

REPORT ON GEOTECHNICAL INVESTIGATION

for

PROPOSED NEW RESIDENTIAL APARTMENT BUILDING

at

140-142 OCEAN STREET, NARRABEEN, NSW

Prepared For

Trio Industries Pty Ltd

Project No.: 2021-073.1

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**GEOTECHNICAL REPORT FOR PROPOSED NEW RESIDENTIAL APARTMENT BUILDING
140 - 142 OCEAN STREET, NARRABEEN, NSW**

1. INTRODUCTION:

This report details the results of a geotechnical investigation carried out for a proposed residential apartment building at No.140 - 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 proposed works involve demolition of existing site structures and construction of a new two and three storey apartment block with a basement level garage. The apartment block is to occupy the majority of the site and require bulk excavation to a maximum of approximately 4.8m depth. A concrete driveway will extend from the southeastern corner of the site providing access to the basement level. The new development is to be considered a Class 2 Development as per the Design and Building Practitioners Act 2020.

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 "Class 4".

An initial investigation and reporting were undertaken (Project No.: 2021-073, Dated: 27/04/2021), with a secondary investigation and update to the original report undertaken as per the Proposal P24-432, Dated: 9th September 2024 (Phase 2). The investigation and reporting were prepared to assist in the Development Application and preliminary design and construction tendering.

This update to the original 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.

Phase 1 of the investigation comprised:

- a) A detailed geotechnical inspection and mapping of No.142 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.

Phase 2 of the investigation comprised:

- a) A detailed geotechnical inspection and mapping of No.140 and inspection of adjacent properties by a Geotechnical Engineer.
- b) Drilling of two boreholes using a restricted access drill rig employing solid stem spiral flighted augers with a tungsten carbide bit to identify the subsurface geology
- c) Conducting of Dynamic Cone Penetrometer (DCP) testing at three locations
- d) A photographic record of site conditions
- e) All fieldwork was conducted under the full-time supervision of an experienced Geotechnical Professional

The following plans and drawings were supplied for the work:

- Architectural Drawings – Popov Bass, Project No.: 0649, Drawing No.: DA100 – DA121, Revision: G, Dated: 17/12/2024
- Hydraulic Drawings – Capital Engineering Consultants, SW24372, Drawing No.: SW001, SW010, SW020 – SW022, SW030, SW040, SW050, ER001, Dated: 16/01/2025
- Preliminary Structural Drawings – Capital Engineering Consultants, STA2435, Drawing No.: S1 – S5, Revision: B, Dated: 15/01/2025
- 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 across No.140 and No.142, the merging of the two properties and the subsequent construction of a two and three storey residential apartment building over a basement garage. The basement level (FFL 5.30m) will be accessed via a concrete driveway extending from the southeastern corner of the site. Bulk excavation for the basement level will be required to depths between approximately 3.3m towards the rear and 4.8m towards the front of the site.

The living levels overlying the basement level will be formed with subfloors between the front and rear, these levels will include; Ground Floor A (FFL 8.27m), Ground Floor (FFL 9.94m), Level 01A (FFL 11.37m), Level 01 (13.09m), Level 02A (FFL14.47m) and Level 02 (FFL 16.34m). All levels will be connected via a central northern elevator.

The proposed basement level is to be set back between 2.8m and 3.8m from the northern side boundary, between 1.0m and 4.4m from the southern side boundary, 6.0m from the western rear boundary and 6.2m from the eastern front boundary. Setbacks are anticipated to reduce by at least 300mm during construction due to excavation support, formwork and general excavation process.

3. SITE FEATURES:

3.1. Site Description:

The site includes No.140 and No.142 and is a broadly rectangular shaped block covering an area of 1890m³, with total front east and rear west boundaries of 31.03m and northern and southern side boundaries of 60.90m, 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 No.140 within the southern half of the block and No.142 within the northern half of the block. No.140 contains a single storey clad house with a southern carport positioned towards the front of the block with a grassed lawn located within the rear. No.142 contains a one and two storey brick and clad house

with a grassed lawn within the rear and a concrete driveway extending along the northern boundary. Views of the front of No.142 and No.140 are shown in Photographs 2 and 3.



