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REPORT ON GEOTECHNICAL SITE INVESTIGATION

for

PROPOSED NEW RESIDENTIAL APARTMENT BLOCK

at

142 OCEAN STREET, NARRABEEN, NSW

PREPARED FOR

Trio Industries Pty Ltd

Project No.: 2021-073

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CROZIER
GEOTECHNICAL CONSULTANTS

TABLE OF CONTENTS

APPENDICES

1	Notes Relating to this Report
2	Figure 1 – Site Plan, Figure 2 – Interpreted Geological Model, Borehole Log sheets and Dynamic Penetrometer Test Results
3	Risk Tables
4	Laboratory Test Results
5	AGS Terms and Descriptions

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Date: 26th April 2021
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GEOTECHNICAL REPORT FOR PROPOSED NEW RESIDENTIAL APARTMENT BLOCK
142 OCEAN STREET, NARRABEEN, NSW

1. INTRODUCTION:

This report details the results of a geotechnical investigation carried out for a proposed residential apartment block at No.142 Ocean Street, Narrabeen, NSW. The investigation was undertaken by Crozier Geotechnical Consultants (CGC) at the request of the client Trio Industries Pty Ltd.

It is understood that the existing site structures are to be demolished with the construction of a three storey apartment block which includes a lower ground floor car park level. The development is to include four apartments, along with a swimming pool within the rear. Bulk excavation will be required to a maximum of 2.5m depth for the construction of the lower ground floor level.

A review of Northern Beaches Council (Warringah LEP/DCP 2011) identified that the site is located within the 'Class A' landslip hazard zone (LSR_009). The proposed works involve excavation >2.00m depth and therefore a 'full' geotechnical report will be required as part of the Development Application (DA). The site is also defined as being within Acid Sulfate Soils hazard "Class4".

This report includes a description of site and sub-surface conditions, a geotechnical assessment of the development, site mapping/plan, a geological section, an acid sulfate soils assessment, site risk assessment in accordance with AGS March 2007 publication and provides recommendations for design, construction and stormwater disposal including infiltration.

The investigation and reporting were undertaken as per the Proposal P21-117, Dated: 16th March 2021. The investigation and reporting were prepared to assist in the Development Application and preliminary design and construction tendering.

The investigation comprised:

a) A detailed geotechnical inspection and mapping of the site and inspection of adjacent properties by a Geotechnical Engineer.

b) Drilling of five boreholes using hand tools along with five Dynamic Penetrometer (DCP) tests at specific locations to investigate sub-surface conditions.

c) Conducting of an in-situ infiltration test at the rear of the site, using a modified version of the Australian Standard AS1289.6.7.2 - 2000 Falling Head Permeability Method.

d) Collection of soil samples for logging to AS1726-2017 and submission for analysis of actual and potential acid sulfate soils.

The following plans and drawings were supplied for the work:

- Architectural Drawings – Popov Bass Architects, Project; Trio Narrabeen Apartments, Drawing No.0586-DA100, DA102, DA103,-DA105, DA112, DA113, Revision: 01, Dated 31/03/2021
- Survey Drawing – C&A Surveyors, Ref. No. 16303-21, Dated 20/01/2021

2. PROPOSED DEVELOPMENT:

The proposed works involve the demolition of all site structures and the construction of a three storey apartment block. The apartment block is to comprise four apartments within the upper two living levels and a lower ground floor level which will contain garage spaces, storage and a rumpus room. Bulk excavation will be required to between 2.5m and 1.0m depth, with the deeper portions of excavation positioned towards the front of the site, due to the topography of the block.

The proposed development includes Lower Ground Floor Level is to have 6.0m front and rear setbacks, a 2.0m northern side setback and 0.5m southern side setback. A swimming pool is to be located in the south western corner of the site, approximately 0.5m from the southern and western boundaries, excavation depth for the swimming pool is unknown though anticipated at ≤2.0m depth.

3. SITE FEATURES:

3.1. Site Description:

The site is a rectangular shaped block covering an area of 933m^3, with a front east boundary of 15.44m, northern and southern side boundaries of 60.92m and a rear west boundary of 15.18m, as referenced from the provided Survey Plan. The site is located on the western side of Ocean Street, within gentle (1-2°) west dipping topography.

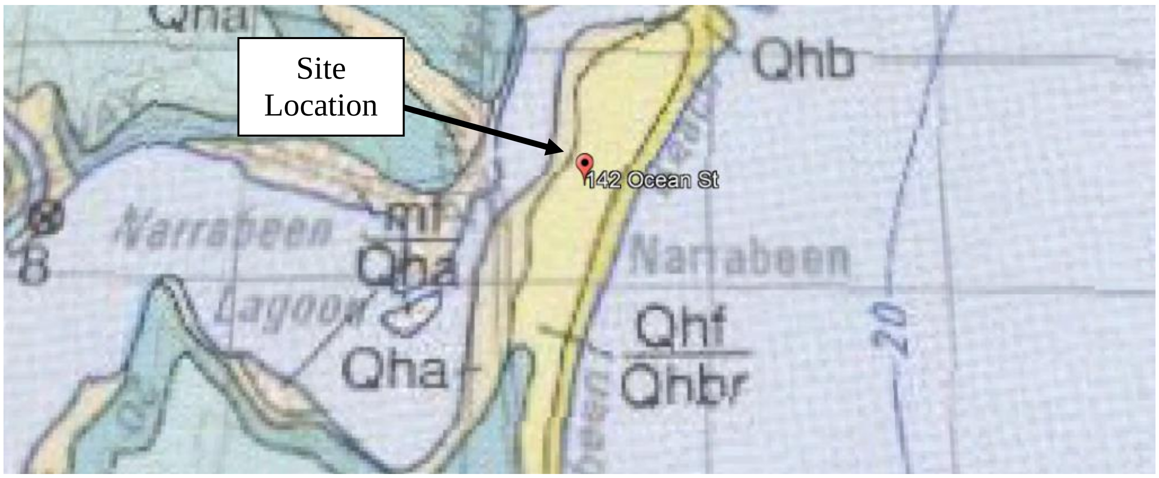
Photograph 1. Aerial photograph of site and surrounds

The site contains a one and two storey brick and clad house located within the central portion of the block. A concrete driveway is located within the north eastern corner of the site which provides vehicle access from the road to an attached carport structure and garage. The rear of the site contains gravel, grass and concrete surfaces, along with a metal shed, timber deck and low (≤0.6m high) timber retaining walls.

Photograph 2. View of the front of the house, facing south

3.2. Geology:

Reference to the Sydney 1: 100,000 Geological Series sheet (9130) indicates that the site is underlain by medium to fine 'marine' sand and windblown quartz sand, minor shell content, inter-dune silt and fine sand. An extract of the Sydney Series sheet is provided as Extract 1.



Extract 1:100,000 Sydney Series Geological reference extract

4. FIELD WORK:

4.1. Methods:

The field investigation comprised a walk over inspection, mapping of the site and limited inspection of adjacent properties on the 1st April 2021 by a Geotechnical Engineer. It included a photographic record of site conditions as well as geological/geomorphological mapping of the site and adjacent land with examination of existing features and ground conditions.

It also included the drilling of five auger boreholes (BH1 – BH4) using hand tools to investigate sub-surface geology and collect samples.

DCP testing was carried out from the ground surface adjacent to the boreholes as well as at one other nominated location in accordance with AS1289.6.3.2 – 1997, "Determination of the penetration resistance of a soil – 9kg Perth Sand Penetrometer" to estimate near surface soil conditions.

An in-situ infiltration test was conducted within the rear of the site at BH5, using a modified version of the Australian Standard AS1289.6.7.2 - 2000 Falling Head Permeability Method.

Test locations were positioned using existing site features and the proposed development along with onsite service location results. Test elevations were determined by interpolation from the supplied survey plan.

