the fingers or indented by thumbnail
>30	Hard (H)	>4.0	Cannot be imprinted by fingers or difficult to indent by thumbnail.

* Uncorrected blow count

SOIL PLASTICITY DESCRIPTIONS

Plasticity Index	Plasticity	Adjective for Soil Type, Texture, and Plasticity Chart Location		
Range	Adjective	ML & MH (SILT)	CL & CH (CLAY)	OL & OH (ORGANIC SILT OR CLAY)
0	Non plastic	--	--	ORGANIC SILT
1 - 10	Low plasticity	--	silty	ORGANIC SILT
>10 – 20	Medium plastic	Clayey	silty to no adj.	ORGANIC clayey SILT
> 20 – 40	High plasticity	Clayey	--	ORGANIC silty CLAY
>40	Very plastic	Clayey	--	ORGANIC CLAY

NOTES FOR SOIL DESCRITION ON BOREHOLE AND TEST PIT LOGS

SOIL PLASTICITY DESCRIPTIONS

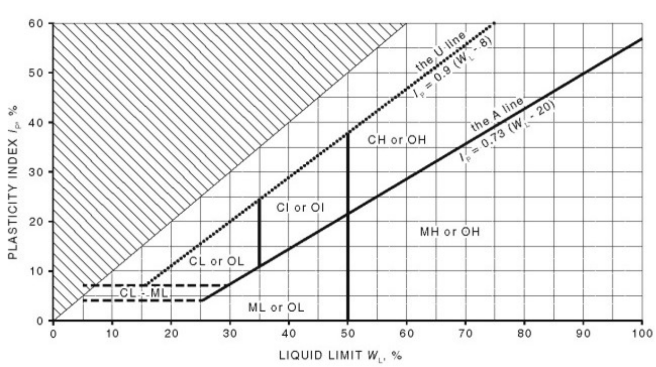
Plasticity Index	Plasticity	Adjective for Soil Type, Texture, and Plasticity Chart Location		
Range	Adjective	ML & MH (SILT)	CL & CH (CLAY)	OL & OH (ORGANIC SILT OR CLAY)
0	Non plastic	--	--	ORGANIC SILT
1 - 10	Low plasticity	--	silty	ORGANIC SILT
>10 – 20	Medium plastic	Clayey	silty to no adj.	ORGANIC clayey SILT
> 20 – 40	High plasticity	Clayey	--	ORGANIC silty CLAY
>40	Very plastic	Clayey	--	ORGANIC CLAY

* Soil type is the same for above or below the “A” – line, the dual group symbol (CL/OL or CH/OH) identifies the soil types above the “A”-line. See Plasticity Chart below

FIELD METHODS TO DESCRIBE PLASTICITY

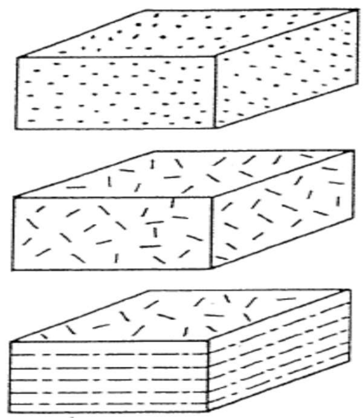
Plasticity Range	Adjective	Dry Strength	Smear Test	Thread Smallest Diameter, mm
0	Non plastic	non – crumbles into powder with mere pressure	gritty or rough	ball cracks
1 – 10	Low plasticity	low – crumbles into powder with some finger pressure	rough to smooth	6 to 3
>10 – 20	Medium plastic	medium – breaks into pieces or crumbles with considerable finger pressure	smooth to dull	1.6
>20 – 40	High plasticity	high – cannot be broken with finger pressure; spec. will break into pieces between thumb and a hard surface	shiny	0.8
>40	Very plastic	very high – can’t be broken between thumb and a hard surface	very shiny and waxy	0.4

Plasticity Chart



NOTES FOR ROCK DESCRITION ON BOREHOLE AND TEST PIT LOGS

TEXTURE AND FABRIC OF ROCK

Geological description	Diagram	Fabric type
Massive		Effectively homogeneous and isotropic. Bulky or equidimensional grains uniformly distributed.
		Effectively homogeneous and isotropic. Elongated or tabular grains uniformly distributed, randomly orientated.
Layered (bedded foliate cleaved)		Effectively homogeneous with planar anisotropy. Elongated or tabular grains or pores in a layered arrangement.

