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REPORT ON GEOTECHNICAL SITE INVESTIGATION

for

PROPOSED DEVELOPMENT

at

LONG REEF SURF LIFE SAVING CLUB, COLLAROY

Prepared For

Northern Beaches Council

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GEOTECHNICAL REPORT FOR PROPOSED NEW DEVELOPMENT
LONG REEF SURF LIFE SAVING CLUB, COLLAROY, NSW

1. INTRODUCTION:

This report details the results of a geotechnical investigation (Stage 2: Development Application) carried out for the proposed new development of Long Reef Surf Life Saving Club, Collaroy, NSW. The investigation was undertaken by Crozier Geotechnical Consultants (CGC) at the request of the Adriano Pupilli Architects on behalf of the client Northern Beaches Council.

The site is located adjacent to the rear of the Long Reef Beach frontal dune system and at the base of a slope which rises up towards Collaroy Plateau. The site is currently occupied by single storey building structures which are generally of masonry construction and surrounded by pavements to the south and bushland to the north. The existing building structures show no signs of significant ground movement.

As per review of the draft Coastal Assessment report by Royal Haskoning DHV (Dated: 26th May 2017), the majority of the existing building is within a zone considered to have an óAcceptableô risk level to coastal processes for shallow/conventional footing systems with a small portion at the eastern end within the pile footing zone.

Northern Beaches (Warringah) Councilôs LEP 2011 Section E10 Landslip Risk Map, Sheet LSR_009 indicates that the site is located within Landslip Risk óArea Aô whilst the Acid Sulfate Soils Map, Sheet ASS_009 identifies it as being within óClass 3ô and óClass 5ô Acid Sulfate soils hazard zones. As such any excavation works (i.e. footings) extending below the natural ground surface levels that could intersect acid sulfate soils or result in an impact to the natural water table will require a geotechnical assessment and an Acid Sulfate Management plan. The site is also located within a harsh coastal environment and as such concrete and steel aggressivity may also impact the structure and its footings therefore assessment for design is also considered.

This investigation and report are part of the óRequest for tenderô 2017/075 and are completed as part of Stage 2: Development Application. It comprises an investigation into site conditions for footing design purposes, reporting for submission to Council and to allow preliminary structural engineering design.

This report therefore includes a description of site and sub-surface conditions, a geotechnical assessment of the development, site mapping/plan, geological sections and provides construction recommendations on site classification and footing design.

Previously CGC carried out a geotechnical investigation into subsurface soil conditions at Long Reef Surf Life Saving Clubhouse to assess potential Acid Sulfate Soil conditions (Project No. 2581, Dated: 27th August 2005) and information from that report has also been used for preparing this report.

The investigation and reporting were undertaken as per the Tender: P17 ï 248, Dated: 20th June 2017.

The investigation comprised:

a) Four standard Cone Penetration Test (CPT) holes using a truck mounted test rig to determine the underlying geology.
b) Drilling of two boreholes using a restricted access drill rig along with Dynamic Cone Penetrometer (DCP) testing to investigate the subsurface geology and identification of groundwater conditions.
c) Soil sampling and laboratory testing for Acid Sulfate soils and soil aggressivity to concrete and steel.

The following plans and diagrams were supplied by the Architect for the work:

- Architectural Design by Adriano Pupilli Architects, Project No.: LRSC.01, Drawing No.: 000 to 017 and 020, Revision A, Dated: 3th December 2019;
- Preliminary Structural Concept by Partridge Engineering, Job No.: 201750392, Drawing No.: SK01, SK02.1, SK04 and SK05, Dated: 1st June 2019, SK02.2 and SK03, Dated: 6th June 2018;
- Site Survey Plan by Total Surveying Solutions (TSS), Job no.: 172507, Plan No.: 172507_A, Date of Survey: 14th December 2017.

2. PROPOSED DEVELOPMENT:

It is understood that the existing building/s will be replaced by a modern two storey structure and that a footing system suitable to meet coastal erosion conditions is required. It is expected that bulk excavation will be negligible however pile footings may be required to meet coastal, structural or geotechnical issues.

3. SITE FEATURES:

3.1. Description:

The site is an irregular shaped area located on the low side of the north-east public car park at Long Reef. The land surface generally slopes towards the south-east, with angular side boundary of about 12 metres and north side boundary of 22 metres as referenced from the provided survey plan.

Currently, there is a single storey 1960ôs style brick Club House on the site with public amenities and shop contained within a separate brick structure, as shown below in Photograph 1:

Photograph 1: The existing Cub House on site, view looking east

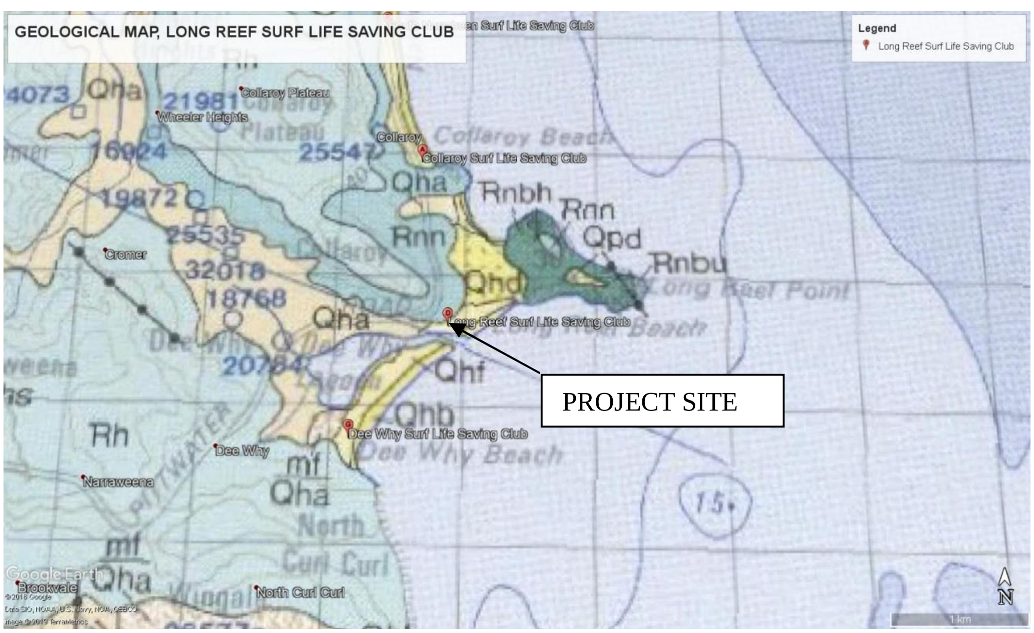
The site is located within 200 m of Dee Why Lagoon and 70 m of Long Reef Beach. It is located at the base of a slope pediment that runs from a south east striking ridge that initiates on Collaroy Plateau. It is at about where colluvial slope wash materials, lagoonal and surf beach sediments accumulate above the incised bedrock. The existing site has an average surface slope angle of -04°/172°mN.

An aerial view of the site is shown below in Photograph 2:

Photograph 2: Aerial view of site, courtesy Google Earth Maps.

3.2. Geology:

Reference to the Sydney 1:100,000 Geological Series Sheet (9130) indicates that the surface of the site is close to the intersection where fine to medium grained Marine sands overlie Quaternary/Holocene sediments (Qha). These Holocene sediments consist of silty to peaty quartz sand, silt and clay that are ferruginous with humic cementation in places, and shell layers are common.



4. FIELD WORK

4.1. Methods:

The field investigation comprised a walk over inspection of the site on the 30^{th} January 2019 by the Principal and Senior Engineering Geologists. It included a photographic record of site conditions and adjacent land with examination of existing structures. It also included drilling of two auger boreholes (BH1 and BH2) using a restricted access drill rig employing solid stem, spiral flight augers and tungsten carbide bit to investigate the sub-surface geology.

Dynamic Cone Penetrometer (DCP) testing was carried out from ground surface adjacent to and through the boreholes, in accordance with AS1289.6.3.3 ï 1997, ñDetermination of the penetration resistance of a soil ï 9kg Perth Sand Penetrometerò to estimate near surface soil conditions.

Standard Cone Penetration Testing (CPT) was carried out on the 5^{th} February 2019 using a 16 tonne truck mounted probe operated by Ground Test Pty Ltd at four locations across the site to investigate the underlying geology. The water table was measured within the test holes following the extraction of the test rods.

Explanatory notes are included in Appendix: 1. Test locations are shown on Figure: 1, a geological model/section is provided as Figure: 2, along with detailed borehole and CPT log sheets and DCP results in Appendix: 2.

4.2. Field Testing:

4.2.1 Boreholes

The results of the boreholes indicate that underlying an up to 0.15m thick layer of concrete, there is a layer of fill up to approximately 1.00m depth over the project site. At the test locations the topsoil/fill generally appeared to be very loose to medium dense and is comprised of fine grained sand with roots. Underlying the topsoil/fill, very loose through very dense, fine grained silty/clayey sands were encountered to a maximum depth of 4.10m (BH2) which overlie silty/sandy clay to the maximum investigated depth of 7.00m below the existing ground surface. The clay encountered was stiff to hard with low to high plasticity.

Significant seepage was encountered at 4.30m (RL 0.29m) and 2.20m (RL 3.02m) depth within BH1 and BH2 respectively.

4.2.2 CPT Testing

CPT testing was carried out within the concrete paved areas to the south and within unpaved areas to the north of the existing club building (see Figure 1).