Logging was undertaken in accordance with AS1726:2017 'Geotechnical Site Investigations' and select samples were subsequently submitted to a NATA accredited chemical testing laboratory for Acid Sulfate Soils assessment in line with the recommendations of the Acid Sulfate Soils Manual.

Explanatory notes are included in Appendix: 1. Mapping information and test locations are shown on Figure: 1, along with detailed borehole log and DCP sheets in Appendix: 2, a geological models/section is provided as Figure: 2, Appendix: 2.

4.2. Field Observations:

The site is situated on the west side of the road within gentle west dipping topography related to the western side of a dune environment. Ocean Street is formed with near level bitumen pavement and concrete kerb/gutter, a concrete public pathway and nature strip are located along the western side of the road reserve. There were no signs of significant cracking within the surrounding road reserve to suggest any underlying movement.

The site contains a one and two storey brick and clad house positioned centrally within the site, vehicle access is provided from the north eastern corner of the site via a concrete driveway which connects to Ocean Street. The front of the site contains a gravel car parking area with surrounding low gardens beds, access to the rear of the site is provided along the northern boundary. The rear of the site contains gravel, grass and concrete surfaces, along with a timber deck and metal sheds. A concrete slab is located within the north eastern corner of the site, with ≤0.6m high retained gardens surrounding the slab along the adjacent site boundaries.

The main structure appears to have undergone significant alterations and additions, as the ground floor level appears to be of 1960's construction, whilst the first-floor level is of a modern construction (2000's). The front of the structure consists of an open carport timber structure, with a first-floor balcony above, an internal garage is located to the west of this carport. The main structure appeared to be in good condition with no obvious signs of cracking or settlement within any external walls.

A gentle west dipping soil slope (≈ 3-5°) is located within the rear of the site between the upper gravel region and the lower grassed area. A wooden deck is located at the crest of this slope, this structure showed signs of minor settlement with some rotting of the timber planks also evident, this is shown in Photograph 3.

Stormwater drainage and gutter systems were observed across the site structure, with down pipes discharging into drainage pits, however faults in some of the PVC stormwater pipes and metal water pipes were identified, as shown in Photograph 4, however no determined erosion appeared related to these issues. A sewer main intersects the south western portion of the site, with local sewer lines extending from the rear of the site house to the adjacent sewer main. Based on available DBYD information it is understood the sewer main comprises a 450mm diameter vitrified clay pipe.

Photograph 3: Timber deck within rear of site, with rotation/rotting of timber planks and minor settlement evident, facing south west

Photograph 4: Fault opening in PVC stormwater down pipe along southern external wall of site house, facing north east

The neighbouring property to the south (No.140 Ocean Street) contains a single storey weatherboard house with a fibro garage on the south eastern side of the property. An unsealed car parking area is located to the front of the dwelling, with a concrete driveway providing access from the south eastern corner of the block. The rear of the site contains a large grassed lawn beyond a paved patio area and garden bed with palm trees, there is also a metal shed in the rear south west corner of the site.

The neighbouring property to the north (No.144 Ocean Street) contains a four storey brick unit block. The ground floor of the structure appears to comprise garages, whilst the upper three levels comprise apartment living levels. A concrete driveway is located along the northern boundary of the property, providing access to the ground floor garage level. The main structure is positioned approximately 2.5m from the common boundary with the site, with a concrete pathway situated adjacent to the common boundary. Stormwater drains and gutter systems were identified across the structure, with downpipes extending to unknown discharge points.

The neighbouring property to the west (No.59 Lagoon Street) contains a two storey brick apartment block which is positioned towards the front of the property. A concrete driveway extends along the southern side of the property to provide vehicle access to the rear single storey brick garage structure, this structure is situated on the common boundary with the site. The concrete driveway at the rear of the property is approximately 0.6m higher than the level of the concrete slab at the rear of the site.

4.3. Ground Conditions:

For a description of the ground conditions encountered at the individual borehole/DCP test locations, the Borehole Log and DCP results sheets should be consulted however a very broad summary of the subsurface conditions encountered is provided below.

- **FILL/TOPSOIL –** this layer was encountered from the existing ground surface level at all test locations to a maximum depth of 0.70m (BH1). The topsoil/fill soils comprised brown, silty sand trace gravel and rootlets.
- **SAND –** Natural sand was encountered in all boreholes underlying the fill soils, to a maximum drilled depth of 5.00m depth (BH1), in which the borehole was terminated. The deposit comprised very loose grading to dense/very dense, orange brown grading to pale brown, medium grained, moist, sand. Minor shell fragments and fine quartz sub rounded gravel were identified at different depths within the boreholes.

A free standing ground water table or significant water seepage were not identified within any of the boreholes. No signs of ground water were observed after the retrieval of the DCP rods.

4.4. Acid Sulfate Soils Testing

Of the soil samples collected, representative samples were kept on ice and transported to NATA accredited laboratory (Envirolab) for testing via the SPOCAS, pH and pHFOX 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 Table: 2 below:

Table 1: Preliminary field test

Sample Location	pH field	pH_{FOX} field peroxide test
BH4, 4.50m – 4.60m	8.7	9.2
BH2, 2.90m - 3.00m	8.7	9.5
BH4, 2.50m – 2.60m	8.7	7.6
BH2, 1.00m – 1.10m	8.2	5.5

Table 2: sPOCAS +%S w/w

Test Location	Description	pH (KCL)	pH (OX)	TPA (moles H^+ / t)	Spos (% S)	Liming Rate (kg CaCO3 / t)
BH4 4.5 – 4.6m	SAND	9.7	8.2	<5	<0.005	<0.75

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

The investigation did not intersect any soils that would exhibit actual or potential acid sulfate soil characteristics. The results of the laboratory testing of the soils within or adjacent to the footprint of the anticipated excavation indicated minimal acidity, well below the level required for action criteria in the Acid Sulfate Soils Manual. No groundwater was encountered to well below the proposed excavation level, therefore no dewatering will be required. It is therefore considered that the proposed excavation will have no impact on Acid Sulfate soils within or adjacent to the site.

The laboratory test results indicate that Acid Sulfate Soils are not present within the soils on site. Therefore according to the Acid Sulphate Soils Management Advisory Committee (ASSMAC), a management plan will not be required.

4.5. Infiltration test for storm water design

An infiltration test was conducted within the rear of the site (BH5) approximately 3.0m from the western boundary and 6.5m from the northern boundary for the estimation of in-situ soil stormwater infiltration/absorption rates and stormwater disposal.

A review of the Bureau of Meteorology Rainfall Observations for the nearest site (Collaroy – Long Reef Golf Club) suggests the site received ≈ 411mm of rainfall in the 28 days preceding the investigation. This is significantly higher than the average ≈ 165mm of rainfall for the month of March within this area.

A 104mm diameter test hole was excavated to 0.65m depth within the dune sand deposit. This test hole was saturated for 115 minutes prior to testing, which then determined an average vertical infiltration rate of **2.19** litres per second per square metre.

A summary of the results of the infiltration test with respect to previous investigations within the area and local knowledge:

1. Depth to water table: Not encountered (expected at ≥8.0m depth)
2. Determined vertical Infiltration rate: **2.19** L/sec/m².
3. Suggested Long term infiltration rate: **2.00** L/sec/m².
4. Minimum distance of stormwater disposal from boundaries: ≥ 2m
5. The use of any waterproofing to protect underground areas: Not Applicable
6. Any special requirements for the design of walls or footings on site in relation to stormwater: None

5. COMMENTS:

5.1. Geotechnical Assessment:

The site investigation identified the presence of silty sand topsoil and fill to a maximum depth of 0.70m (BH1), underlain by natural sand from a minimum of 0.15m depth (BH3) to a maximum drilled depth of 5.00m (BH1). The boreholes and DCP tests were terminated in dense to very dense sand between 3.0m and 5.0m depth. No signs of seepage or a freestanding groundwater table were identified in any of the boreholes or on any of the retrieved DCP rods.