ROCK STRENGTH

Term	Letter Symbol	Point Load Strength Index (MPa) $I_{s(50)}$	Field Guide to Strength
Extremely low	EL	$\leq$ 0.03	Easily remoulded by hand to a material with soil properties.
Very low	VL	>0.03 $\leq$ 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut triaxial sample by hand. Pieces up to 3cm thick can be broken by finger pressure.
Low	L	>0.1 $\leq$ 0.3	Easily scores with a knife; indentations 1mm to 3mm show in the specimen with firm blows of pick point; has dull sound under hammer. A piece of core 150 mm long, 50 mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	M	>0.3 $\leq$ 1.0	Readily scored with a knife; a piece of core 150 mm long, 50 mm diameter can be broken by hand with difficulty.
High	H	>1 $\leq$ 3	A piece of core 150 mm long, 50mm diameter cannot be broken by hand but can be broken by a geological pick with a single firm blow; rock rings under hammer.
Very High	VH	>3 $\leq$ 10	Hand specimen breaks with geological pick after more than one blow; rock rings under hammer.
Extremely High	EH	>10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.

 # Rock Strength Test Results

▼ Point Load Strength Index, $Is_{(50)}$, Axial test (MPa)

● Point Load Strength Index, $Is_{(50)}$, Diametral test (MPa)

Relationship between rock strength test result ($Is_{(50)}$) and unconfined compressive strength (UCS) will vary with rock type and strength, and should be determined on a site-specific basis. However UCS is typically 20 x $Is_{(50)}$.

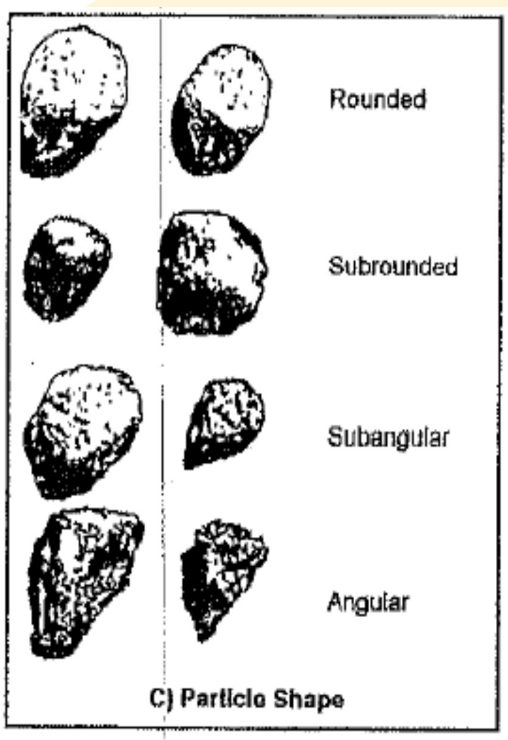
NOTES FOR ROCK DESCRITION ON BOREHOLE AND TEST PIT LOGS

ROCK WEATHERING/ALTERNATION

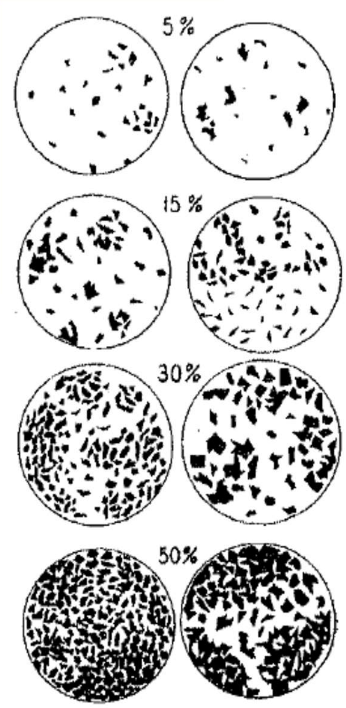
Term	Symbol	Field Identification
Fresh	FR	Rock shows no sign of decomposition or staining.
Slightly weathered	SW	Rock is slightly discoloured but shows little or no change in strength from fresh rock.
Distinctly weathered	DW	Rock strength usually changed by weathering. The rock may be highly discoloured usually by iron staining. Porosity may be increased by leaching or may be decreased due to deposition of weathering products in pores.
Extremely weathered	XW	Rock is weathered to such an extent that it has `soil □ properties, i.e. it either disintegrates or can be remoulded, in water.
Residual soil	RS	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.