The testing identified the following profiles:

TEST LOCATION	DEPTH (M)		SOIL TYPE
	FROM	TO	
CPT-1	0.00	0.15	CONCRETE
	0.15	0.40	Medium dense Sand to Silty Sand
	0.40	0.60	Medium dense Sand to Silty Sand
	0.60	0.80	Loose Sand to Silty Sand
	0.80	1.00	Medium dense Sand to Silty Sand
	1.00	1.20	Medium dense Sand to Silty Sand
	1.20	1.40	Medium dense Sand to Silty Sand
	1.40	1.60	Loose Sand to Silty Sand
	1.60	1.80	Loose Sand to Silty Sand
	1.80	2.00	Loose Sand to Silty Sand
	2.00	2.20	Medium dense Sand to Silty Sand
	2.20	2.40	Medium dense Sand to Silty Sand
	2.40	2.60	Medium dense Sand to Silty Sand
	2.60	2.80	Medium dense Sand to Silty Sand
	2.80	3.00	Medium dense Sand to Silty Sand
	3.00	3.20	Medium dense Sand to Silty Sand
	3.20	3.40	Medium dense Sand to Silty Sand
	3.40	3.60	Medium dense Sand to Silty Sand
	3.60	3.80	Medium dense Silty Sand
	3.80	4.00	Loose Sand to Silty Sand
	4.00	4.20	Loose Sand to Silty Sand
	4.20	4.40	Firm Clay
	4.40	4.60	Soft Clay
	4.60	4.80	Soft Clay
	4.80	5.00	Firm Clay
	5.00	5.20	Stiff Clay
	5.20	5.40	Stiff Clay
	5.40	5.60	Stiff Clay
	5.60	5.80	Stiff Clay
	5.80	6.00	Stiff Clay

Groundwater was identified at 2.80m depth below the existing ground level following the removal of the test rods.

TEST LOCATION	DEPTH (M)		SOIL TYPE
	FROM	TO	
CPT-2	0.00	0.15	CONCRETE
	0.15	0.40	Medium dense Sand to Silty Sand
	0.40	0.60	Medium dense Sand to Silty Sand
	0.60	0.80	Loose Sand to Silty Sand
	0.80	1.00	Medium dense Sand to Silty Sand
	1.00	1.20	Medium dense Sand to Silty Sand
	1.20	1.40	Medium dense Sand to Silty Sand
	1.40	1.60	Medium dense Sand to Silty Sand
	1.60	1.80	Medium dense Sand to Silty Sand
	1.80	2.00	Medium dense Sand to Silty Sand
	2.00	2.20	Medium dense Sand to Silty Sand
	2.20	2.40	Medium dense Sand to Silty Sand
	2.40	2.60	Medium dense Sand to Silty Sand
	2.60	2.80	Firm Sandy Silt to Clayey Silt
	2.80	3.00	Stiff Clay
	3.00	3.20	Stiff Clay
	3.20	3.40	Firm Clay
	3.40	3.60	Firm Clay
	3.60	3.80	Loose Silty Sand
	3.80	4.00	Loose Sandy Silt
	4.00	4.20	Loose Sandy Silt
	4.20	4.40	Loose Sandy Silt
	4.40	4.60	Loose Sandy Silt
	4.60	4.80	Loose Sandy Silt
	4.80	5.00	Very Stiff Silty Clay
	5.00	5.20	Very Stiff Silty Clay
	5.20	5.40	Very Stiff Silty Clay
	5.40	5.60	Very Stiff Silty Clay
	5.60	5.80	Very Stiff Silty Clay
	5.80	6.00	Very Stiff Silty Clay
	6.00	6.20	Medium dense Silty Sand to Sandy Silt
	6.20	6.40	Very Stiff Silty Clay
	6.40	6.60	Very Stiff Silty Clay
	6.60	6.80	Very Stiff Silty Clay
	6.80	7.00	Very Stiff Silty Clay

Groundwater was identified at 2.80m depth below the existing ground level following the removal of the test rods.

TEST LOCATION	DEPTH (M)		SOIL TYPE
	FROM	TO	
CPT-3	0.00	0.15	Very loose Sand to Silty Sand
	0.15	0.40	Loose Sand to Silty Sand
	0.40	0.60	Medium dense Sand to Silty Sand
	0.60	0.80	Medium dense Sand to Silty Sand
	0.80	1.00	Medium dense Sand to Silty Sand
	1.00	1.20	Medium dense Sand to Silty Sand
	1.20	1.40	Medium dense Sand to Silty Sand
	1.40	1.60	Medium dense Sand to Silty Sand
	1.60	1.80	Medium dense Sand to Silty Sand
	1.80	2.00	Medium dense Sand to Silty Sand
	2.00	2.20	Medium dense Sand to Silty Sand
	2.20	2.40	Medium dense Sand to Silty Sand
	2.40	2.60	Medium dense Sand to Silty Sand
	2.60	2.80	Medium dense Sand to Silty Sand
	2.80	3.00	Medium dense Sand to Silty Sand
	3.00	3.20	Medium dense Sand to Silty Sand
	3.20	3.40	Medium dense Sand to Silty Sand
	3.40	3.60	Medium dense Sand to Silty Sand
	3.60	3.80	Medium dense Sand to Silty Sand
	3.80	4.00	Medium dense Sand to Silty Sand
	4.00	4.20	Medium dense Sand to Silty Sand
	4.20	4.40	Medium dense Sand to Silty Sand
	4.40	4.60	Medium dense Sand to Silty Sand
	4.60	4.80	Medium dense Sand to Silty Sand
	4.80	5.00	Very stiff Silty Clay
	5.00	5.20	Very stiff Silty Clay
	5.20	5.40	Very stiff Silty Clay
	5.40	5.60	Hard Clay
	5.60	5.80	Hard Clay
	5.80	6.00	Hard Clay
	6.00	6.20	Hard Clay
	6.20	6.40	Hard Clay
	6.40	6.60	Hard Clay
	6.60	6.80	Very stiff Silty Clay
	6.80	7.00	Very stiff Clay

Groundwater was identified at 2.20m depth below the existing ground level following the removal of the test rods.

TEST LOCATION	DEPTH (M)		SOIL TYPE
	FROM	TO	
CPT-4	0.00	0.15	Medium dense Sand to Silty Sand
	0.15	0.40	Medium dense Sand to Silty Sand
	0.40	0.60	Medium dense Sand to Silty Sand
	0.60	0.80	Medium dense Sand to Silty Sand
	0.80	1.00	Medium dense Sand to Silty Sand
	1.00	1.20	Medium dense Sand to Silty Sand
	1.20	1.40	Medium dense Sand to Silty Sand
	1.40	1.60	Medium dense Sand to Silty Sand
	1.60	1.80	Medium dense Sand to Silty Sand
	1.80	2.00	Medium dense Sand to Silty Sand
	2.00	2.20	Medium dense Sand to Silty Sand
	2.20	2.40	Medium dense Sand to Silty Sand
	2.40	2.60	Medium dense Sand to Silty Sand
	2.60	2.80	Medium dense Sand to Silty Sand
	2.80	3.00	Medium dense Sand to Silty Sand
	3.00	3.20	Medium dense Sand to Silty Sand
	3.20	3.40	Medium dense Sand to Silty Sand
	3.40	3.60	Medium dense Sand to Silty Sand
	3.60	3.80	Medium dense Sand to Silty Sand
	3.80	4.00	Medium dense Sand to Silty Sand
	4.00	4.20	Medium dense Sand to Silty Sand
	4.20	4.40	Loose Silty Sand to Sandy Silt
	4.40	4.60	Loose Silty Sand to Sandy Silt
	4.60	4.80	Loose Silty Sand to Sandy Silt
	4.80	5.00	Very stiff Silty Clay
	5.00	5.20	Very stiff Clay
	5.20	5.40	Very stiff Clay
	5.40	5.60	Hard Clay
	5.60	5.80	Hard Clay
	5.80	6.00	Hard Clay

Groundwater was identified at 2.30m depth below the existing ground level following the removal of the test rods.

4.3. Laboratory Testing

4.3.1. Preliminary Acid Sulfate Soils

Of the soil samples collected, representative samples were supplied to a NATA accredited laboratory (Envirolabs) for testing via the pH, pHFOX and sPOCAS methods, based on the recommendations of the Acid Sulfate Soils Laboratory Methods Guidelines, Version: 2.1, June 2004. A summary of the test results are listed in Table: 1 and 2 below:

Table: 1 – pH, pHFOX Test Results

Borehole	Depth (m)	pH $_{field}$	pH $_{oxidised}$
1	0.50	8.1	6.6
1	2.00	8.4	8.3
1	3.90	7.0	4.2
1	5.00	4.6	2.3
1	6.40	5.0	3.5
2	1.50	7.5	7.2
2	3.00	5.9	1.4
2	4.00	5.4	1.8
2	6.00	5.2	3.0
2	7.00	5.7	3.3

A summary of the sPOCAS test results is given Table 2, together with Envirolabôs calculated liming rates for the neutralisation of each sample, based on the use of good quality, fine ag-lime, with a neutralising value of 100% and incorporating a factor of safety of 1.5.

Table: 2 – sPOCAS Test Results

Borehole	Depth (m)	pH	pH (oxidized)	TPA moles H^+ / t	Spos % w / w	Liming Rate kg CaCO3 / t
1	1.00	9.7	7.5	<5	0.005	<0.75
2	2.50	6.5	2.2	**560***	**0.88***	42

* - Results in **Bold** exceed the Acid Sulfate Soils Advisory committee (ASSMAC) Action Criteria for disturbance of <1000 tonnes of soil (refer Section 4.2)

4.3.2. Soil Aggressivity

Three samples were tested to investigate aggressivity of the soils below the site to provide durability classification for concrete structures and steel as per AS2159. The reported results are summarised in Table 3.