The proposed works include the demolition of all site structures and the construction of a three-storey apartment block, which includes a lower ground floor garage level. Bulk excavation is anticipated to be required between 2.5m depth towards the front of the site and 1.0m depth towards the rear of the site, with potential for further bulk excavation within the south western corner of the site for the swimming pool. The minimum side setback of the structure will be along the southern boundary in which a minimum setback of 0.5m is anticipated.

Based on the investigation it is anticipated that only very loose to medium dense/dense fill and natural sand soils will be intersected for the proposed bulk excavation. An excavator with bucket will be sufficient for all proposed excavations. As a result of the proximity of the excavation to the site boundaries, in particular the side boundaries, temporary safe batter slopes of 1.5:1 will not be feasible along some excavation faces. Temporary safe batter slopes will not be able to be formed on the southern side of the excavation and the majority of the northern side (rear portions of northern excavation face may allow for safe batter slopes to be formed due to reduced excavation depth).

Where batter slopes are not feasible, support prior to excavation which should consist of contiguous pile (or similar) shoring walls should be installed, however it would be prudent to extend shoring walls around the entire perimeter of the proposed excavations. Where excavation is adjacent to boundaries or structures then careful control of pile drilling/support installation is required whilst all gaps in the wall must be sealed during excavation to prevent erosion between piles. Driven style support systems (i.e. sheet piling, concrete/timber piles) are not suitable for use on this site.

At all footing locations it appears that piles would need to be adopted to enable the footings to bear within very dense sand. Due to the soil conditions underlaying the site, piles would need to be fully encased bored piles or CFA piles to mitigate the chance of pile hole collapse within the sandy soil. From the DCP results it is considered that the natural sand deposit grades from very loose to very dense, with very dense soils identified between 2.80m depth (DCP4) and 4.60m depth (DCP1). It is recommended that footings should extend to bear within very dense soils, which provides an initial allowable bearing capacity of 300kPa. Higher bearing pressures are achievable for pile footings in D-VD sand however further analysis based on proposed loads is required. Strongly cemented sands were not identified during the investigation which terminated at a maximum drilled depth of 5.00m.

It is understood that a Sydney Water (SW) sewer underlies the site and near the proposed swimming pool. CGC has not undertaken any investigation into the construction/type/depth etc, of the sewer however DBYD plan indicate it is a 450mm diameter Vitreous Clay Style pipe with invert at approximately 4.75m depth. Based on previous experience it is recommended that Sydney Water be contacted as soon as possible to determine what requirements may exist in order to protect the asset. This will likely be a condition of the CC however the precautions SW may require could impact the scope of required field investigation, geotechnical reporting and footing design.

Existing landslip hazards were not identified however the excavation will create potential stability hazards to adjacent properties, these will need to be considered during design and construction.

The proposed works are considered suitable for the site and may be completed with negligible impact to existing nearby structures within the site or neighbouring properties provided the recommendations of this report are implemented in the design and construction phases.

The recommendations and conclusions in this report are based on an investigation utilising only surface observations and a limited scope of investigation using augering techniques only. This investigation provides limited data from small isolated test points across the entire site with limited penetration into rock, therefore some minor variation to the interpreted sub-surface conditions is possible, especially between test locations. However the results of the investigation provide a reasonable basis for the analysis and subsequent design of the proposed works.

5.2. Site Specific Risk Assessment:

Based on our site investigation we have identified the following geological/geotechnical landslip hazards which need to be considered in relation to the existing site and the proposed works. The hazards are:

A. Landslip of surficial soils from excavation works for lower ground floor garage excavation.

The hazards have been assessed in accordance with the methods of the Australian Geomechanics Society (Landslide Risk Management, AGS Subcommittee, May 2002 and March 2007), see Tables: A and B, Appendix: 3 The Australian Geomechanics Society Qualitative Risk Analysis Matrix is enclosed in Appendix: 4 along with relevant AGS notes and figures. The frequency of failure was interpreted from existing site conditions and previous experience in these geological units.

The **Risk to Life** from **Hazard A** was estimated to be up to **1.00×10^{-7}** for a single person, whilst the **Risk to Property** from the hazards were considered to be up to **'Moderate'**.

Although the risk to property levels are considered to be 'Unacceptable' against the AGS Guidelines, the assessments were based on excavations with no support or planning. Provided the recommendations of this report are implemented the likelihood of any failure becomes 'Rare' and as such the consequences reduce and risk levels become within the 'Acceptable' risk management criteria. As such the project is considered suitable for the site provided the recommendations of this report are implemented.

5.3. Design & Construction Recommendations:

Design and the construction recommendations are tabulated below:

5.3.1. New Footings:	
Site Classification as per AS2870 – 2011 for new footing design	Class 'P' – Due to fill. Class 'A' where excavation into natural sands occurs
Type of Footing	Piles and or shallow footings
Sub-grade material and Maximum Allowable Bearing Capacity for shallow footings	- Medium dense: 150kPa - Dense sand: 250kPa - Very dense sand: 300kPa *
Site sub-soil classification as per *Structural design actions AS1170.4 – 2007, Part 4: Earthquake actions in Australia*	Class C_e – Shallow soil site
Remarks: *Requires at least 1.5m of dense sand below footing with no loose/soft underlying material It is recommended that all footings extend to bear within dense soils via pile footings, however if pad/strip footings are utilised at the base of an excavation into dense sand it is recommended that the medium dense bearing pressure be utilised to account for loosening during/following excavation. The density of shallow foundations will be difficult to maintain, therefore where proposed an allowance for recompacting prior to footing construction is recommended. All new excavated footings must be inspected and shallow footings tested by an experienced geotechnical professional before concrete or steel are placed to verify the density/consistency of the founding strata. This is mandatory to allow them to be 'certified' at the end of the project. Individual structures should not be founded on materials with varying bearing and settlement.	

5.3.2. Excavation:	
Depth of Excavation	Lower ground floor level ≤2.50m depth
Distance of Excavation to Neighbouring Properties	No. 140 Ocean Street: 0.5m from the common boundary, with main structure a minimum of 1.0m further. No.144 Ocean Street: 2.0m from the common boundary, with main structure 2.5m further. Road Reserve: 2.5m deep excavation 6.5m from Ocean Street, with inclined driveway excavation extending to road reserve

Type of Material to be Excavated	- Very loose to medium dense silty sand fill to maximum depth of 0.70m (BH1) - Loose sand between a minimum of 0.30m depth (BH4) to a maximum of 0.80m depth (DCP1) - Medium dense sand between a minimum of 0.15m depth (DCP4) to a maximum of 3.80m depth (DCP1) - Dense sand; between a minimum of 2.20m (DCP4) to a maximum of 4.50m (DCP1) - Very dense sand from a minimum of 2.70 (DCP4) and from a maximum of 4.50m (DCP1)

Guidelines for batter slopes for general information are tabulated below:

Material	Safe Batter Slope (H:V)*	
	Short Term/Temporary	Long Term/Permanent
Sandy Topsoil, very loose to medium dense soils	1.5:1	2.5:1

Where safe batter slopes are not implemented, the stability of the excavation cannot be guaranteed until permanent support measures are installed. This should be considered with respect to safe working conditions and protections of boundaries, structures and services.

Equipment for Excavation	Topsoil/fill and natural sand	Excavator with bucket
Recommended Vibration Limits (Maximum Peak Particle Velocity (PPV))	3mm/s to protect against compaction of very loose sand extending to areas requiring compaction.	
Vibration Calibration Tests Required	N/A	
Full time vibration Monitoring Required	N/A	
Geotechnical Inspection Requirement	Yes, recommended that these inspections be undertaken as per below mentioned sequence: • During installation of excavation support measures and/or underpinning of footings • At completion of the excavation	
Dilapidation Surveys Requirement	On neighbouring structures or parts thereof within 5m of the excavation perimeter prior to site work.	