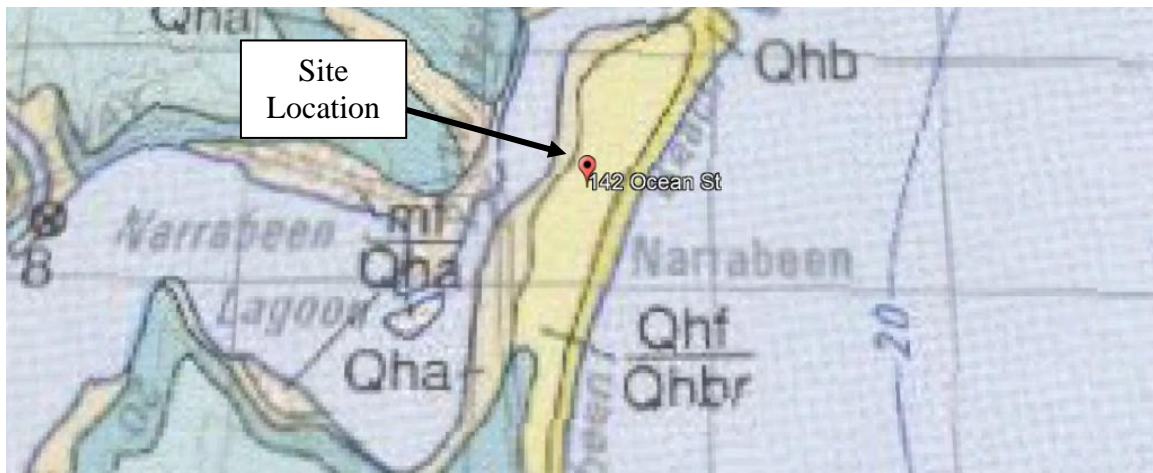
Photograph 2. View of the front of the house within No.142, facing southwest



Photograph 3. View of the front of the house within No.140, facing west

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 as Phase 1 with an additional geotechnical investigation undertaken on the 14th October 2024 by a Geotechnical Engineer as Phase 2 of the investigation. The investigations 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.

Phase 1 of the investigation included the drilling of five auger boreholes (BH1 – BH5) using hand tools to investigate sub-surface geology and collect samples across No. 142 Ocean Street. Phase 2 of the investigation included the drilling of two boreholes (BH6 – BH7) using a restricted access drill rig employing solid stem spiral flighted augers with a tungsten carbide bit to investigate sub-surface geology at No. 140 Ocean Street.

DCP testing was carried out from the ground surface adjacent to the boreholes as well as at two other nominated locations 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 No.142 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, geological models/sections are provided as Figure: 2 and Figure 3, 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 northern portion of the site (No.142) 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 extending from Ocean Street. The front of No.142 contains a gravel car parking area with surrounding low gardens beds, access to the rear is provided along the northern boundary. The rear contains gravel, grass and concrete surfaces, along with a timber deck and metal sheds. A concrete slab is located within the north western corner of the site, with $\leq 0.6\text{m}$ high retained gardens surrounding the slab along the adjacent site boundaries.

The main structure within No.142 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 ($\approx 3-5^\circ$) is located within the rear of No.142 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 4.

Stormwater drainage and gutter systems were observed across the main structure within No.142, 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 5, however no determined erosion appeared related to these issues. A Sydney Water (SW) sewer main intersects the south western portion of the site. Based on available DBYD information it is understood the sewer main comprises a 450mm diameter vitrified clay pipe.



Photograph 4: Timber deck within rear of site, with rotation/rotting of timber planks and minor settlement evident, facing south west



Photograph 5: Fault opening in PVC stormwater down pipe along southern external wall of site house, facing north east

The southern portion of the site (No.140) contains a single storey clad dwelling supported by low brick piers with a fibro garage connected to the southwestern portion of the dwelling. The main dwelling is of an estimated 1930's construction age and is in a fair condition with deterioration of timber members identified across the structure and minor deflection of some brick piers. However, no major cracking or settlement was identified across the main structure.