Table 3: Summary of Reported Chemical Analysis

Sample Location	pH	Electrical Conductivity (µS/cm)	Resistivity (ohm/m)	Chloride, (mg/kg)	Sulfate, SO4 (mg/kg)
BH1, 1.10m	8.0	96	100	20	<10
BH1, 4.10m	4.9	110	94	10	120
BH2, 6.00m	5.9	73	140	35	25

Detailed soil chemical analyses sheets are provided in Appendix: 3

5. COMMENTS:

5.1. Geotechnical Assessment:

The CPT testing and boreholes identified the presence of sandy fill (potentially disturbed natural sands) up to 1.00m depth over the project site. The presence of the disturbed/loose zones could be attributed to natural depositional variation or post placement disturbance. It is expected that there has been some potential disturbance of the near surface soils in at least parts of the site over the last 40 ï 50 years since the existing building. However, that would be very limited below the existing pavements and building itself, therefore it is likely that the sandy soils/fill below the existing building is generally in the more dense state. Underlying the fill/disturbed zone, natural soils comprising medium dense to very dense (with inter-bedded layers of very loose to loose) silty sand with occasional clayey sand were encountered which overlie stiff to hard silty/sandy clay soils to the maximum investigated depth of 7.00m below the existing ground surface.

The fill/disturbed natural sands encountered at the test locations appeared of variable densities ranging from very loose to very dense and it is not known whether the existing fill material at the site is ćcontrolledô (i.e. it is not known whether the fill has been placed and uniformly compacted to an appropriate engineering specification). If the existing fill is required to support on-ground slabs, supporting documentation should be obtained and checked to confirm that the fill has been placed in a controlled manner to a specification that is appropriate for the proposed development. If documentation does not exist (or the specification used for filling is not appropriate for the proposed development) then it is suggested that the existing fill be assumed to be uncontrolled.

If the fill cannot be shown to be controlled, then consideration should be given to the potential for adverse variation to exist in both the composition and degree of compaction of the fill.

To minimise the risk of potentially adverse settlement occurring, it is recommended that all uncontrolled fill present in settlement sensitive areas be either removed and replaced/re-compacted with controlled granular fill <u>or</u> the structure should be supported on footings extending through the fill and founding in suitable materials. Preliminary geotechnical parameters for a range of footing types are provided in Section 5.4.2.

Depending on proposed loadings a raft slab may be suitable providing any fill/loose soils achieve an appropriate engineering specification. Parameters for fill compaction and recommendations for compaction methodology are provided in Sections 5.4.2.1 and 5.4.2.2.

Bored piers, shallow strip or pad footings extending through the fill would also be suitable and preliminary geotechnical design parameters are provided in Section 5.4.2.

The laboratory test results indicate that Actual or Potential Acid Sulfate Soils (PASS) are not present within the marine sands to approximately 2.50m depth however Potential Acid Sulfate Soils exist below 2.50m depth. Therefore an Acid Sulfate Soils Management Plan (ASSMP) will need to be in place to appropriately treat excavated material from below 2.50m depth, prior to removal. A detailed management plan is required if disturbing > 1000 tonnes of ASS (oxidisable S Ó0.03%S or equivalent TPA or TAA)ô, (Table 4.5, Acid Sulfate Soil Manual).

The recommendations and conclusions in this report are based on the results of boreholes/CPTôs from small isolated test points across the entire site, therefore some minor variation to the interpreted sub-surface conditions is possible, especially between and below test locations. However the results of the investigation provide a reasonable basis for the analysis and subsequent design of the proposed works.

5.2. Acid Sulfate Soils (ASS):

5.2.1 Assessment Criteria of Acid Sulfate Soils:

Acid Sulfate Soils in NSW are assessed in accordance with the ASSMAC Guidelines which provide action criteria for assessing the results of laboratory testing quantifying the acid producing effects based on the sum of existing plus potential acidity. These action criteria are presented in Table 5-1.

Table 5-1: Action Criteria Based on ASS Analysis for Three Broad Texture Categories

Type of Material		Action Criteria (1 – 1000 tonnes disturbed)		Action Criteria (> 1000 tonnes disturbed)	
Texture Range	**Approximate Clay Content (%)**	**Sulfur trail %S oxidisable**	**Acid Trail Mol H^+/tonne**	**Sulfur trail %S oxidisable**	**Acid Trail Mol H^+/tonne**
Coarse Texture Sands to loamy sands	<5	0.03	18	0.03	18
Medium Texture Sandy loams to light clays	5-40	0.06	36	0.03	18
Fine Texture Medium to heavy clays, silty clays	>40	0.1	62	0.03	18

It is anticipated that the volume of natural soil to be disturbed during site development works will not exceed 1,000 tonnes, thus the *<1,000 tonnes disturbed Action Criteria* for the relevant soil types from Table 2 has been used as the basis for assessment of the presence of ASS requiring treatment.

5.2.2 Acid Sulfate Soil Assessment:

Several samples subjected to pH and pH_{fox} tests returned positive results whilst the sample collected from 2.50m depth and subjected to sPOCAS testing returned potential net acidity values that exceed the Action Criteria. Therefore, the soil horizons below approximately 2.50m depth are considered to be ASS and will require management and treatment to neutralise the net acidity if excavated.

The highest required liming rate to ‘neutralise’ the acid generating capacity of the one ASS sample was calculated to be 42kg agricultural lime (ag-lime)/dry tonne of soil. However, soils with a higher required liming percentage may exist at the site and additional testing from additional bores should be considered. As this horizon was not identified in other test location, further investigation is recommended to define its spatial limits across the site should excavation below 2.50m depth be proposed.

Liming rates are calculated and reported on a dry weight basis assuming use of fine ag-lime ($CaCO_3$) with a neutralising value of 100% and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime.

If ASS are unable to be separated from non ASS and their locations cannot be effectively (and auditably) tracked as part of excavation works, all excavated soils should be combined and treated to neutralise the ASS potential.

Due to the presence of ASS on the site and as a general precaution, all groundwater collected during earthworks should be immediately checked for pH prior to off-site discharge; if the pH is outside the range 6.5pH to 8.5pH units, it should be treated to bring it within this range, prior to discharge.

5.3. Soil Aggressivity Assessment:

The results of the soil chemical testing undertaken on the soil samples were compared against the Australian Standard AS 2159 – 2009 Pile Design and Installation. Soil Condition B was considered suitable for the tested soils.

The results were compared against Table 6.4.2 (C) Exposure Classification for Concrete Piles – Piles in Soil. The results suggest that the site soils are ‘non-aggressive to mild’ to concrete from Sulfate, pH and Chlorides.

The results were also compared against Table 6.5.2 (C) Exposure Classification for Steel Piles – Piles in Soil. The results indicate that the soil is ‘non-aggressive’ to steel with regards to resistivity, pH and Chlorides.

5.4. Design & Construction Recommendations:

5.4.1 Earthworks:

5.4.1.1 Fill:

Any fill that is used to support structure loads/on ground slabs etc should be controlled i.e. placed in layers not exceeding 250mm loose thickness and uniformly compacted to an appropriate engineering specification. It is suggested that a minimum dry density ratio of 100% (Standard) be adopted underlying the building.

Consideration could also be given to proof rolling and the placement of a coarse crushed layer of rock to provide a sufficient base to compact óoffô. It is suggested that a non-vibratory roller of at least 8 tonne be utilized if fill compaction is undertaken. This would also assist with site trafficability prior to earthworks.

Geotechnical testing as set out in Section 8 of Australian Standard AS3798 ï 2007 *Guidelines on Earthworks for commercial and residential developments* would be required to achieve adequate control of fill placement for engineered footing design and construction. It is recommended that earthworks in settlement sensitive areas be placed under óLevel 1ô geotechnical supervision/testing.

5.4.1.2 Excavation:

Any excavation required can be carried out by using conventional equipment (excavator with bucket). It is considered that the near surface sands (both fill and natural) have the potential for short term instability and if personnel entry into any confined excavation is envisaged they should be battered back at no steeper than 1.50 (H):1.00(V) or fully supported to maintain personnel safety.

5.4.2 New Footings:

The design of the building footings will depend on whether the Surf Club structure lies within either the ñZone of Reduced Foundation Capacity or the Stable Foundation Zoneò as determined by Coastal Engineers.

The results of the investigation indicate that the site is underlain by fill (or disturbed natural sands) to a depth of approximately 1.00m underlain in turn by inter-bedded very loose to very dense silty/clayey sand which overlie predominately stiff to hard silty/sandy clay to the maximum investigated depth of 7.00m. Design parameters for various footing types are provided in Table 5-2 to Table 5-4. It is recommended that individual footings bear on similar strength materials to reduce the potential for excessive differential settlement. All footing excavations should be dry and free of any loose material immediately prior to pouring of concrete.

The installation of all footings must be inspected by an experienced geotechnical professional before concrete or steel are placed to verify their bearing capacity and the in-situ nature of the founding strata. Inspection of bored piles must also occur for confirmation of expected ground conditions. These inspections are mandatory to allow footings to be ócertifiedô at the end of the project.

5.4.2.1 Shallow Footings:

Design for strip and pad footings or stiffening beams for a stiffened raft could be based on the maximum bearing pressures provided below. These values are considered to result in elastic settlement of Ò25mm.