Note: this terminology is not in accordance with Appendix A of AS1726.

Particle Shape



Percentage of Grains



NOTES FOR ROCK MATERIAL DESCRITION AND DEFECTS

CLASSIFICATION AND INFERRED STRATIGRAPHY
Rock is broadly classified and described in Borehole and Test Pit Logs using the preferred method given in AS1726 – 2017, Section 6.2 – Rock identification, description and classification.

DETAILED ROCK DEFECT SPACING

Defect Spacing

Spacing/width (mm)	Descriptor	Symbol
<20	Extremely Close	EC
20-60	Very Close	VC
60-200	Close	C
200-600	Medium	M
600-2000	Wide	W
2000-6000	Very Wide	VW

Bedding Thickness (Stratification)

Term	Spacing (mm)
Thinly laminated	<6
Laminated	6 – 20
Very thinly bedded	20 – 60
Thinly bedded	60 – 200
Medium bedded	200 – 600
Thickly bedded	600 – 2,000
Very thickly bedded	> 2,000

ABBREVIATIONS AND DESCRIPTIONS FOR DEFECT TYPES

Defect Type	Abbr.	Description
Joint	JT	Surface of a fracture or parting, formed without displacement, across which the rock has little or no tensile strength. May be closed or filled by air, water or soil or rock substance, which acts as cement.
Bedding Parting	BP	Surface of fracture or parting, across which the rock has little or no tensile strength, parallel or sub-parallel to layering/ bedding. Bedding refers to the layering or stratification of a rock, indicating orientation during deposition, resulting in planar anisotropy in the rock material.
Contact	CO	The surface between two types or ages of rock.
Sheared Surface	SSU	A near planar, curved or undulating surface which is usually smooth, polished or slickensided.
Sheared Seam/ Zone (Fault)	SS/SZ	Seam or zone with roughly parallel almost planar boundaries of rock substance cut by closely spaced (often <50 mm) parallel and usually smooth or slickensided joints or cleavage planes.
Crushed Seam/ Zone (Fault)	CS/CZ	Seam or zone composed of disoriented usually angular fragments of the host rock substance, with roughly parallel near-planar boundaries. The brecciated fragments may be of clay, silt, sand or gravel sizes or mixtures of these.
Extremely Weathered Seam/ Zone	XWS/XWZ	Seam of soil substance, often with gradational boundaries, formed by weathering of the rock material in places.
Infilled Seam	IS	Seam of soil substance, usually clay or clayey, with very distinct roughly parallel boundaries, formed by soil migrating into joint or open cavity.
Vein	VN	Distinct sheet-like body of minerals crystallised within rock through typically open-space filling or crack-seal growth.

NOTE: Defects size of <100mm SS, CS and XWS. Defects size of >100mm SZ, CZ and XWZ.

ABBREVIATIONS AND DESCRIPTIONS FOR DEFECT SHAPE AND ROUGHNESS

Shape	Abbr.	Description	Roughness	Abbr.	Description
Planar	PR	Consistent orientation	Polished	POL	Shiny smooth surface
Curved	CU	Gradual change in	Slickensided	SL	Grooved or striated surface, usually polished
Undulating	UN	Wavy surface	Smooth	SM	Smooth to touch. Few or no surface irregularities
Stepped	ST	One or more well defined steps	Rough	RO	Many small surface irregularities (amplitude generally <1mm). Feels like fine to coarse sandpaper
Irregular	IR	Many sharp changes in orientation	Very Rough	VR	Many large surface irregularities, amplitude generally >1mm. Feels like very coarse sandpaper

Orientation: **Vertical Boreholes –** The dip (inclination from horizontal) of the defect.
Inclined Boreholes – The inclination is measured as the acute angle to the core axis.

ABBREVIATIONS AND DESCRIPTIONS FOR DEFECT COATING

Coating	Abbr.	Description
Clean	CN	No visible coating or infilling
Stain	SN	No visible coating but surfaces are discoloured by staining, often limonite (orange-brown)
Veneer	VNR	A visible coating of soil or mineral substance, usually too thin to measure (< 1 mm); may be patchy

DEFECT APERTURE

Aperture	Abbr.	Description
Closed	CL	Closed.
Open	OP	Without any infill material.
Infilled	-	Soil or rock i.e. clay, silt, talc, pyrite, quartz, etc.