The fibro garage structure within No.140 is accessed via a concrete driveway extending along the southern side boundary, this driveway is in a poor condition with major cracking and settlement identified across the pavement, as shown in Photograph 5. The front portion of No.140 contains a grassed lawn with a pedestrian access paved pathway extending from the front boundary.

The rear of No.140 contains a large grassed lawn, garden and paved area to the immediate west of the main structure with a low retained concrete block retaining wall ($\leq 0.20\text{m}$ high) positioned centrally. The rear of the garage structure extends into a rear shed and is in a dilapidated condition, as shown in Photograph 6.



Photograph 5: Cracking within front driveway concrete pavement (No.140), facing west



Photograph 6: Rear of garage structure (No.140) in a dilapidated condition, facing east

The neighbouring property to the south (No.138 Ocean Street) contains a two storey residential apartment building with a basement level garage which occupies the majority of the block. The structure appeared to be in a good condition with no visible signs of cracking or settlement. The property is at the approximate same level as the site with low retaining walls ($\leq 1.0\text{m}$ high) positioned adjacent to the common boundary with the site positioned towards the rear western end.

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.

Two properties neighbour the site to the west (No.59 Lagoon Street and No.53-55 Lagoon Street). No.59 Lagoon Street contains a two storey brick apartment building positioned broadly towards the front of the block with a concrete driveway and parking area positioned within the rear. A single storey brick garage structure is located within the rear of the property and extends to 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. No.53-55 Lagoon Street contains a two storey rendered apartment building with a basement level garage. The main structure appeared to be in a good condition with no visible signs of cracking or settlement issues.

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, greater depths of fill were generally encountered within No.142.
- **SAND** – Natural sand was encountered in all boreholes underlying the fill soils, to a maximum drilled depth of 8.50m depth (BH6 & BH7), in which the boreholes were terminated. The deposit comprised very loose grading to very dense, orange brown grading to pale brown, medium grained, moist, sand with some weakly cemented sand layers. Minor shell fragments and fine quartz sub rounded gravel were identified at varying depths within the boreholes.

A free standing ground water table or significant water seepage were not identified within any of the boreholes.

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 CaCO ₃ / 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 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 $\approx 411\text{mm}$ of rainfall in the 28 days preceding the investigation. This is significantly higher than the average $\approx 165\text{mm}$ 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 $\geq 8.0\text{m}$ 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: $\geq 2\text{m}$
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 0.10m depth (BH6) to a maximum drilled depth of 8.50m (BH6 & BH7). All boreholes and DCP tests were terminated in dense to very dense sand between 3.0m and 8.5m 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, the merging of the two properties and the construction of a three storey residential apartment building with a basement level garage. Bulk excavation will be required to approximately 4.8m depth, with the proposed basement level setback a minimum of 1.0m from the southern side boundary, a minimum of 2.8m from the northern side boundary and approximately 6.0m from the front and rear boundaries.

Based on the investigation it is anticipated that only fill and natural sand soils will be intersected during 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, temporary safe batter slopes of 1.5:1 do not appear feasible along the northern, southern or eastern sides of the excavation.

Where batter slopes are not feasible, support prior to excavation will be required. It is recommended that contiguous pile (or similar) shoring walls are utilised to provide permanent excavation support. Batter slopes at the rear western end of the excavation appear to be achievable however it would be prudent to extend the shoring walls around the perimeter of the excavation.

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.

It is recommended that all footings extend to bear within very dense sand. From the investigation results it appears that the excavation will largely extend into this layer. Section 5.3.2 provides preliminary allowable bearing pressures.

Due to the soil conditions underlying the site, the contiguous piles would need to be fully encased bored piles or CFA piles to mitigate the chance of pile hole collapse within the sandy soils. From the DCP results

it is considered that the natural sand deposit grades from very loose to very dense, with very dense soils identified from a minimum of 2.80m depth (DCP4) and a maximum 4.60m depth (DCP1). Weakly cemented sands were also identified in intermittent layers from 5.80m depth (BH6). Where higher bearing pressures are required for structural design further analysis can be undertaken.