Table 5-2: Maximum Working Bearing Pressures for Shallow Footings

Material	Strength	Maximum Allowable Working Bearing Pressure (kPa)
Controlled Fill	Level 1 Supervision	100
Silty/Clayey Sand	Very Loose to Loose	Not recommended
	Medium Dense	150
	Dense	250
	Very Dense	300
Sandy/Silty Clay	Firm	50
	Stiff	100
	Very Stiff	200

Due to the presence of fill underlying the site it is considered a Class óPô site as per the Australian Standard for Residential Slabs and Footings AS2870 ï 2011.

For shallow footings in sandy soils, watering of the sandy soils followed by compaction of the soils near surface via a light (<2t) compaction roller could be employed to increase near surface soil densities. For greater depth of compaction, larger rollers will be required however these will need to be rubber tyred/tracked and will likely require the placement of a trafficking layer. The use of any vibratory system will need to consider the existing structures and service lines on site prior to its use. Any compaction works should be undertaken as per recommendations of the earthworks Australian Standards *AS 3798-2007*. Compaction should be carried out under the supervision of a geotechnical engineer and may require testing of the ground to confirm compaction. Following preparation of the sub-grade the sandy soils should be sealed (i.e. cementitious capping or plastic) to maintain moisture contents and densities.

5.4.2.2 Raft Slab:

For assessment of raft slab performance the parameters presented in the table may be adopted based on the results on the bores/DCPôs/CPTôs and published correlations.

Table 5-3: Soil Settlement Modulus for Raft Design

Material	Strength	Settlement Modulus ï E (MPa)	Poissons Ratio
Controlled Fill	Level 1 Supervision	8-20	0.25
Silty/Clayey Sand	Loose	1-3 (Not recommended, vibration sensitive)	
	Medium Dense	20-30	
	Dense	30-50	
	Very Dense	50-90	
Silty/Sandy Clay	Firm	5-10	
	Stiff	10-20	
	Very Stiff/Hard	20-40	

If a raft slab is adopted it would be necessary to excavate and re-compact the existing granular fill and any loose sands encountered (e.g. BH2, 1.00m ï 2.20m) using an appropriate engineering specification (See Section 5.4.1.1). A plate compactor or similar could be used for compaction of soils under the raft ribs. If vibratory compaction is adopted, very strict vibration controls will need to be implemented and on-going monitoring would be required to reduce the potential for settlement of the existing structures within the adjacent car park.

5.4.2.3 Bored Piles

Should bored pile footings be adopted for the proposed development the maximum allowable bearing pressures are provided in Table 5-4:

Table 5-4: Working Shaft Adhesion/End Bearing for Pile Design

Material	Strength	Maximum Allowable Bearing Pressure (kPa) +	
		Shaft Adhesion	End Bearing
Silty/Clayey Sand	Loose	Not recommended	Not recommended
	Medium Dense	10	150
	Dense	20	300
	Very Dense	30	450
Silty/Sandy Clay	Stiff	10	150
	Very Stiff	15	200
	Hard	20	300

+ Not underlain by ósofterô material.

If a bored pile footing system is adopted care will have to be taken in design to ensure that the loose sands encountered at ódepthô do not fall within the zone of influence below the base of the piles, which may result in excessive settlement. The inter-bedded layers of loose sands encountered below the disturbed zone (top 1.00m section below ground surface) at various test locations are detailed below:

- CPT1 ï from 1.40m to 2.00m and from 3.80m to 4.20m depth,
- CPT2 ï from 3.60m to 4.80m depth,
- CPT4 ï from 4.20m to 4.80m depth.

Attention is drawn to the likelihood for instability/caving within the water charged sands underlying the site which may require the use of caissons/liners and tremmie placed concrete which should be allowed for in project costing/timetable etc. Alternatively, continuous flight auger (CFA) piles could be considered.

Due to the presence of loose sand layers and soft/firm clay soils layers within the zone extending to 5.00m depth below the existing ground surface, to reduce potential for variable/differential settlement it is recommended that the bored piles should be founded below 5.00m depth, to be founded within stiff to very stiff clay.

For bored pile footings founded at 5.00m depth in stiff to very stiff clay an ultimate, unfactored end bearing pressure ($R_{d,ug}$) of 1800kPa is recommended. Ultimate side friction through the overlying medium dense silty sand is estimated at 10kPa. A geotechnical strength reduction factor ($\wedge_{g}$) of 0.50 (AS2159 ï 2009) is considered appropriate based on the expected design and construction detail to limit settlement to approximately 2% of the pile diameter. Should this footing option be chosen a CFA/grout injected method will be required to maintain the integrity of the pile and foundation below the water table.

5.4.3 Surface Water Drainage

Site earthworks will need to be properly drained so that water does not cause additional wetting up and softening of sub-grade soils. All collected stormwater should be discharged to the Councilôs stormwater system off site. The requirement to adopt groundwater dewatering systems is not anticipated unless bulk excavation below approximately 2.50m depth is envisaged. Trafficking wet sub-grades (without a trafficability layer) with any plant would be expected to result in significant sub-grade damage.

5.4.4 Earthquake Site Factor

With reference to Australian Standard AS1170.4 ï 2007 *Structural design actions, Part 4: Earthquake actions in Australia*, it is considered that the following may be adopted for the site:

- Hazard Factor (Z): 0.08
- Class Definition: The site is assessed as a sub-soil Class C_e, Shallow Soil site.

6. CONCLUSION:

The investigation identified the presence of sandy fill (potentially disturbed natural sands) to approximately 1.00m depth over the project site which could be attributed to post placement disturbance. It is anticipated that the disturbance would not have occurred below the existing building itself so it is likely that the sandy soils/fill below the existing building is generally in the more dense state. Underlying the fill, very loose to very dense silty/clayey sand were encountered which overlie stiff to hard silty/sandy clay soils to the maximum investigated depth of 7.00m below the existing ground surface.

Various footing types are feasible including raft, strip, pad or bored piers however the disturbed sandy soil encountered underlying the site is not considered a suitable founding material due the potential for variation in consistency. The disturbed natural sand should either be proof rolled compacted or footings should extend through the fill/disturbed layer and bear on natural soils or bedrock. Regardless of footing selection, care will have to be taken in selection of design bearing pressure parameters where óweakerô soils underlie or have the potential to underlie óstrongerô soils and a conservative approach should be considered.

Should a raft or ground bearing slab be adopted the existing disturbed sand soils would require removal or re-compacting to an appropriate engineering specification. Care would need to be taken during fill compaction to ensure any vibratory machinery does not induce settlement of any existing footing in the vicinity.

The water table is likely be intersected within 2.50m depth of the surface (with possible shallower seepages) therefore any footing excavation below 2.50m depth may be impacted by groundwater ingress and loosening of sub-grade soils, potentially reducing the bearing pressures and increasing settlements.

The laboratory test results indicate that Actual or Potential Acid Sulfate Soils (PASS) are not present within the marine sands to approximately 2.50m depth. However Potential Acid Sulfate Soils exist below 2.50m depth and a management plan will be required if excavation for bulk levels or footings is proposed below this level.

For design of concrete and steel for soil aggressivity, based on the results of the laboratory testing the site would be classified as ôNon-aggressive to Mildô for concrete piles, as per Table: 6.4.2 (C) under and as ôNon-aggressiveô for steel piles, as per Table 6.5.2 (C), Australian Standard for Piling ï Design and Installation AS2159 ï 2009.

Prepared by:	Reviewed by:
Shahzada Rizvi	Troy Crozier
Senior Engineering Geologist	Principal
	MAIG. RPGeo-Geotechnical & Engineering
	Registration No.: 10197

7. REFERENCES:

1. Pells et. al. Design loadings for foundations on shale and sandstone in the Sydney region. Australian Geomechanics Society Journal, 1978.
2. Australian Standard AS 3798 ï 2007, Guidelines on Earthworks for Commercial and Residential Developments.
3. Australian Standard AS2870 ï 1996, Residential Slabs and Footings ï Construction.
4. Australian Standard for Piling AS 2159 ï 2009, Design and Installation
5. Australian Standard AS1170.4 ï 2007 *Structural design actions, Part 4: Earthquake actions in Australia.*
6. Acid Sulphate Soils Assessment Guidelines, August 1998, by The Acid Sulfate Soils Management Advisory Committee, NSW.

Appendix 1

CROZIER GEOTECHNICAL CONSULTANTS

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Brookvale NSW 2100 Email: info@croziergeotech.com.au
Crozier Geotechnical Consultants, a division of PJC Geo-Engineering Pty Ltd

NOTES RELATING TO THIS REPORT

Introduction

These notes have been provided to amplify the geotechnical report in regard to classification methods, specialist field procedures and certain matters relating to the Discussion and Comments section. Not all, of course, are necessarily relevant to all reports.

Geotechnical reports are based on information gained from limited subsurface test boring and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Description and classification Methods

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

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (eg. Sandy clay) on the following bases:

Soil Classification	Particle Size
Clay	less than 0.002 mm
Silt	0.002 to 0.06 mm
Sand	0.06 to 2.00 mm
Gravel	2.00 to 60.00mm

Cohesive soils are classified on the basis of strength either by laboratory testing or engineering examination.
The strength terms are defined as follows:

Classification	Undrained Shear Strength kPa
Very soft	Less than 12
Soft	12 - 25
Firm	25 – 50
Stiff	50 – 100
Very stiff	100 - 200
Hard	Greater than 200

Non-cohesive soils are classified on the basis of relative density, generally from the results of standard penetration tests (SPT) or Dutch cone penetrometer tests (CPT) as below:

Relative Density	SPT “N” Value (blows/300mm)	CPT Cone Value (Qc – MPa)
Very loose	less than 5	less than 2
Loose	5 – 10	2 – 5
Medium dense	10 – 30	5 -15
Dense	30 – 50	15 – 25
Very dense	greater than 50	greater than 25

Rock types are classified by their geological names. Where relevant, further information regarding rock classification is given on the following sheet.