Appendix B – Laboratory Test Results

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS

Contact	Admin
Client	NEO CONSULTING PTY LTD
Address	PO BOX 279 RIVERSTONE NSW 2765
Telephone	0416 680 375
Facsimile	(Not specified)
Email	admin@neoconsulting.com.au
Project	**NR163 - 31-37 Phillip Street Raymond Ter**
Order Number	**NR163**
Samples	15

LABORATORY DETAILS

Manager	Huong Crawford
Laboratory	SGS Alexandria Environmental
Address	Unit 16, 33 Maddox St Alexandria NSW 2015
Telephone	+61 2 8594 0400
Facsimile	+61 2 8594 0499
Email	au.environmental.sydney@sgs.com
SGS Reference	**SE265824 R0**
Date Received	27/5/2024
Date Reported	6/6/2024

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(4354).

SPOCAS and CRS subcontracted to SGS Cairns, 2/58 Comport St, Portsmith QLD 4870, NATA Accreditation Number: 2562, Site Number: 3146. Report No. CE175370.

SIGNATORIES

Huong CRAWFORD
Production Manager

Ying Ying ZHANG
Laboratory Technician

Field pH for Acid Sulphate Soil [AN104] Tested: 30/5/2024

PARAMETER	UOM	LOR	BH1 (0.5-1.0)_S1 SOIL - 24/5/2024 SE265824.001	BH1 (1.5-2.0)_S2 SOIL - 24/5/2024 SE265824.002	BH1 (2.5-3.0)_S3 SOIL - 24/5/2024 SE265824.003	BH1 (3.5-4.0)_S4 SOIL - 24/5/2024 SE265824.004	BH2 (0.5-1.0)_S1 SOIL - 24/5/2024 SE265824.005
pHf	pH Units	-	6.0	5.5	5.8	5.8	5.8
pHfox	pH Units	-	3.9	4.9	5.3	6.1	4.3
Reaction Rate (pHfox)*	No unit	-	1	1	1	1	1
pH Difference*	pH Units	-10	2.1	0.7	0.5	-0.3	1.5

PARAMETER	UOM	LOR	BH2 (1.5-2.0)_S2 SOIL - 24/5/2024 SE265824.006	BH2 (2.5-3.0)_S3 SOIL - 24/5/2024 SE265824.007	BH2 (3.5-4.0)_S4 SOIL - 24/5/2024 SE265824.008	BH3 (0.5-1.0)_S1 SOIL - 24/5/2024 SE265824.009	BH3 (1.5-2.0)_S2 SOIL - 24/5/2024 SE265824.010
pHf	pH Units	-	5.7	5.0	5.4	6.1	5.0
pHfox	pH Units	-	5.1	5.3	5.6	5.0	4.4
Reaction Rate (pHfox)*	No unit	-	1	1	1	1	1
pH Difference*	pH Units	-10	0.6	-0.2	-0.2	1.1	0.6

PARAMETER	UOM	LOR	BH3 (2.5-3.0)_S3 SOIL - 24/5/2024 SE265824.011	BH4 (0.5-1.0)_S1 SOIL - 24/5/2024 SE265824.012	BH4 (1.5-2.0)_S2 SOIL - 24/5/2024 SE265824.013	BH4 (2.5-3.0)_S3 SOIL - 24/5/2024 SE265824.014	BH4 (3.5-4.0)_S4 SOIL - 24/5/2024 SE265824.015
pHf	pH Units	-	4.5	5.5	5.7	6.3	5.9
pHfox	pH Units	-	3.9	4.2	5.3	5.8	5.6
Reaction Rate (pHfox)*	No unit	-	1	1	1	1	1
pH Difference*	pH Units	-10	0.7	1.3	0.3	0.5	0.4

Moisture Content [AN002] Tested: 6/6/2024

PARAMETER	UOM	LOR	BH4 (1.5-2.0)_S2 SOIL - 24/5/2024 SE265824.013
% Moisture	%w/w	0.5	**7.9**