The SW sewer main which intersects the rear of the site appears to underlie the proposed building footprint. CGC have not undertaken any investigation into the construction/type/depth etc, of the sewer however DBYD plan indicates it is a 450mm diameter Vitreous Clay style pipe with nearby invert levels between 2.225m to the southeast and 4.75m depth to the northwest. 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, 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 (soil slide $\leq 6.0\text{m}^3$) at crest of excavation for basement level.

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 8.33×10^{-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 <i>Structural design actions AS1170.4 – 2007, Part 4: Earthquake actions in Australia</i>	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 very dense soils, 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 soils for 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			Between 3.3m and 4.8m depth for basement level		
Property Separation:					
The table below shows the properties potentially affected by the proposed excavation, excavation depth and the separation distances to the shared property boundary/structure.					
<i>Table 1: Property separation distances</i>					
Boundary	Property	Structure	Bulk Excavation Depth (m bgl)	Separation Distances (m)*	
				Boundary	Structure
North	No.144 Ocean Street	Apartment building	3.3m - 4.8m	2.8m – 3.8m	Garden/lawn adjacent to boundary, structure a further 2.8m.
South	No.138 Ocean Street	Apartment building	3.3m - 4.8m	1.0m – 4.4m	Gardens and low retaining walls adjacent to boundary, structure a further 4.2m to 5.9m.
East	Ocean Street road reserve	Nature strip, pathway and road pavement	4.8m	6.2m	Nature strip and pathway adjacent to boundary, road pavement a further 3.5m.
West	No.59 Lagoon Street	Driveway and garage structure	3.3m	6.0m	Driveway and garage adjacent to boundary
West	No.53-55 Lagoon Street	Apartment building	3.3m	6.0m	Gardens adjacent to boundary, main structure a further 6.0m
Type of material to be excavated			Up to 0.7m depth		Topsoil/fill
			from minimum of 0.10m to excavation base		Natural sand (VL – VD)

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: <ul style="list-style-type: none"> • 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 basement 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/m ³)	Long Term (Drained)	Earth Pressure Coefficients		Passive Earth Pressure Coefficient * (K _p)
			Active (K _a)	At Rest (K ₀)	
Very loose/loose fill and natural soils	16	$\phi' = 26^\circ$	0.39	0.56	N/A
Medium dense sand	18	$\phi' = 30^\circ$	0.33	0.50	3.0
Dense sand	20	$\phi' = 36^\circ$	0.26	0.41	3.9
Very dense sand	21	$\phi' = 39^\circ$	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 (K _a). 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 (see Section 4.5)
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 0.10m depth (BH6) to a maximum drilled depth of 8.50m (BH6 & BH7). Very dense sand is interpreted to underlie the site from between 2.8m depth (DCP4) and 4.6m depth (DCP1). No signs of seepage or a freestanding groundwater table were identified in any of the boreholes or on any of the retrieved DCP rods.

It is understood that the proposed works involve demolition of existing site structures with construction of a new two and three storey apartment block with a basement level garage. The apartment block is to occupy the majority of the site and require bulk excavation to a maximum of approximately 4.8m depth.

Careful consideration should be taken during the excavation phase for the basement level to maintain excavation and boundary stability. 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 appear to be feasible along the rear western excavation face, 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 300kPa. Where higher bearing pressure values are required

for structural design CGC may undertake additional analysis. Geotechnical testing will be required once footings have been excavated to confirm founding conditions in respect to Structural requirements, as per Section 5.4 of this report.

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.