Sampling

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

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

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

Drilling Methods

The following is a brief summary of drilling methods currently adopted by the company and some comments on their use and application.

Test Pits – these are excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils if it is safe to descent into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (eg. Pengo) – the hole is advanced by a rotating plate or short spiral auger, generally 300mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube sampling.

Continuous Sample Drilling – the hole is advanced by pushing a 100mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling soils, since moisture content is unchanged and soil structure, strength, etc. is only marginally affected.

Continuous Spiral Flight Augers – the hole is advanced using 90 – 115mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPT's or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling - the hole is advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from 'feel' and rate of penetration.

Rotary Mud Drilling – similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (eg. From SPT).

Continuous Core Drilling – a continuous core sample is obtained using a diamond-tipped core barrel, usually 50mm internal diameter. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

Standard Penetration Tests

Standard penetration tests (abbreviated as SPT) are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample. The test procedures is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" – Test 6.3.1.

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

The test results are reported in the following form.

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

The results of the test can be related empirically to the engineering properties of the soil. Occasionally, the test method is used to obtain samples in 50mm diameter thin wall sample tubes in clay. In such circumstances, the test results are shown on the borelogs in brackets.

Cone Penetrometer Testing and Interpretation

Cone penetrometer testing (sometimes referred to as Dutch Cone – abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in Australia Standard 1289, Test 6.4.1.

In tests, a 35mm diameter rod with a cone-tipped end is pushed continually into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the friction resistance on a separte 130mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected buy electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) their information is plotted on a computer screen and at the end of the test is stored on the computer for later plotting of the results.

The information provided on the plotted results comprises: -

- Cone resistance – the actual end bearing force divided by the cross-sectional area of the cone – expressed in MPa.
- Sleeve friction – the frictional force on the sleeve divided by the surface area – expressed in kPa.
- Friction ratio - the ratio of sleeve friction to cone resistance, expressed in percent.

There are two scales available for measurement of cone resistance. The lower scale (0 – 5 MPa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main scale (0 – 50 MPa) is less sensitive and is shown as a full line. The ratios of the sleeve friction to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios 1% - 2% are commonly encountered in sands and very soft clays rising to 4% - 10% in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range: -

Q_c (MPa) = (0.4 to 0.6) N blows (blows per 300mm)

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range: -

Q_c = (12 to 18) C_u

Interpretation of CPT values can also be made to allow estimation of modulus or compressibility values to allow calculations of foundation settlements.

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes, etc. This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on soil classification is required, direct drilling and sampling may be preferable.

Dynamic Penetrometers

Dynamic penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150mm increments of penetration. Normally, there is a depth limitation of 1.2m but this may be extended in certain conditions by the use of extension rods.

Two relatively similar tests are used.

- Perth sand penetrometer – a 16mm diameter flattened rod is driven with a 9kg hammer, dropping 600mm (AS1289, Test 6.3.3). The test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
- Cone penetrometer (sometimes known as Scala Penetrometer) – a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS 1289, Test 6.3.2). The test was developed initially for pavement sub-grade investigations, and published correlations of the test results with California bearing ratio have been published by various Road Authorities.

Laboratory Testing

Laboratory testing is generally carried out in accordance with Australian Standard 1289 "Methods of Testing Soil for Engineering Purposes". Details of the test procedure used are given on the individual report forms.

Borehole Logs

The bore logs presented herein are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable, or possible to justify on economic grounds. In any case, the boreholes represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes, the frequency of sampling and the possibility of other than 'straight line' variations between the boreholes.

Details of the type and method of sampling are given in the report and the following sample codes are on the borehole logs where applicable:

D	Disturbed Sample	E	Environmental sample	DT	Diatube
B	Bulk Sample	PP	Pocket Penetrometer Test		
U50	50mm Undisturbed Tube Sample	SPT	Standard Penetration Test		
U63	63mm " " " " "	C	Core		

Ground Water

Where ground water levels are measured in boreholes there are several potential problems:

- In low permeability soils, ground water although present, may enter the hole slowly or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report.
- The use of water or mud as a drilling fluid will mask any ground water inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water observations are to be made. More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be interference from a perched water table.

Engineering Reports

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg. A three-storey building), the information and interpretation may not be relevant if the design proposal is changed (eg. to a twenty-storey building). If this happens, the Company will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface condition, discussion of geotechnical aspects and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- unexpected variations in ground conditions – the potential for this will depend partly on bore spacing and sampling frequency,
- changes in policy or interpretation of policy by statutory authorities,
- the actions of contractors responding to commercial pressures,

If these occur, the Company will be pleased to assist with investigation or advice to resolve the matter.

Site Anomalies

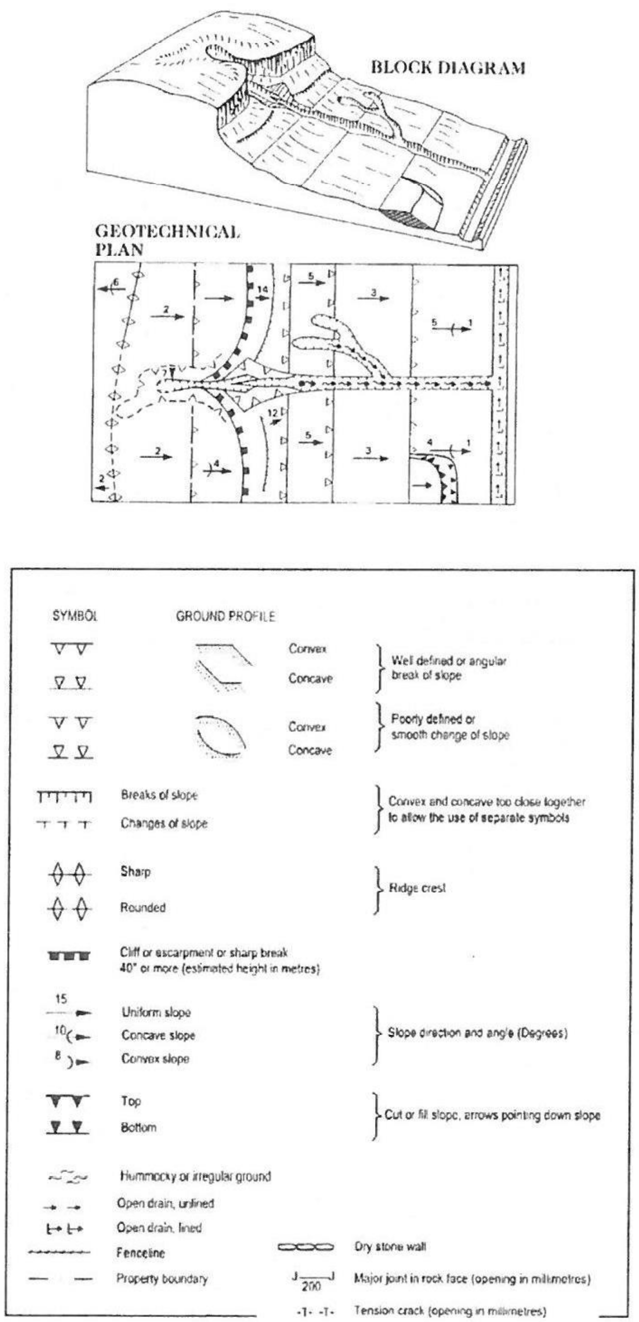
In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the Company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed than at some later stage, well after the event.

Reproduction of Information for Contractual Purposes

Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Tender Documents", published by the Institution of Engineers Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a special ally edited document. The Company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