TAA (Titratable Actual Acidity) [AN219] Tested: 6/6/2024

PARAMETER	UOM	LOR	BH1 (2.5-3.0)_S3 SOIL - 24/5/2024 SE265824.003	BH2 (3.5-4.0)_S4 SOIL - 24/5/2024 SE265824.008	BH3 (2.5-3.0)_S3 SOIL - 24/5/2024 SE265824.011	BH4 (1.5-2.0)_S2 SOIL - 24/5/2024 SE265824.013
pH KCl*	pH Units	-	5.7	5.9	4.2	5.3
Titratable Actual Acidity	kg H2SO4/T	0.25	<0.25	<0.25	3.3	0.49
Titratable Actual Acidity (TAA) moles H+/tonne	moles H+/T	5	<5	<5	67	10
Titratable Actual Acidity (TAA) S%w/w	%w/w S	0.01	<0.01	<0.01	0.11	0.02
Sulphur (SKCl)	%w/w	0.005	<0.005	<0.005	0.012	<0.005
Calcium (CaKCl)	%w/w	0.005	<0.005	<0.005	0.013	<0.005
Magnesium (MgKCl)	%w/w	0.005	<0.005	<0.005	0.024	<0.005

TPA (Titratable Peroxide Acidity) [AN218] Tested: 6/6/2024

PARAMETER	UOM	LOR	BH1 (2.5-3.0)_S3 SOIL - 24/5/2024 SE265824.003	BH2 (3.5-4.0)_S4 SOIL - 24/5/2024 SE265824.008	BH3 (2.5-3.0)_S3 SOIL - 24/5/2024 SE265824.011	BH4 (1.5-2.0)_S2 SOIL - 24/5/2024 SE265824.013
Peroxide pH (pH Ox)	pH Units	-	5.2	5.9	4.5	4.9
TPA as kg H_2SO_4/tonne	kg H2SO4/T	0.25	0.37	<0.25	3.9	0.37
TPA as moles H+/tonne	moles H+/T	5	7	<5	80	7
TPA as S % W/W	%w/w S	0.01	0.01	<0.01	0.13	0.01
Titratable Sulfidic Acidity as moles H+/tonne	moles H+/T	5	<5	<5	12	<5
Titratable Sulfidic Acidity as kg H_2SO_4/tonne	kg H2SO4/T	0.25	<0.25	<0.25	0.61	<0.25
Titratable Sulfidic Acidity as S % W/W	%w/w S	0.01	<0.01	<0.01	0.02	<0.01
ANCE as % $CaCO_3$	% CaCO3	0.01	<0.01	<0.01	<0.01	<0.01
ANCE as moles H+/tonne	moles H+/T	5	<5	<5	<5	<5
ANCE as S % W/W	%w/w S	0.01	<0.01	<0.01	<0.01	<0.01
Peroxide Oxidisable Sulphur (Spos)*	%w/w	0.005	<0.005	<0.005	<0.005	<0.005
Peroxide Oxidisable Sulphur as moles H+/tonne*	moles H+/T	5	<5	<5	<5	<5
Sulphur (Sp)	%w/w	0.005	<0.005	<0.005	0.014	<0.005
Calcium (Cap)	%w/w	0.005	<0.005	<0.005	0.013	0.005
Reacted Calcium (CaA)*	%w/w	0.005	<0.005	<0.005	<0.005	<0.005
Reacted Calcium (CaA)*	moles H+/T	5	<5	<5	<5	<5
Magnesium (Mgp)	%w/w	0.005	<0.005	<0.005	0.024	<0.005
Reacted Magnesium (MgA)*	%w/w	0.005	<0.005	<0.005	<0.005	<0.005
Reacted Magnesium (MgA)*	moles H+/T	5	<5	<5	<5	<5
Net Acid Soluble Sulphur as % w/w*	%w/w	0.005	-	-	<0.005	-
Net Acid Soluble Sulphur as moles H+/tonne*	moles H+/T	5	-	-	<5	-

SPOCAS Net Acidity Calculations [AN220] Tested: 6/6/2024

PARAMETER	UOM	LOR	BH1 (2.5-3.0)_S3 SOIL - 24/5/2024 SE265824.003	BH2 (3.5-4.0)_S4 SOIL - 24/5/2024 SE265824.008	BH3 (2.5-3.0)_S3 SOIL - 24/5/2024 SE265824.011	BH4 (1.5-2.0)_S2 SOIL - 24/5/2024 SE265824.013
s-Net Acidity	%w/w S	0.005	0.016	<0.005	0.20	0.025
a-Net Acidity	moles H+/T	5	10	5	120	16
Liming Rate*	kg CaCO3/T	0.1	NA	NA	9.3	NA
Verification s-Net Acidity*	%w/w S	-20	0.01	0.01	0.09	0.01
a-Net Acidity without ANCE*	moles H+/T	5	5	<5	70	11
Liming Rate without ANCE*	kg CaCO3/T	0.1	NA	<0.1	5.3	NA