Remarks:

Water ingress into exposed excavations can result in erosion and stability concern in sandy soils. Drainage measures will need to be in place during excavation works to divert any surface flow away from the excavation crest and any batter slope.

5.3.3. Retaining Structures:

Required	As part of Lower Ground Floor excavation perimeter
Types	Contiguous, bored pile wall or similar where safe temporary batters cannot be formed for excavation. Steel reinforced concrete/concrete block walls post excavation, where temporary batters as per section 5.3.2 are achievable or prior to fill. Designed in accordance with Australian Standards AS4678-2002 Earth Retaining Structures.

Parameters for calculating pressures acting on retaining walls for the materials likely to be retained:

Material	Unit Weight (kN/m3)	Long Term (Drained)	Earth Pressure Coefficients		Passive Earth Pressure Coefficient * (Kp)
			Active (Ka)	At Rest (K_0)	
Very loose/loose fill and natural soils	16	$\phi' = 26°$	0.39	0.56	N/A
Medium dense sand	18	$\phi' = 30°$	0.33	0.50	3.0
Dense sand	20	$\phi' = 36°$	0.26	0.41	3.9
Very dense sand	21	$\phi' = 39°$	0.23	0.37	4.4

Remarks:

Retaining structures near site boundaries or existing structures should be designed with the use of at rest (K_0) earth pressure coefficients to reduce the risk of movement in the excavation support and resulting surface movement in adjoining areas. Backfilled retaining walls within the site, away from site boundaries or existing structures, that may deflect can utilize active earth pressure coefficients (Ka).

For contiguous piled systems, core is required to ensure over excavation as loss of sand between piles is prevented as any loosening beyond the support system will result in settlement of adjoining structures.

5.3.4. Drainage and Hydrogeology		
Groundwater Table or Seepage identified in Investigation		No
Excavation likely to intersect	Water Table	No
	Seepage	No
Site Location and Topography		On western side of road within gentle west dipping topography
Impact of development on local hydrogeology		Negligible
Onsite Stormwater Disposal		Possible via absorption
Remarks: Trenches, as well as all new building gutters, down pipes and stormwater intercept trenches should be connected to a stormwater system designed by a Hydraulic Engineer.		

5.4. Conditions Relating to Design and Construction Monitoring:

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

1. Review and approve the structural design drawings and final architectural drawings, including the retaining structure design and construction methodology, for compliance with the recommendations of this report prior to construction,
2. Supervise installation of any support measures,
3. Inspect all new footings and earthworks to confirm compliance to design assumptions with respect to allowable bearing pressure, basal cleanness and stability prior to the placement of steel or concrete,
4. Inspect completed works to ensure no new landslip hazards have been created by site works and that all required stabilisation and drainage measures are in place.

Crozier Geotechnical Consultants cannot provide certification for the Occupation Certificate if it has not been called to site to undertake the required inspections.

6. CONCLUSION:

The site investigation identified the presence of silty sand topsoil and fill to a maximum depth of 0.70m (BH1), underlain by a natural sand deposit from a minimum of 0.15m depth (BH3) to a maximum drilled depth of 5.00m (BH1). The investigation was conducted to a maximum drilled depth of 5.0m (BH1/DCP1), with all boreholes and DCP tests discontinuing within dense to very dense sand. No signs of seepage or a freestanding groundwater table were identified in any of the boreholes or on any of the retrieved DCP rods.

The proposed works involve the demolition of the existing site structures and the construction of a three-storey apartment block. Bulk excavation will be required to a maximum of 2.5m depth for the lower ground floor level, with potential for further bulk excavation at the rear of the site for the swimming pool, which is anticipated to ≤2.0m depth, however this is unconfirmed.

Careful consideration should be taken during the excavation phase for the lower ground floor level, as it is anticipated that excavations will extend to a minimum of 0.5m from the boundaries. Excavation will only intersect sandy soils; therefore, it is recommended that supports prior to excavation (i.e. contiguous pile walls) are established. Temporary safe batter slopes will be feasible within some portions of the excavation (western side and regions of the northern and eastern sides), however it would be prudent to establish shoring walls around the entire excavation perimeter.

It is recommended that all footings for the proposed main structure extend to bear within very dense natural sand to provide an allowable bearing capacity of at least 300kPa. If shallow footings at the base of the excavation are adopted, then a conservative 150kPa allowable bearing capacity should be taken.

There were no existing/credible landslip hazards identified, it is also envisaged that the proposed works should not create any new instability provided the recommendations of this report are implemented. No soils intersected during the investigation exhibited actual or potential acid sulfate soil characteristics. Therefore, the proposed excavation should have no impact on Acid Sulfate soils within or adjacent to the site.

The risks associated with the proposed development can be maintained within 'Acceptable' levels (AGS 2007) with negligible impact to the neighbouring properties or structures provided the recommendations of this report and any future geotechnical directive are implemented. As such the site is considered suitable for the proposed construction works provided that the recommendations outlined in this report are followed.

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7. REFERENCES:

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2. Geological Society Engineering Group Working Party 1972, "The preparation of maps and plans in terms of engineering geology" Quarterly Journal Engineering Geology, Volume 5, Pages 295 - 382.
3. C. W. Fetter 1995, "Applied Hydrology" by Prentice Hall.
4. V. Gardiner & R. Dackombe 1983, "Geomorphological Field Manual" by George Allen & Unwin
5. Australian Standard AS1170.4 – 2007 *Structural design actions, Part 4: Earthquake actions in Australia.*
6. Acid Sulfate Soil Manual, New South Wales Acid Sulfate Soil Management Advisory Committee, August 1998.

Appendix 1

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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.

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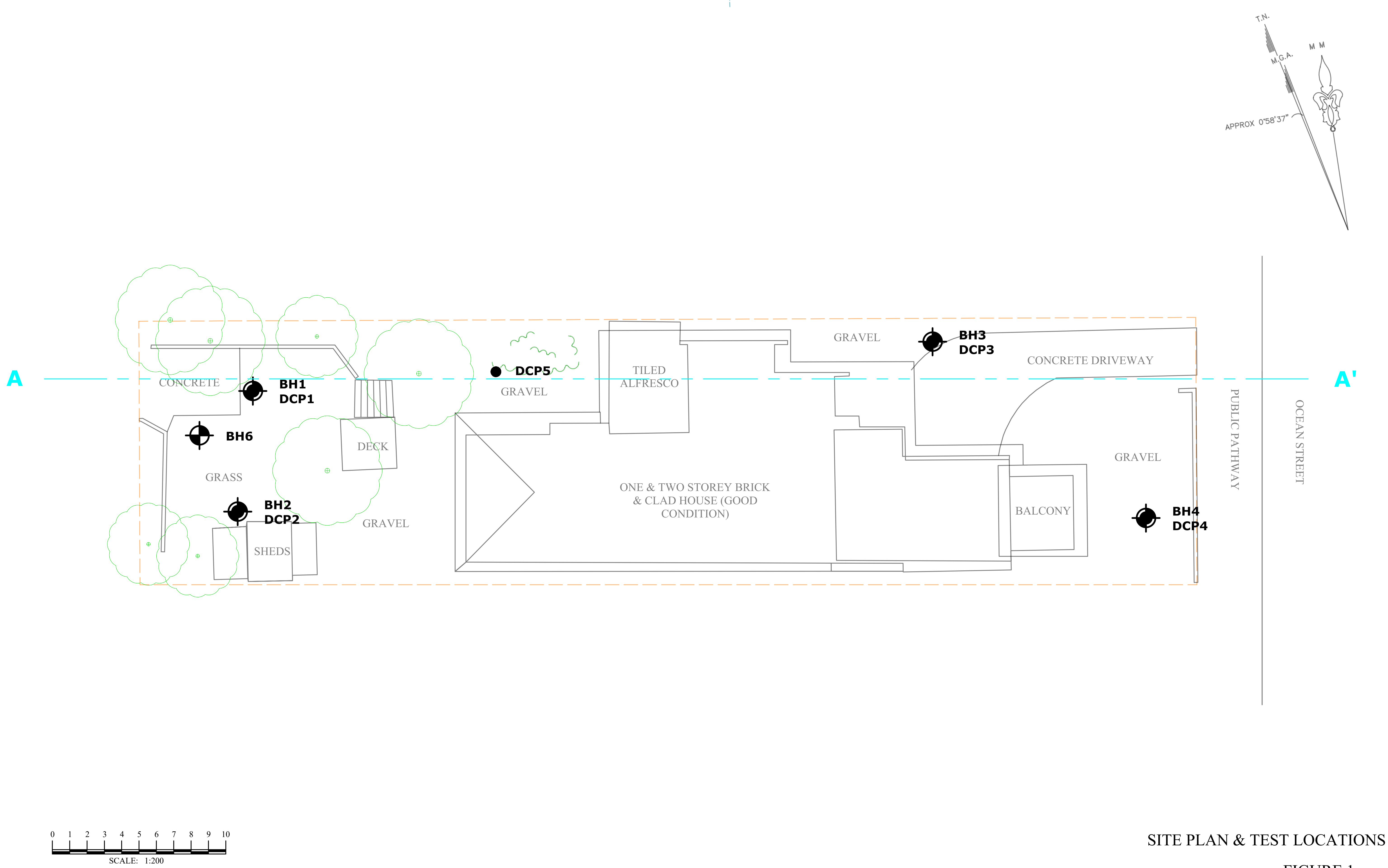
Appendix 2