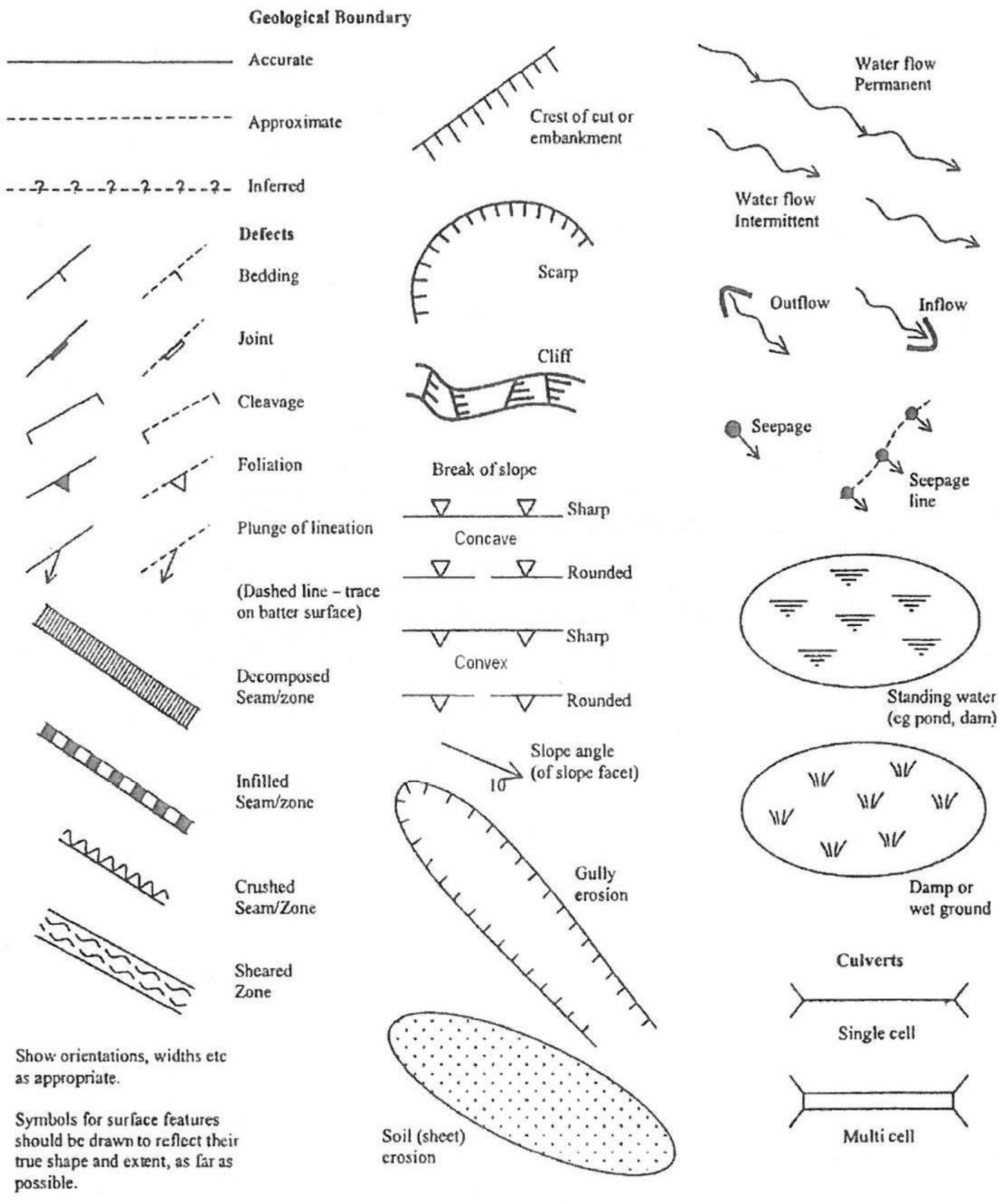
Site Inspection

The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.



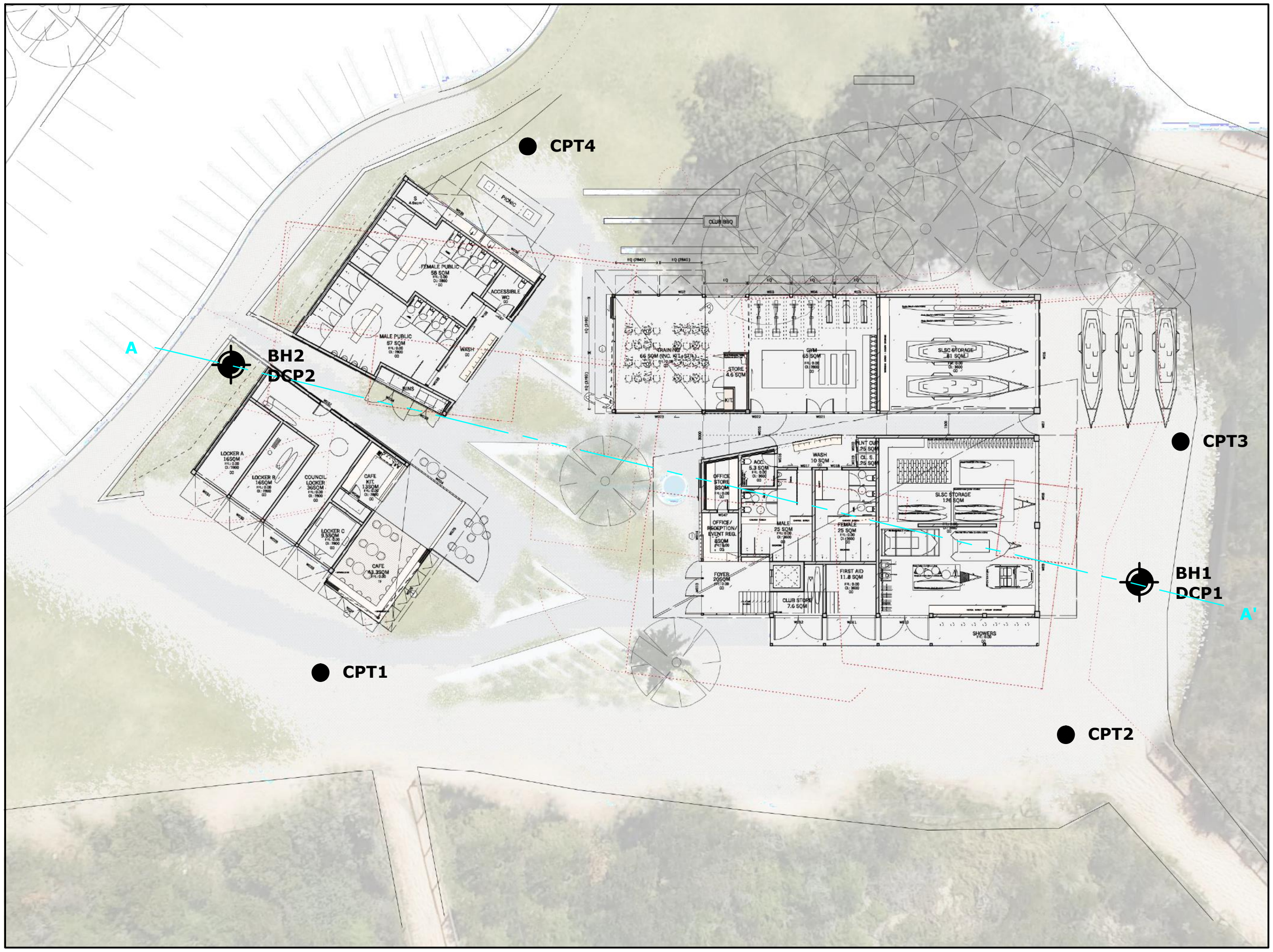
Example of Mapping Symbols
(after V Gardiner & R V Dackombe (1983).Geomorphological Field Manual. George Allen & Unwin).

APPENDIX E - GEOLOGICAL AND GEOMORPHOLOGICAL MAPPING SYMBOLS AND TERMINOLOGY



Examples of Mapping Symbols (after Guide to Slope Risk Analysis Version 3.1 November 2001, Roads and Traffic Authority of New South Wales).

Appendix 2



SITE PLAN & TEST LOCATIONS FIGURE 1.

CROZIER
GEOTECHNICAL CONSULTANTS

Crozier Geotechnical
Unit 12, 42-46 Wattle Road
Brookvale NSW 2100
ABN: 96 113 453 624
Phone: (02) 9939 1882
Fax: (02) 9939 1883
Crozier Geotechnical is a division of PJC Geo-Engineering Pty Ltd

LEGEND

● CPT — CPT TEST LOCATION

BH DCP — AUGER / DYNAMIC CONE PENETROMETER LOCATION

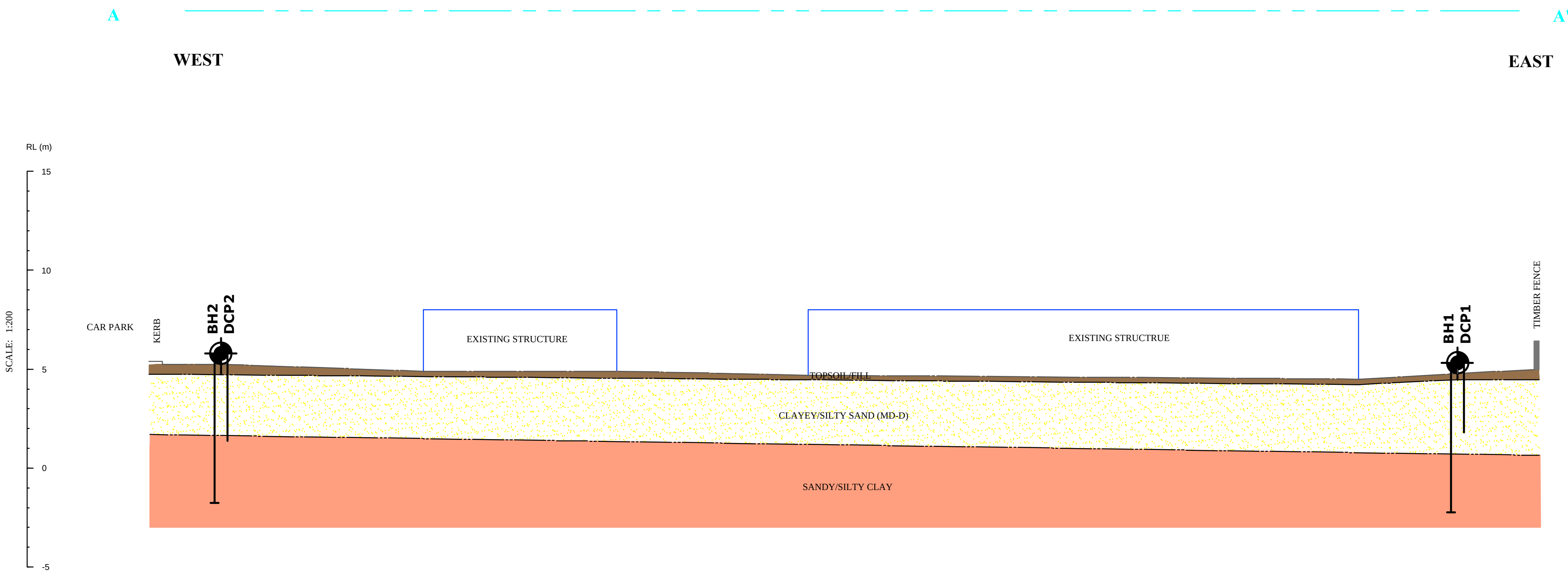
SCALE:	NOT TO SCALE
DRAWING:	FIGURE 1.
DATE:	08/02/2019
APPROVED BY:	TMC
DRAWN BY:	JY
PROJECT:	2017-235