Chromium Reducible Sulfur (CRS) [AN217] Tested: 6/6/2024

PARAMETER	UOM	LOR	BH1 (2.5-3.0)_S3 SOIL - 24/5/2024 SE265824.003	BH2 (3.5-4.0)_S4 SOIL - 24/5/2024 SE265824.008	BH3 (2.5-3.0)_S3 SOIL - 24/5/2024 SE265824.011	BH4 (1.5-2.0)_S2 SOIL - 24/5/2024 SE265824.013
Chromium Reducible Sulfur (Scr)	%	0.005	<0.005	<0.005	<0.005	<0.005
Chromium Reducible Sulfur (Scr)	moles H+/T	5	<5	<5	<5	<5

HCl Extractable S, Ca and Mg in Soil/Solids ICP OES [AN014]   Tested: 6/6/2024

			BH3 (2.5-3.0)_S3
			SOIL
			-
			24/5/2024
PARAMETER	UOM	LOR	SE265824.011
Acid Soluble Sulfur (SHCl)	%w/w	0.005	**0.015**

Chromium Suite Net Acidity Calculations [AN220] Tested: 6/6/2024

PARAMETER	UOM	LOR	BH1 (2.5-3.0)_S3 SOIL - 24/5/2024 SE265824.003	BH2 (3.5-4.0)_S4 SOIL - 24/5/2024 SE265824.008	BH3 (2.5-3.0)_S3 SOIL - 24/5/2024 SE265824.011	BH4 (1.5-2.0)_S2 SOIL - 24/5/2024 SE265824.013
s-Net Acidity	%w/w S	0.005	<0.005	<0.005	0.11	0.016
a-Net Acidity	moles H+/T	5	<5	<5	69	10
Liming Rate*	kg CaCO3/T	0.1	<0.1	<0.1	5.2	NA
Verification s-Net Acidity*	%w/w S	-20	0.00	0.00	0.00	0.00
a-Net Acidity without ANCBT*	moles H+/T	5	<5	<5	69	10
Liming Rate without ANCBT*	kg CaCO3/T	0.1	<0.1	<0.1	5.2	NA
s-Net Acidity without ANC	%w/w S	0.005	0.008	<0.005	0.11	0.016

METHOD	METHODOLOGY SUMMARY
AN002	The test is carried out by drying (at either 40°C or 105°C) a known mass of sample in a weighed evaporating basin. After fully dry the sample is re-weighed. Samples such as sludge and sediment having high percentages of moisture will take some time in a drying oven for complete removal of water.
AN014	This method is for the determination of soluble sulfate (SO4-S) by extraction with hydrochloric acid. Sulphides should not react and would normally be expelled. Sulfate as Sulfur is determined by ICP.
AN104	pHF is determined on an extract of approximately 2g of as received sample in approximately 10 mL of deionised water with pH determined after standing 30 minutes.
AN104	pHFox is determined on an extract of approximately 2g of as received sample with a few mLs of 30% hydrogen peroxide (adjusted to pH 4.5 to 5.5) with the extract reaction being rated from slight to extreme, with pH determined after reaction is complete and extract has cooled. Referenced to ASS Laboratory Methods Guidelines, method 23Af-Bf, 2004. 0 No Reaction 1 Slight Reaction 2 Moderate Reaction 3 Strong/High Reaction 4 Extreme/Vigorous Reaction (gas evolution and heat generation)
AN214	Acid Neutralising Capacity (ANC)or Neutralising Value (NV): The crushed or as received sample is reacted with excess normal acid (HCl) and then back titrated with standard sodium hydroxide to determine the acid consumed. The result is expressed as kg H2SO4/tonne or %CaCO3. Based on AS4969-13.
AN217	Dried pulped sample is mixed with acid and chromium metal in a rapid distillation unit to produce hydrogen sulfide (H2S) which is collected and titrated with iodine (I2(aq)) to measure SCR.
AN218	Soil samples are subjected to extreme oxidising conditions using hydrogen peroxide. Continuous application of heat and peroxide ensure all sulfide is converted to sulfuric acid. Excess peroxide is broken down by a copper catalyst prior to titration for acidity. Calcium, magnesium, and sulfur are determined by ICP-OES. Also included is a carbonate modification step which, depending on pH after the initial oxidation, gives a measure of ANC.
AN219	Dried pulped sample is extracted for 4 hours in a 1 M KCl solution. The ratio of sample to solution is 1:40. The extract is titrated for acidity. Calcium, magnesium, and sulfur are determined by ICP-AES.
AN220	Chromium Suite: Scheme for the calculation of net acidities and liming rates using a Fineness Factor of 1.5.