Prepared By:



Josh Cotton
Geotechnical Engineer

Reviewed By:



Troy Crozier
Principal
MIE Aust. MAIG. CPEng (NER)
RPGeo: Geotechnical and Engineering

7. REFERENCES:

1. Australian Geomechanics Society 2007, "Landslide Risk Assessment and Management", Australian Geomechanics Journal Vol. 42, No 1, March 2007.
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

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:

<u>Soil Classification</u>	<u>Particle Size</u>
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:

<u>Classification</u>	<u>Undrained Shear Strength kPa</u>
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:

<u>Relative Density</u>	<u>SPT "N" Value (blows/300mm)</u>	<u>CPT Cone Value (Qc - MPa)</u>
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 separate 130mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected by 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: -

$$Q_c \text{ (MPa)} = (0.4 \text{ to } 0.6) N \text{ blows (blows per 300mm)}$$

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

$$Q_c = (12 \text{ to } 18) C_u$$

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.

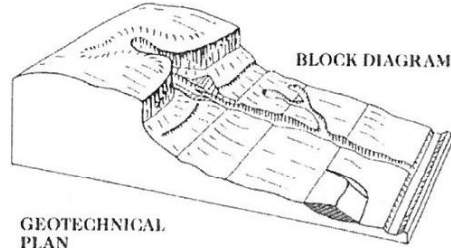
Reproduction of Information for Contractual Purposes

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.

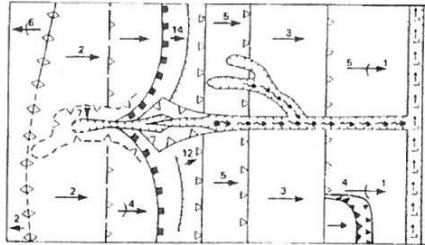
Site Inspection

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.

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007



GEOTECHNICAL PLAN



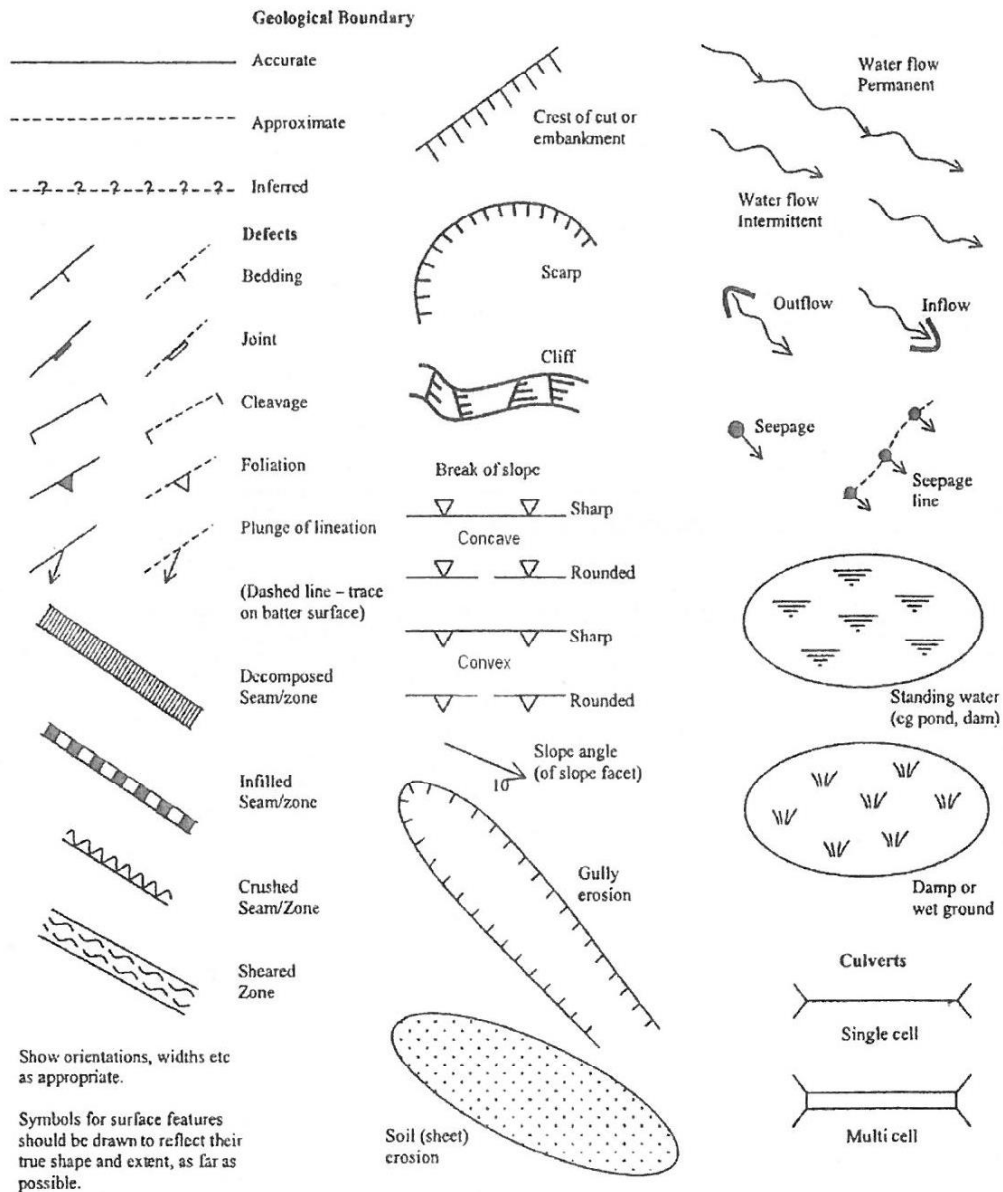
SYMBOL	GROUND PROFILE		
		Convex	Well defined or angular break of slope
		Concave	
		Convex	Poorly defined or smooth change of slope
		Concave	
		Breaks of slope	Convex and concave too close together to allow the use of separate symbols
		Changes of slope	
		Sharp	Ridge crest
		Rounded	
		Cliff or escarpment or sharp break 40° or more (estimated height in metres)	
		Uniform slope	Slope direction and angle (Degrees)
		Concave slope	
		Convex slope	
		Top	Cut or fill slope, arrows pointing down slope
		Bottom	
		Hummocky or irregular ground	
		Open drain, unlined	
		Open drain, lined	
		Fence line	
		Property boundary	
		Dry stone wall	
		Major joint in rock face (opening in millimetres)	
		Tension crack (opening in millimetres)	