PREPARED FOR:

Northern Beaches Council

ADDRESS:

Long Reef Surf Life Saving Club



0 1 2 3 4 5 6 7 8 9 10

SCALE: 1:200

VL - Very Loose	VS - Very Soft	ELS - Extremely Low Strength	EW - Extremely Weathered	fg - Fine Grained
L - Loose	S - Soft	VLS - Very Low Strength	HW - Highly Weathered	mg - Medium Grained
MD - Medium Dense	F - Firm	LS - Low Strength	DW - Distinctly Weathered	cg - Coarse Grained
D - Dense	St - Stiff	MS - Medium Strength	MW - Moderately Weathered	MAS - Massive
VD - Very Dense	VSt - Very Stiff	HS - High Strength	SW - Slightly Weathered	BD - Bedded
	H - Hard	VHS - Very High Strength	FR - Fresh	OC - Outcrop

NB. FOR LOCATION OF SECTION A-A', PLEASE REFER TO FIGURE 1. SITE PLAN AND TEST LOCATIONS

GEOLOGICAL MODEL FIGURE 2.

CROZIER GEOTECHNICAL CONSULTANTS

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LEGEND

- A — A' CROSS-SECTION REFERENCE LINE
- BH DCP AUGER / DYNAMIC CONE PENETROMETER LOCATION
- CLAYEY/SILTY SAND
- SOIL/FILL
- SANDY/SILTY CLAY

SCALE: 1:200
DRAWING: FIGURE 2.
DATE: 08/02/2019

APPROVED BY: TMC
DRAWN BY: JY
PROJECT: 2017-235

PREPARED FOR:
Northern Beaches Council

ADDRESS:
Long Reef Surf Life Saving Club

TEST BORE REPORT

CLIENT: Northern Beaches Council **DATE:** 30/01/2019 **BORE No.:** 1

PROJECT: Proposed New Development **PROJECT No.:** 2017-235 **SHEET:** 1 of 2

LOCATION: Long Reef Surf Life Saving Club **SURFACE LEVEL:** RL 4.59m

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)	Laboratory Testing Type	Results	
0.00	TOPSOIL/FILL: Loose to medium dense, black, fine grained moist sand with roots					
0.30	SAND: Medium Dense, pale orange, fine grained, moist sand *0.45m depth grading dense to very dense	D	0.50	ASS	pH_F pH_{FOX}	8.1 6.6
1.00		D	1.00			
1.10		D	1.10			
	Clayey SAND: Dense, black, fine grained, moist clayey sand with shell fragments	D	1.10 - 1.20	Aggressivity	pH Cl SO4	8.0 20ppm <10ppm
1.70	SAND: Medium dense to dense, white/pale grey, fine grained, moist sand	D	1.80 - 1.90			
2.00	* 2.10m depth: becoming pale grey	D	2.00	ASS	pH_F pH_{FOX}	8.4 8.3
3.00						
		D	3.40 - 3.50			
		D	3.90 - 4.00			
4.00				ASS	pH_F pH_{FOX}	7.0 4.2
4.10	Sandy CLAY: red / orange / pale grey, medium to high plasticity, moist sandy clay *4.30m depth: Ground water encountered	D	4.10 - 4.20	Aggressivity	pH Cl SO4	4.9 10ppm 120ppm
5.00						

RIG: Dingo Restricted Access Rig DRILLER: AC LOGGED: TJ

METHOD: Solid stem, spiral flight augers with tungsten carbide bit

GROUND WATER OBSERVATIONS: 4.30m depth

REMARKS:

CHECKED:

TEST BORE REPORT

CLIENT: Northern Beaches Council **DATE:** 30/01/2019 **BORE No.:** 1

PROJECT: Proposed New Development **PROJECT No.:** 2017-235 **SHEET:** 2 of 2

LOCATION: Long Reef Surf Life Saving Club **SURFACE LEVEL:** RL 4.59m

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)	Laboratory Testing Type	Results	
5.00		D	5.00	ASS	pH_F pH_{FOX}	4.6 2.3
	* 5.50m depth: Sandy Clay becoming red	D	5.50 - 5.60			
6.00		D	6.00 - 6.10			
	* 6.50m depth: becoming white / pale grey	D	6.40 - 6.50	ASS	pH_F pH_{FOX}	5.0 3.5
7.00		D	6.90 - 7.00			
	Drilling discontinued at 7.00m depth in Sandy Clay					
8.00						
9.00						
10.00						

RIG: Dingo Restricted Access Rig DRILLER: AC LOGGED: TJ

METHOD: Solid stem, spiral flight augers with tungsten carbide bit

GROUND WATER OBSERVATIONS: 4.30m depth

REMARKS: CHECKED:

TEST BORE REPORT

CLIENT: Northern Beaches Council **DATE:** 30/01/2019 **BORE No.:** 2

PROJECT: Proposed New Development **PROJECT No.:** 2017-235 **SHEET:** 1 of 2

LOCATION: Long Reef Surf Life Saving Club **SURFACE LEVEL:** RL 5.22m

Depth (m)		Description of Strata PRIMARY SOIL - strength/density, colour, grainsize/plasticity, moisture, soil type incl. secondary constituents, other remarks	Sampling		Laboratory Testing		
			Type	Depth (m)	Type	Results	
0.00		TOPSOIL/FILL: Very loose to medium dense, brown/pale grey, fine grained, dry sand with roots and gravel					
	0.50	SAND: Dense, orange, fine grained, moist sand with gravel					
1.00		*1.00m depth grading to very loose to medium dense					
			D	1.50	ASS	pH_F pH_{FOX}	7.5 7.2
2.00			D	2.00 - 2.10			
	2.20	Clayey/Silty SAND: Medium dense, black, fine grained, wet clayey/silty sand	D	2.20 - 2.30			
		* 2.30m depth: Groundwater Observed	D	2.50			
3.00			D	3.00 - 3.10	ASS	pH_F pH_{FOX}	5.9 1.4
	3.60	Silty CLAY: Hard, black, low to medium plasticity, wet, silty clay					
4.00							
	4.10	CLAY: Pale grey, medium to high plasticity, wet, Clay	D	4.00 - 4.10	ASS	pH_F pH_{FOX}	5.4 1.8
5.00							

RIG: Dingo Restricted Access Rig DRILLER: AC LOGGED: TJ

METHOD: Solid stem, spiral flight augers with tungsten carbide bit

GROUND WATER OBSERVATIONS: 2.30m

REMARKS: CHECKED:

TEST BORE REPORT

CLIENT: Northern Beaches Council **DATE:** 30/01/2019 **BORE No.:** 2

PROJECT: Proposed New Development **PROJECT No.:** 2017-235 **SHEET:** 2 of 2

LOCATION: Long Reef Surf Life Saving Club **SURFACE LEVEL:** RL 5.22m

Depth (m)	Description of Strata PRIMARY SOIL - strength/density, colour, grainsize/plasticity, moisture, soil type incl. secondary constituents, other remarks	Sampling		Laboratory Testing		
		Type	Depth (m)	Type	Results	
5.00						
	*5.20m depth: Clay becoming yellow	D	5.00 - 5.10			
6.00		D	6.00	ASS	pH_F	5.2
		D	6.00 - 6.10		pH_{FOX}	3.0
				Aggressivity	pH	5.9
					Cl	35ppm
					SO4	25ppm
7.00		D	7.00	ASS	pH_F	5.7
	Drilling discontinued at 7.00m depth in Clay				pH_{FOX}	3.3
8.00						
9.00						
10.00						

RIG: Dingo Restricted Access Rig DRILLER: AC LOGGED: TJ

METHOD: Solid stem, spiral flight augers with tungsten carbide bit

GROUND WATER OBSERVATIONS: 2.30m depth

REMARKS: CHECKED:

DYNAMIC PENETROMETER TEST SHEET

CLIENT: Northern Beaches Council **DATE:** 30/01/2019

PROJECT: Proposed New Development **PROJECT No.:** 2017-235

LOCATION: Long Reef Surf Life Saving Club **SHEET:** 1 of 1

	Test Location							
Depth (m)	DCP1	DCP2	DCP2	DCP2A				
0.00 - 0.15	2	1	2	1				
0.15 - 0.30	5	4	5	4				
0.30 - 0.45	8	8 (B)	8	7				
0.45 - 0.60	11	Ref @ 0.44m in fill	6	11				
0.60 - 0.75	14		8	17				
0.75 - 0.90	17		10 (B)	12				
0.90 - 1.05	19		Ref @ 0.80m in fill	8				
1.05 - 1.20	16			4				
1.20 - 1.35	10			1				
1.35 - 1.50	10			1				
1.50 - 1.65	10			1				
1.65 - 1.80	9			4				
1.80 - 1.95	12			6				
1.95 - 2.10	9			11				
2.10 - 2.25	8			10				
2.25 - 2.40	8			6				
2.40 - 2.55	9			4				
2.55 - 2.70	10			3				
2.70 - 2.85	9			2				
2.85 - 3.00	11			3				
3.00 - 3.15	Discont. at 3.00m			--				
3.15 - 3.30				2				
3.30 - 3.45				4				
3.45 - 3.60				12				
3.60 - 3.75				17				
3.75 - 3.90				22 (B)				
3.90 - 4.05				Ref @ 3.87m				
4.05 - 4.20								