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

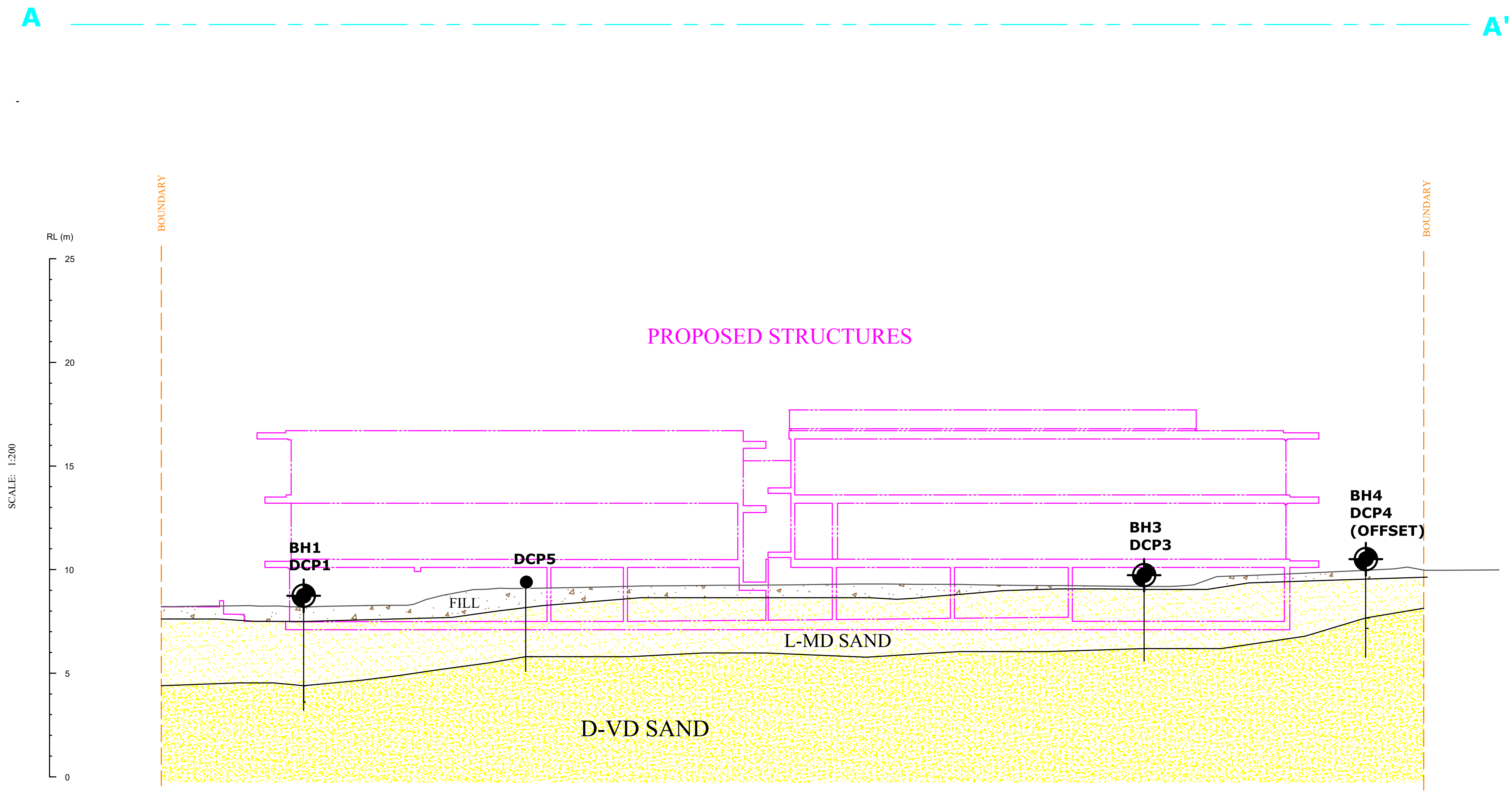
LEGEND

BH DCP	AUGER / DYNAMIC CONE PENETROMETER LOCATION
BH	AUGER LOCATION FOR INFILTRATION TEST
DCP	DYNAMIC CONE PENETROMETER
A —— A'	CROSS-SECTION REFERENCE LINE
(orange dashed line)	PROPERTY BOUNDARY
(green line)	TREES

SCALE:	1:200 @ A3
DRAWING:	FIGURE 1
DATE:	8/04/2021
APPROVED BY:	TMC
DRAWN BY:	JC
PROJECT:	2021-073

PREPARED FOR:
TRIO INDUSTRIES PTY/LTD

ADDRESS:
142 OCEAN STREET,
NARRABEEN



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

Crozier Geotechnical
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LEGEND

- BH DCP — AUGER / DYNAMIC CONE PENETROMETER LOCATION
- DCP — DYNAMIC CONE PENETROMETER
- A — A' — CROSS-SECTION REFERENCE LINE
- PROPOSED DEVELOPMENT
- PROPERTY BOUNDARY
- DENSE TO VERY DENSE SAND
- EXISTING GROUND SURFACE
- FILL
- VERY LOOSE TO MEDIUM DENSE SAND

SCALE:	1:200 @ A3
DRAWING:	FIGURE 2
DATE:	8/04/2021
APPROVED BY:	TMC
DRAWN BY:	JC
PROJECT:	2021-073

PREPARED FOR:
TRIO INDUSTRIES PTY/LTD

ADDRESS:
142 OCEAN STREET,
NARRABEEN

BOREHOLE LOG

CLIENT: Trio Industries Pty Ltd **DATE:** 1/04/2021 **BORE No.:** 1

PROJECT: Demolition of existing house and construction of new apartment block **PROJECT No.:** 2021-073 **SHEET:** 1 of 1