FOOTNOTES

*	NATA accreditation does not cover the performance of this service.	-	Not analysed.	UOM	Unit of Measure.
**	Indicative data, theoretical holding time exceeded.	NVL	Not validated.	LOR	Limit of Reporting.
***	Indicates that both * and ** apply.	IS	Insufficient sample for analysis.	↑↓	Raised/lowered Limit of Reporting.
		LNR	Sample listed, but not received.		

Unless it is reported that sampling has been performed by SGS, the samples have been analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calculated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC and MU criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: www.sgs.com.au/en-gb/environment-health-and-safety.

Appendix C – Important Information

Important Information

SCOPE OF SERVICES

The geotechnical report ("the report") has been prepared in accordance with the scope of services as set out in the contract, or as otherwise agreed, between the Client and NR Engineering Consultants ("NR"). The scope of work may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

RELIANCE ON DATA

NR has relied on data provided by the Client and other individuals and organizations, to prepare the report. Such data may include surveys, analyses, designs, maps and plans. NR has not verified the accuracy or completeness of the data except as stated in the report. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations ("conclusions") are based in whole or part on the data, NR will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to NR.

GEOTECHNICAL ENGINEERING

Geotechnical engineering is based extensively on judgment and opinion. It is far less exact than other engineering disciplines. Geotechnical engineering reports are prepared for a specific client, for a specific project and to meet specific needs, and may not be adequate for other clients or other purposes (e.g. a report prepared for a consulting civil engineer may not be adequate for a construction contractor). The report should not be used for other than its intended purpose without seeking additional geotechnical advice. Also, unless further geotechnical advice is obtained, the report cannot be used where the nature and/or details of the proposed development are changed.

LIMITATIONS OF SITE INVESTIGATION

The investigation programme undertaken is a professional estimate of the scope of investigation required to provide a general profile of subsurface conditions. The data derived from the site investigation programme and subsequent laboratory testing are extrapolated across the site to form an inferred geological model, and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour with regard to the proposed development. Despite investigation, the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies. The engineering logs are the subjective interpretation of subsurface conditions at a particular location and time, made by trained personnel. The actual interface between materials may be more gradual or abrupt than a report indicates.

SUBSURFACE CONDITIONS ARE TIME DEPENDENT

Subsurface conditions can be modified by changing natural forces or man-made influences. The report is based on conditions that existed at the time of subsurface exploration. Construction operations adjacent to the site, and natural events such as floods, or ground water fluctuations, may also affect subsurface conditions, and thus the continuing adequacy of a geotechnical report. NR should be kept appraised of any such events, and should be consulted to determine if any additional tests are necessary.

VERIFICATION OF SITE CONDITIONS

Where ground conditions encountered at the site differ significantly from those anticipated in the report, either due to natural variability of subsurface conditions or construction activities, it is a condition of the report that NR be notified of any variations and be provided with an opportunity to review the recommendations of this report. Recognition of change of soil and rock conditions requires experience and it is recommended that a suitably experienced geotechnical engineer be engaged to visit the site with sufficient frequency to detect if conditions have changed significantly.

REPORTS

This report is the property of NR Engineering Consultants Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal.

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REPORT FOR BENEFIT OF CLIENT

The report has been prepared for the benefit of the Client and no other party. NR assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of NR or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own inquiries and obtain independent advice in relation to such matters.

OTHER LIMITATIONS

NR will not be liable to update or revise the report to take into account any events or emergent circumstances or fact occurring or becoming apparent after the date of the report.