TEST METHOD:

AS 1289. F3.3, PERTH SAND PENETROMETER

REMARKS:

(B) Test hammer bouncing upon refusal on solid object

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

Appendix 3

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CERTIFICATE OF ANALYSIS 210615

Client Details

Client	Crozier Geotechnical Consultants
Attention	Troy Crozier
Address	Unit 12/42-46 Wattle Rd, Brookvale, NSW, 2100

Sample Details

Your Reference	**2017-235, Long Reef SLSC**
Number of Samples	14 SOIL
Date samples received	01/02/2019
Date completed instructions received	01/02/2019

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date results requested by	08/02/2019
Date of Issue	08/02/2019

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Results Approved By
Nick Sarlamis, Inorganics Supervisor
Priya Samarawickrama, Senior Chemist

Authorised By

Jacinta Hurst, Laboratory Manager

Soil Aggressivity				
Our Reference		210615-5	210615-8	210615-13
Your Reference	UNITS	BH1	BH1	BH2
Depth		4.1	1.1	6.0
Date Sampled		31/01/2019	31/01/2019	31/01/2019
Type of sample		SOIL	SOIL	SOIL
pH 1:5 soil:water	pH Units	4.9	8.0	5.9
Electrical Conductivity 1:5 soil:water	µS/cm	110	96	73
Resistivity by calculation	ohm m	94	100	140
Chloride, Cl 1:5 soil:water	mg/kg	10	20	35
Sulphate, SO4 1:5 soil:water	mg/kg	120	<10	25

sPOCAS + %S w/w			
Our Reference		210615-2	210615-10
Your Reference	UNITS	BH1	BH2
Depth		1.0	2.5
Date Sampled		31/01/2019	31/01/2019
Type of sample		SOIL	SOIL
Date prepared	-	07/02/2019	07/02/2019
Date analysed	-	07/02/2019	07/02/2019
pH_{kcl}	pH units	9.7	6.5
TAA pH 6.5	moles H^+/t	<5	<5
s-TAA pH 6.5	%w/w S	<0.01	<0.01
pH_{Ox}	pH units	7.5	2.2
TPA pH 6.5	moles H^+/t	<5	560
s-TPA pH 6.5	%w/w S	<0.01	0.89
TSA pH 6.5	moles H^+/t	<5	560
s-TSA pH 6.5	%w/w S	<0.01	0.89
ANC_E	% $CaCO_3$	0.88	<0.05
a-ANC_E	moles H^+/t	180	<5
s-ANC_E	%w/w S	0.28	<0.05
S_{KCl}	%w/w S	<0.005	0.07
S_P	%w/w	0.006	0.95
S_{POS}	%w/w	0.005	0.88
a-S_{POS}	moles H^+/t	<5	550
Ca_{KCl}	%w/w	0.11	0.12
Ca_P	%w/w	0.54	0.16
Ca_A	%w/w	0.43	0.038
Mg_{KCl}	%w/w	0.008	0.046
Mg_P	%w/w	0.026	0.043
Mg_A	%w/w	0.018	<0.005
S_{HCl}	%w/w S	<0.005	<0.005
S_{NAS}	%w/w S	<0.005	<0.005
a-S_{NAS}	moles H^+/t	<5	<5
s-S_{NAS}	%w/w S	<0.01	<0.01
Fineness Factor	-	1.5	1.5
a-Net Acidity	moles H^+/t	<5	560
s-Net Acidity	%w/w S	<0.01	0.89
Liming rate	kg $CaCO_3$/t	<0.75	42
s-Net Acidity without -ANCE	%w/w S	<0.01	0.89
a-Net Acidity without ANCE	moles H^+/t	<5	560
Liming rate without ANCE	kg $CaCO_3$/t	<0.75	42

sPOCAS field test						
Our Reference		210615-1	210615-3	210615-4	210615-6	210615-7
Your Reference	UNITS	BH1	BH1	BH1	BH1	BH1
Depth		0.5	2.0	3.9	5.0	6.4
Date Sampled		31/01/2019	31/01/2019	31/01/2019	31/01/2019	31/01/2019
Type of sample		SOIL	SOIL	SOIL	SOIL	SOIL
Date prepared	-	07/02/2019	07/02/2019	07/02/2019	07/02/2019	07/02/2019
Date analysed	-	07/02/2019	07/02/2019	07/02/2019	07/02/2019	07/02/2019
pH_F (field pH test)*	pH Units	8.1	8.4	7.0	4.6	5.0
pH_{FOX} (field peroxide test)*	pH Units	6.6	8.3	4.2	2.3	3.5
Reaction Rate*	-	Slight	High	Vigorous	High	Slight

sPOCAS field test						
Our Reference		210615-9	210615-11	210615-12	210615-13	210615-14
Your Reference	UNITS	BH2	BH2	BH2	BH2	BH2
Depth		1.5	3.0	4.0	6.0	7.0
Date Sampled		31/01/2019	31/01/2019	31/01/2019	31/01/2019	31/01/2019
Type of sample		SOIL	SOIL	SOIL	SOIL	SOIL
Date prepared	-	07/02/2019	07/02/2019	07/02/2019	05/02/2019	07/02/2019
Date analysed	-	07/02/2019	07/02/2019	07/02/2019	05/02/2019	07/02/2019
pH_F (field pH test)*	pH Units	7.5	5.9	5.4	5.2	5.7
pH_{FOX} (field peroxide test)*	pH Units	7.2	1.4	1.8	3.0	3.3
Reaction Rate*	-	Moderate	Vigorous	Vigorous	Vigorous	Vigorous

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25°C in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA 22nd ED 2510 and Rayment & Lyons. Resistivity is calculated from Conductivity.
Inorg-063	pH- measured using pH meter and electrode. Soil is oxidised with Hydrogen Peroxide or extracted with water. Based on section H, Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004. To ensure accurate results these tests are recommended to be done in the field as pH may change with time thus these results may not be representative of true field conditions.
Inorg-064	sPOCAS determined using titrimetric and ICP-AES techniques. Based on Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Alternatively determined by colourimetry/turbidity using Discrete Analyer.

QUALITY CONTROL: Soil Aggressivity					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	[NT]	[NT]	103	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	[NT]	[NT]	[NT]	[NT]	103	[NT]
Resistivity by calculation	ohm m	0.1	Inorg-002	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	94	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	102	[NT]

QUALITY CONTROL: sPOCAS + %S w/w						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			07/02/2019	[NT]	[NT]	[NT]	[NT]	07/02/2019	[NT]
Date analysed	-			07/02/2019	[NT]	[NT]	[NT]	[NT]	07/02/2019	[NT]
pH_{kcl}	pH units		Inorg-064	[NT]	[NT]	[NT]	[NT]	[NT]	92	[NT]
TAA pH 6.5	moles H^+/t	5	Inorg-064	<5	[NT]	[NT]	[NT]	[NT]	90	[NT]
s-TAA pH 6.5	%w/w S	0.01	Inorg-064	<0.01	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
pH_{Ox}	pH units		Inorg-064	[NT]	[NT]	[NT]	[NT]	[NT]	98	[NT]
TPA pH 6.5	moles H^+/t	5	Inorg-064	<5	[NT]	[NT]	[NT]	[NT]	90	[NT]
s-TPA pH 6.5	%w/w S	0.01	Inorg-064	<0.01	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
TSA pH 6.5	moles H^+/t	5	Inorg-064	<5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
s-TSA pH 6.5	%w/w S	0.01	Inorg-064	<0.01	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
ANC_E	% $CaCO_3$	0.05	Inorg-064	<0.05	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
a-ANC_E	moles H^+/t	5	Inorg-064	<5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
s-ANC_E	%w/w S	0.05	Inorg-064	<0.05	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
S_{KCl}	%w/w S	0.005	Inorg-064	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
S_P	%w/w	0.005	Inorg-064	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
S_{POS}	%w/w	0.005	Inorg-064	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
a-S_{POS}	moles H^+/t	5	Inorg-064	<5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Ca_{KCl}	%w/w	0.005	Inorg-064	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Ca_P	%w/w	0.005	Inorg-064	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Ca_A	%w/w	0.005	Inorg-064	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Mg_{KCl}	%w/w	0.005	Inorg-064	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Mg_P	%w/w	0.005	Inorg-064	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Mg_A	%w/w	0.005	Inorg-064	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
S_{HCl}	%w/w S	0.005	Inorg-064	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
S_{NAS}	%w/w S	0.005	Inorg-064	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
a-S_{NAS}	moles H^+/t	5	Inorg-064	<5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
s-S_{NAS}	%w/w S	0.01	Inorg-064	<0.01	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Fineness Factor	-	1.5	Inorg-064	<1.5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
a-Net Acidity	moles H^+/t	5	Inorg-064	<5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
s-Net Acidity	%w/w S	0.01	Inorg-064	<0.01	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Liming rate	kg $CaCO_3$/t	0.75	Inorg-064	<0.75	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
s-Net Acidity without -ANCE	%w/w S	0.01	Inorg-064	<0.01	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
a-Net Acidity without ANCE	moles H^+/t	5	Inorg-064	<5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]

QUALITY CONTROL: sPOCAS + %S w/w					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Liming rate without ANCE	kg $CaCO_3$ /t	0.75	Inorg-064	<0.75	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]

Result Definitions	
NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions	
Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.