LOCATION: 142 Ocean Street, Narrabeen **SURFACE LEVEL:** RL= 8.17m

Depth (m)	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling		In Situ Testing	
			Type	Tests	Type	Results
0.00		FILL/TOPSOIL: Brown, moist, silty sand topsoil trace gravel and roots				
0.70	SP	SAND: Medium dense, orange brown, medium grained, moist, sand				
2.20		…orange-yellow brown				
3.00		…pale brown				
3.80		dense				
4.60		…very dense				
5.00		END OF BOREHOLE @ 5.0m depth				

RIG: N/A DRILLER: JD

METHOD: Hand Auger LOGGED: JC

GROUND WATER OBSERVATIONS: None encountered during auger drilling

REMARKS: CHECKED: TMC

BOREHOLE LOG

CLIENT: Trio Industries Pty Ltd
DATE: 1/04/2021
BORE No.: 2

PROJECT: Demolition of existing house and construction of new apartment block
PROJECT No.: 2021-073
SHEET: 1 of 1

LOCATION: 142 Ocean Street, Narrabeen
SURFACE LEVEL: RL= 8.30m

Depth (m)	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling Type	Sampling Tests	In Situ Testing Type	In Situ Testing Results
0.00		FILL/TOPSOIL: Brown, moist, silty sand topsoil trace rootlets				
				0.50		
0.60			D	0.60		
	SP	SAND: Medium dense, orange brown, medium grained,				
				1.00		
			D	1.10		
				1.50		
			D	1.60		
				2.00		
2.10		…yellow brown	D	2.10		
				2.40		
			D	2.50		
2.90		…pale brown, trace fine quartz gravel		2.90		
3.00			D	3.00		
		END OF BOREHOLE @ 3.0m depth				

RIG: N/A
DRILLER: JD

METHOD: Hand Auger
LOGGED: JC

GROUND WATER OBSERVATIONS: None encountered during auger drilling

REMARKS:
CHECKED: TMC

BOREHOLE LOG

CLIENT: Trio Industries Pty Ltd | **DATE:** 1/04/2021 | **BORE No.:** 3

PROJECT: Demolition of existing house and construction of new apartment block | **PROJECT No.:** 2021-073 | **SHEET:** 1 of 1

LOCATION: 142 Ocean Street, Narrabeen | **SURFACE LEVEL:** RL= 9.50m

Depth (m)	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling		In Situ Testing	
			Type	Tests	Type	Results
0.00		FILL: Medium to coarse grained gravel with silty sand				
0.15	SP	SAND: Loose, orange brown, medium grained, moist, sand				
0.50		…medium dense				
1.70		…pale brown				
3.00		END OF BOREHOLE @ 3.0m depth				

RIG: N/A

DRILLER: JD

METHOD: Hand Auger

LOGGED: JC

GROUND WATER OBSERVATIONS: None encountered during auger drilling

REMARKS:

CHECKED: TMC

BOREHOLE LOG

CLIENT: Trio Industries Pty Ltd **DATE:** 1/04/2021 **BORE No.:** 4

PROJECT: Demolition of existing house and construction of new apartment block **PROJECT No.:** 2021-073 **SHEET:** 1 of 1

LOCATION: 142 Ocean Street, Narrabeen **SURFACE LEVEL:** RL= 9.95m

Depth (m) 0.00	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling Type	Sampling Tests	In Situ Testing Type	In Situ Testing Results
		FILL: Medium to coarse gravel with silty sand				
0.10		…brown, silty sand				
0.30		SAND: Medium dense, orange brown, medium grained, moist, sand	D	0.50 0.60		
			D	1.00 1.10		
1.50		…yellow brown	D	1.50 1.60		
			D	2.00 2.10		
2.40		…dense, pale brown, trace shell fragment and fine quartz gravel	D	2.50 2.60		
2.80		…very dense	D	3.00 3.10		
			D	3.50 3.60		
			D	4.00 4.10		
			D	4.50 4.60		
4.80		END OF BOREHOLE @ 4.8m				

RIG: N/A DRILLER: JD

METHOD: Hand Auger LOGGED: JC

GROUND WATER OBSERVATIONS: None encountered during auger drilling

REMARKS: CHECKED: TMC

BOREHOLE LOG

CLIENT: Trio Industries Pty Ltd **DATE:** 1/04/2021 **BORE No.:** 5

PROJECT: Demolition of existing house and construction of new apartment block **PROJECT No.:** 2021-073 **SHEET:** 1 of 1

LOCATION: 142 Ocean Street, Narrabeen **SURFACE LEVEL:** RL= 8.25m

Depth (m)	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling		In Situ Testing	
0.00			Type	Tests	Type	Results
		FILL: Medium to coarse grained gravel with silty sand				
0.50	SP	SAND: Orange brown, medium grained, moist, sand				
0.65		END OF BOREHOLE @ 0.65m depth within natural sand				

RIG: N/A DRILLER: JD

METHOD: Hand Auger LOGGED: JC

GROUND WATER OBSERVATIONS: None encountered during auger drilling

REMARKS: Borehole used for infiltration test CHECKED: TMC

DYNAMIC PENETROMETER TEST SHEET

CLIENT: Trio Industries Pty Ltd **DATE:** 1/04/2021

PROJECT: Demolition of existing house and construction of new apartment block **PROJECT No.:** 2021-073

LOCATION: 142 Ocean Street, Narrabeen **SHEET:** 1 of 2

	Test Location							
Depth (m)	DCP1	DCP2	DCP3	DCP4	DCP5			
0.00 - 0.10	0	0	--	5	1			
0.10 - 0.20	1	1	2	2	1			
0.20 - 0.30	1	1	2	4	1			
0.30 - 0.40	0	2	2	3	1			
0.40 - 0.50	1	2	4	3	2			
0.50 - 0.60	2	3	3	4	2			
0.60 - 0.70	2	4	4	4	3			
0.70 - 0.80	2	4	3	3	4			
0.80 - 0.90	3	3	3	3	5			
0.90 - 1.00	3	3	4	3	6			
1.00 - 1.10	3	4	3	3	5			
1.10 - 1.20	2	3	3	4	5			
1.20 - 1.30	3	3	4	4	5			
1.30 - 1.40	4	2	3	4	5			
1.40 - 1.50	3	2	4	4	5			
1.50 - 1.60	4	3	3	4	5			
1.60 - 1.70	5	3	3	3	5			
1.70 - 1.80	4	2	3	4	6			
1.80 - 1.90	4	3	2	3	6			
1.90 - 2.00	4	3	3	4	7			
2.00 - 2.10	5	2	2	4	6			
2.10 - 2.20	4	3	2	5	6			
2.20 - 2.30	5	2	3	7	5			
2.30 - 2.40	6	2	3	7	5			
2.40 - 2.50	6	2	3	8	5			
2.50 - 2.60	6	1	2	9	5			
2.60 -2.70	5	2	4	8	5			
2.70 - 2.80	6	1	8	10	4			
2.80 - 2.90	6	2	7	14	5			
2.90 - 3.00	5	2	9	14	5			

DYNAMIC PENETROMETER TEST SHEET

CLIENT: Trio Industries Pty Ltd **DATE:** 1/04/2021

PROJECT: Demolition of existing house and construction of new apartment block **PROJECT No.:** 2021-073

LOCATION: 142 Ocean Street, Narrabeen **SHEET:** 2 of 2

	Test Location							
Depth (m)	DCP1	DCP2	DCP3	DCP4	DCP5			
3.00 - 3.10	5	2	9	12	6			
3.10 - 3.20	4	3	9	10	7			
3.20 - 3.30	4	4	11	10	9			
3.30 - 3.40	4	5	11	11	7			
3.40 - 3.50	4	5	13	12	7			
3.50 - 3.60	3	6	15	8	9			
3.60 - 3.70	4	7	END	12	9			
3.70 - 3.80	5	8		13	12			
3.80 - 3.90	8	7		15	15			
3.90 - 4.00	7	END		14	END			
4.00 - 4.10	8			17				
4.10 - 4.20	8			21				
4.20 - 4.30	9			END				
4.30 - 4.40	9							
4.40 - 4.50	9							
4.50 - 4.60	10							
4.60 - 4.70	10							
4.70 - 4.80	11							
4.80 - 4.90	15							
4.90 - 5.00	END							
5.00 - 5.10								
5.10 - 5.20								
5.20 - 5.30								
5.30 - 5.40								
5.40 - 5.50								
5.50 - 5.60								
5.60 - 5.70								
5.70 - 5.80								
5.80 - 5.90								
5.90 - 6.00								