Example of Mapping Symbols

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

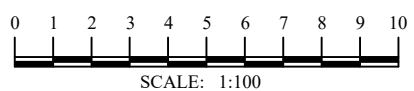
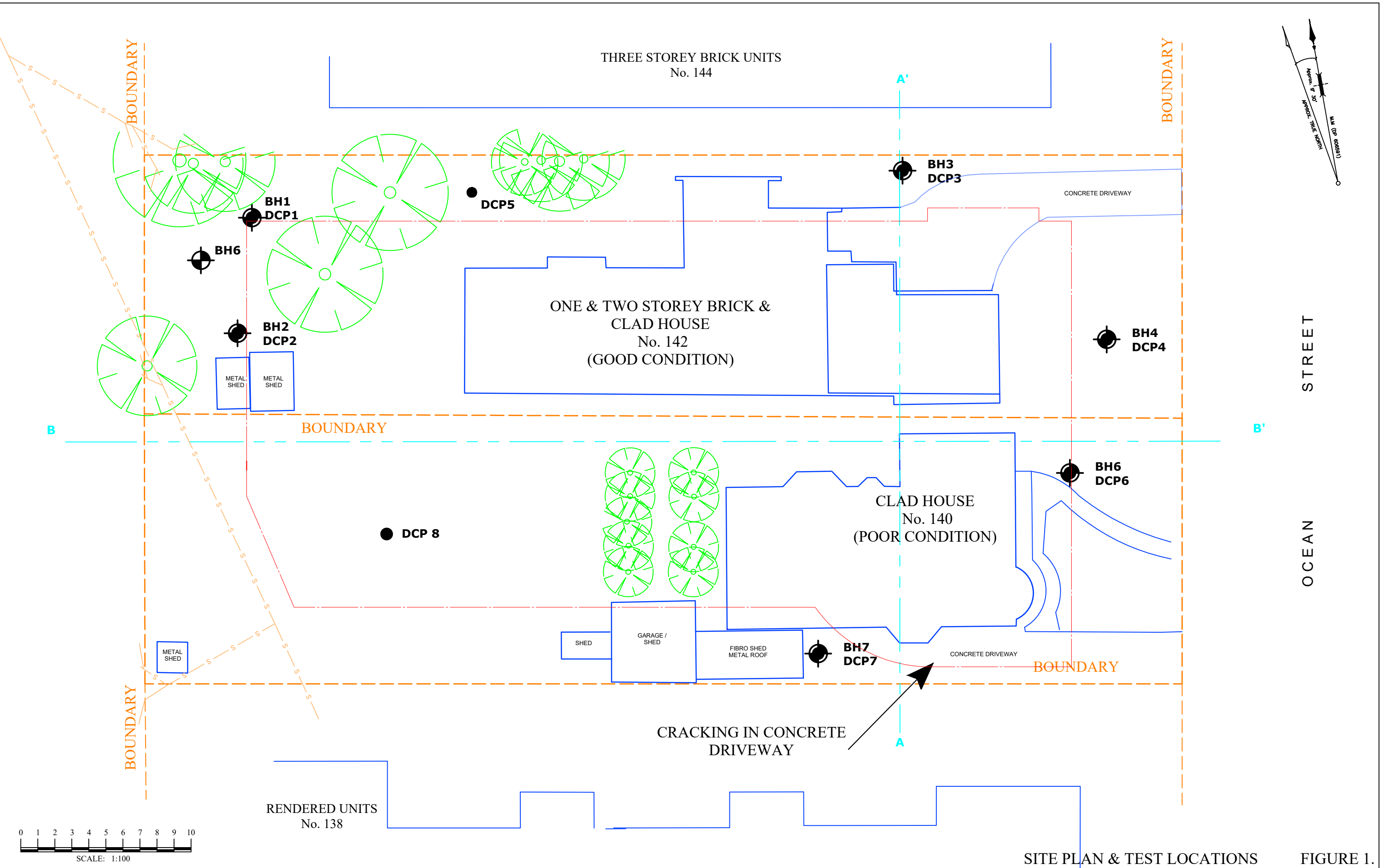
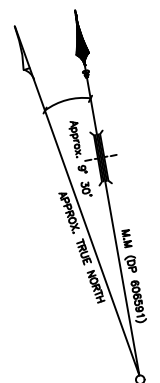
PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

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
 Unit 12, 42-46 Wattle Road
 Brookvale NSW 2100
 Crozier Geotechnical is a division of PJC Geo-Engineering Pty Ltd