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Appendix 3

TABLE : A

Landslide risk assessment for Risk to life

HAZARD	Description	Impacting	Likelihood of Slide	Spatial Impact of Slide		Occupancy	Evacuation	Vulnerability	Risk to Life
A	Landslip (soil slide ≤5m³) at crest of excavation for lower ground floor level		Excavation to 2.5m depth through sandy soils	a) House 1.5m from 2.5m deep excavation, impacted 10% b) Apartment block 3.5m from 2.5m deep excavarion, impacted 2% c) Garage and driveway 6.0m from 2.5m excavation, impacted 1% d) Road reserve adjacent to driveway excavation, however excavation grading from nil to 2.5m over 6.0m lateral distance, away from road reserve		a) Person in house 16hrs/day avge. b) Person in apartment block 20hr/day avge. c) Person in garage or on driveway 2hrs/day avge. d) Person on public pathway 1hr/day avge.	a) Possible to not evacuate b) Possible to not evacuate c) Possible to not evacuate d) likely to evacuate	a) Person in building minor damage only b) Person in building minor damage only c) Person in open space, possible buried d) Person in open space, unlikley buried	
			Possible	**Prob. of Impact**	**Impacted**				
		a) House No.140 Ocean Street	0.001	0.30	0.10	0.6667	0.5	0.01	**1.00E-07**
		b) Apartment block No.144 Ocean Street	0.001	0.05	0.10	0.8333	0.5	0.01	**2.08E-08**
		c) Garage and rear of driveway No. 59 Lagoon Street	0.001	0.01	0.05	0.0833	0.4	0.50	**8.33E-09**
		d) Road Reserve	0.001	0.40	0.10	0.0417	0.25	0.25	**1.04E-07**

* evacuation scale from Almost Certain to not evacuate (1.0), Likely (0.75), Possible (0.5), Unlikely (0.25), Rare to not evacuate (0.01). Based on likelihood of person knowing of landslide and completely evacuating area prior to landslide impact.

* vulnerability assessed using Appendix F - AGS Practice Note Guidelines for Landslide Risk Management 2007

TABLE : B

Landslide risk assessment for Risk to Property

HAZARD	Description	Impacting	Likelihood		Consequences		Risk to Property
A	Landslip (earth slide 5m³) from soils at crest of excavation for lower ground floor	a) House No.140 Ocean Street	Possible	The event could occur under adverse conditions over the design life.	Medium	Moderate damage to some of structure or significant part of site, requires large stabilising works or MINOR damage to neighbouring property.	Moderate
		b) Apartment block No.144 Ocean Street	Possible	The event could occur under adverse conditions over the design life.	Medium	Moderate damage to some of structure or significant part of site, requires large stabilising works or MINOR damage to neighbouring property.	Low
		c) Garage and rear of driveway No. 59 Lagoon Street	Unlikely	The event might occur under very adverse circumstances over the design life.	Minor	Limited Damage to part of structure or site requires some stabilisation or INSIGNIFICANT damage to neighbouring properties.	Low
		d) Road Reserve	Possible	The event could occur under adverse conditions over the design life.	Minor	Limited Damage to part of structure or site requires some stabilisation or INSIGNIFICANT damage to neighbouring properties.	Low

* hazards considered in current condition, without remedial/stabilisation measures and during construction works.
* qualitative expression of likelihood incorporates both frequency analysis estimate and spatial impact probability estimate as per AGS guidelines.
* qualitative measures of consequences to property assessed per Appendix C in AGS Guidelines for Landslide Risk Management.
* Indicative cost of damage expressed as cost of site development with respect to consequence values: Catastrophic : 200%, Major: 60%, Medium: 20%, Minor: 5%, Insignificant: 0.5%.

Appendix 4

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CERTIFICATE OF ANALYSIS 265725

Client Details

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

Sample Details

Your Reference	**2021-073 Narrabeen, 142 Ocean St**
Number of Samples	4 Soil
Date samples received	01/04/2021
Date completed instructions received	01/04/2021

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	12/04/2021
Date of Issue	12/04/2021

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

Authorised By

Nancy Zhang, Laboratory Manager

Misc Inorg - Soil					
Our Reference		265725-1	265725-2	265725-3	265725-4
Your Reference	UNITS	BH4	BH2	BH4	BH2
Depth		4.5-4.6m	2.9-3.0m	2.5-2.6m	1.0-1.1m
Date Sampled		01/04/2021	01/04/2021	01/04/2021	01/04/2021
Type of sample		Soil	Soil	Soil	Soil
Date prepared	-	07/04/2021	07/04/2021	07/04/2021	07/04/2021
Date analysed	-	07/04/2021	07/04/2021	07/04/2021	07/04/2021
pH 1:5 soil:water	pH Units	9.6	9.5	9.5	8.0

sPOCAS field test					
Our Reference		265725-1	265725-2	265725-3	265725-4
Your Reference	UNITS	BH4	BH2	BH4	BH2
Depth		4.5-4.6m	2.9-3.0m	2.5-2.6m	1.0-1.1m
Date Sampled		01/04/2021	01/04/2021	01/04/2021	01/04/2021
Type of sample		Soil	Soil	Soil	Soil
Date prepared	-	06/04/2021	06/04/2021	06/04/2021	06/04/2021
Date analysed	-	06/04/2021	06/04/2021	06/04/2021	06/04/2021
pH_F (field pH test)*	pH Units	8.7	8.7	8.7	8.2
pH_{FOX} (field peroxide test)*	pH Units	9.2	9.5	7.6	5.5
Reaction Rate*	-	Volcanic reaction	High reaction	Medium reaction	Medium reaction

sPOCAS + %S w/w		
Our Reference		265725-1
Your Reference	UNITS	BH4
Depth		4.5-4.6m
Date Sampled		01/04/2021
Type of sample		Soil
Date prepared	-	06/04/2021
Date analysed	-	06/04/2021
pH_{kcl}	pH units	9.7
TAA pH 6.5	moles H^+ /t	<5
s-TAA pH 6.5	%w/w S	<0.01
pH_{Ox}	pH units	8.2
TPA pH 6.5	moles H^+ /t	<5
s-TPA pH 6.5	%w/w S	<0.01
TSA pH 6.5	moles H^+ /t	<5
s-TSA pH 6.5	%w/w S	<0.01
ANC_E	% $CaCO_3$	5.5
a-ANC_E	moles H^+ /t	1,100
s-ANC_E	%w/w S	1.8
S_{KCl}	%w/w S	<0.005
S_P	%w/w	0.007
S_{POS}	%w/w	0.007
a-S_{POS}	moles H^+ /t	<5
Ca_{KCl}	%w/w	0.11
Ca_P	%w/w	2.0
Ca_A	%w/w	1.9
Mg_{KCl}	%w/w	0.007
Mg_P	%w/w	0.093
Mg_A	%w/w	0.086
S_{HCl}	%w/w S	[NT]
S_{NAS}	%w/w S	[NT]
a-S_{NAS}	moles H^+ /t	[NT]
s-S_{NAS}	%w/w S	[NT]
Fineness Factor	-	1.5
a-Net Acidity	moles H^+ /t	<5
s-Net Acidity	%w/w S	<0.01
Liming rate	kg $CaCO_3$ /t	<0.75
s-Net Acidity without -ANCE	%w/w S	<0.01
a-Net Acidity without ANCE	moles H^+ /t	<5
Liming rate without ANCE	kg $CaCO_3$ /t	<0.75

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-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.

QUALITY CONTROL: Misc Inorg - Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			07/04/2021	[NT]	[NT]	[NT]	[NT]	07/04/2021	[NT]
Date analysed	-			07/04/2021	[NT]	[NT]	[NT]	[NT]	07/04/2021	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	[NT]	[NT]	101	[NT]

QUALITY CONTROL: sPOCAS + %S w/w					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			06/04/2021	[NT]	[NT]	[NT]	[NT]	06/04/2021	[NT]
Date analysed	-			06/04/2021	[NT]	[NT]	[NT]	[NT]	06/04/2021	[NT]
pH $_{kcl}$	pH units		Inorg-064	[NT]	[NT]	[NT]	[NT]	[NT]	96	[NT]
TAA pH 6.5	moles H^+/t	5	Inorg-064	<5	[NT]	[NT]	[NT]	[NT]	100	[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]	110	[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]

QUALITY CONTROL: sPOCAS + %S w/w					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
a-Net Acidity without ANCE	moles H^+/t	5	Inorg-064	<5	[NT]	[NT]	[NT]	[NT]	[NT]	[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.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

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 (not SPOCAS); 60-140% for organics/SPOCAS (+/-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.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

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Appendix 5

APPENDIX A

DEFINITION OF TERMS

INTERNATIONAL UNION OF GEOLOGICAL SCIENCES WORKING GROUP ON LANDSLIDES, COMMITTEE ON RISK ASSESSMENT

Risk – A measure of the probability and severity of an adverse effect to health, property or the environment. Risk is often estimated by the product of probability x consequences. However, a more general interpretation of risk involves a comparison of the probability and consequences in a non-product form.

Hazard – A condition with the potential for causing an undesirable consequence (*the landslide*). The description of landslide hazard should include the location, volume (or area), classification and velocity of the potential landslides and any resultant detached material, and the likelihood of their occurrence within a given period of time.

Elements at Risk – Meaning the population, buildings and engineering works, economic activities, public services utilities, infrastructure and environmental features in the area potentially affected by landslides.

Probability – The likelihood of a specific outcome, measured by the ratio of specific outcomes to the total number of possible outcomes. Probability is expressed as a number between 0 and 1, with 0 indicating an impossible outcome, and 1 indicating that an outcome is certain.

Frequency – A measure of likelihood expressed as the number of occurrences of an event in a given time. See also Likelihood and Probability.

Likelihood – used as a qualitative description of probability or frequency.

Temporal Probability – The probability that the element at risk is in the area affected by the landsliding, at the time of the landslide.

Vulnerability – The degree of loss to a given element or set of elements within the area affected by the landslide hazard. It is expressed on a scale of 0 (no loss) to 1 (total loss). For property, the loss will be the value of the damage relative to the value of the property; for persons, it will be the probability that a particular life (the element at risk) will be lost, given the person(s) is affected by the landslide.

Consequence – The outcomes or potential outcomes arising from the occurrence of a landslide expressed qualitatively or quantitatively, in terms of loss, disadvantage or gain, damage, injury or loss of life.

Risk Analysis – The use of available information to estimate the risk to individuals or populations, property, or the environment, from hazards. Risk analyses generally contain the following steps: scope definition, hazard identification, and risk estimation.

Risk Estimation – The process used to produce a measure of the level of health, property, or environmental risks being analysed. Risk estimation contains the following steps: frequency analysis, consequence analysis, and their integration.

Risk Evaluation – The stage at which values and judgements enter the decision process, explicitly or implicitly, by including consideration of the importance of the estimated risks and the associated social, environmental, and economic consequences, in order to identify a range of alternatives for managing the risks.

Risk Assessment – The process of risk analysis and risk evaluation.

Risk Control or Risk Treatment – The process of decision making for managing risk, and the implementation, or enforcement of risk mitigation measures and the re-evaluation of its effectiveness from time to time, using the results of risk assessment as one input.

Risk Management – The complete process of risk assessment and risk control (*or risk treatment*).

Individual Risk – The risk of fatality or injury to any identifiable (named) individual who lives within the zone impacted by the landslide; or who follows a particular pattern of life that might subject him or her to the consequences of the landslide.

Societal Risk – The risk of multiple fatalities or injuries in society as a whole: one where society would have to carry the burden of a landslide causing a number of deaths, injuries, financial, environmental, and other losses.

Acceptable Risk – A risk for which, for the purposes of life or work, we are prepared to accept as it is with no regard to its management. Society does not generally consider expenditure in further reducing such risks justifiable.

Tolerable Risk – A risk that society is willing to live with so as to secure certain net benefits in the confidence that it is being properly controlled, kept under review and further reduced as and when possible.

In some situations risk may be tolerated because the individuals at risk cannot afford to reduce risk even though they recognise it is not properly controlled.

Landslide Intensity – A set of spatially distributed parameters related to the destructive power of a landslide. The parameters may be described quantitatively or qualitatively and may include maximum movement velocity, total displacement, differential displacement, depth of the moving mass, peak discharge per unit width, kinetic energy per unit area.

Note: Reference should also be made to Figure 1 which shows the inter-relationship of many of these terms and the relevant portion of Landslide Risk Management.

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval		Description	Descriptor	Level
Indicative Value	Notional Boundary					
10^{-1}	$5x10^{-2}$	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	$5x10^{-3}$	100 years	200 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	$5x10^{-4}$	1000 years	2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	$5x10^{-5}$	10,000 years	20,000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	$5x10^{-6}$	100,000 years	200,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}		1,000,000 years		The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

Note: (1) The table should be used from left to right; use Approximate Annual Probability or Description to assign Descriptor, not *vice versa*.

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Approximate Cost of Damage		Description	Descriptor	Level
Indicative Value	Notional Boundary			
200%	100%	Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.	CATASTROPHIC	1
60%	40%	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.	MAJOR	2
20%	10%	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.	MEDIUM	3
5%	1%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%		Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5

Notes: (2) The Approximate Cost of Damage is expressed as a percentage of market value, being the cost of the improved value of the unaffected property which includes the land plus the unaffected structures.

(3) The Approximate Cost is to be an estimate of the direct cost of the damage, such as the cost of reinstatement of the damaged portion of the property (land plus structures), stabilisation works required to render the site to tolerable risk level for the landslide which has occurred and professional design fees, and consequential costs such as legal fees, temporary accommodation. It does not include additional stabilisation works to address other landslides which may affect the property.

(4) The table should be used from left to right; use Approximate Cost of Damage or Description to assign Descriptor, not vice versa

APPENDIX C: – QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (CONTINUED)

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	**1: CATASTROPHIC 200%**	**2: MAJOR 60%**	**3: MEDIUM 20%**	**4: MINOR 5%**	**5: INSIGNIFICANT 0.5%**
A – ALMOST CERTAIN	10^{-1}	VH	VH	VH	H	M or **L** (5)
B - LIKELY	10^{-2}	VH	VH	H	M	**L**
C - POSSIBLE	10^{-3}	VH	H	M	M	**VL**
D - UNLIKELY	10^{-4}	H	M	**L**	**L**	**VL**
E - RARE	10^{-5}	M	**L**	**L**	**VL**	**VL**
F - BARELY CREDIBLE	10^{-6}	**L**	**VL**	**VL**	**VL**	**VL**

Notes: (5) For Cell A5, may be subdivided such that a consequence of less than 0.1% is Low Risk.

(6) When considering a risk assessment it must be clearly stated whether it is for existing conditions or with risk control measures which may not be implemented at the current time.

RISK LEVEL IMPLICATIONS

Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.