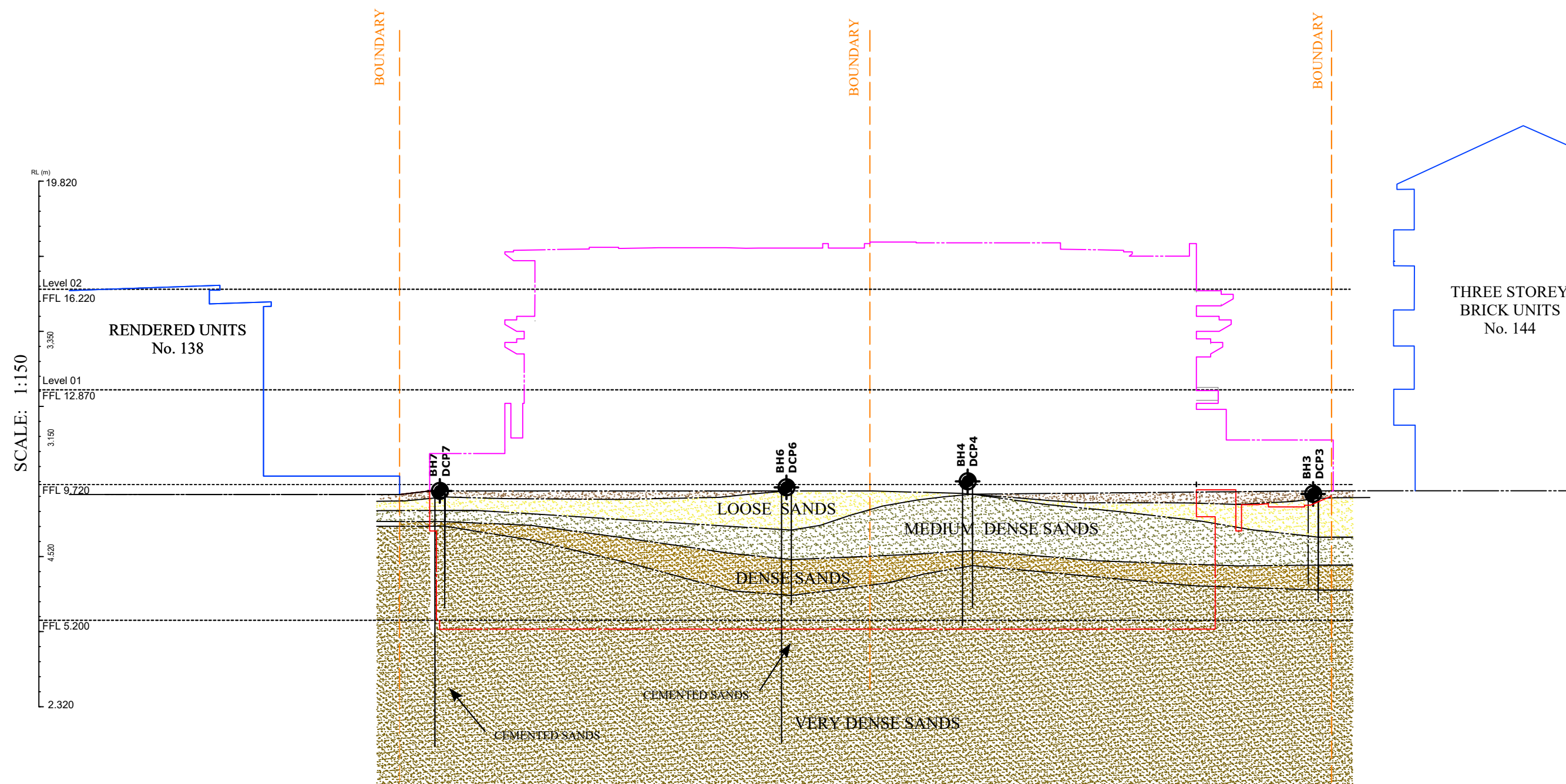
ABN: 96 113 453 624
 Phone: (02) 9939 1882
 Fax: (02) 9939 1883

LEGEND			
	PROPOSED EXCAVATION		EXISTING STRUCTURES
	SEWER		DCP DYNAMIC CONE PENETROMETER
	BH DCP AUGER / DYNAMIC CONE PENETROMETER LOCATION		PROPERTY BOUNDARY
	A—A' CROSS-SECTION REFERENCE LINE		

SCALE:	1:100
DRAWING:	FIG 1
DATE:	06/02/2025
APPROVED BY:	TMC
DRAWN BY:	TS
PROJECT:	2021-073

PREPARED FOR:	TRIO INDUSTRIES
ADDRESS:	140-142 OCEAN STREET, NARABEEN

A ————— A'



SECTION A FIGURE 2.

CROZIER
GEOTECHNICAL CONSULTANTS

Crozier Geotechnical
Unit 12, 42-46 Wattle Road
Brookvale NSW 2100
Crozier Geotechnical is a division of PJC Geo-Engineering Pty Ltd

ABN: 96 113 453 624
Phone: (02) 9939 1882
Fax: (02) 9939 1883

LEGEND					
BH DCP	AUGER / DYNAMIC CONE PENETROMETER LOCATION		PROPERTY BOUNDARY		PROPOSED STRUCTURE
	PROPOSED EXCAVATION		LOOSE SAND		DENSE SAND
	MEDIUM DENSE SAND		VERY DENSE SAND		FILL
	A — A' SECTION LINE				

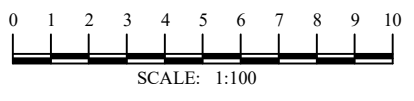
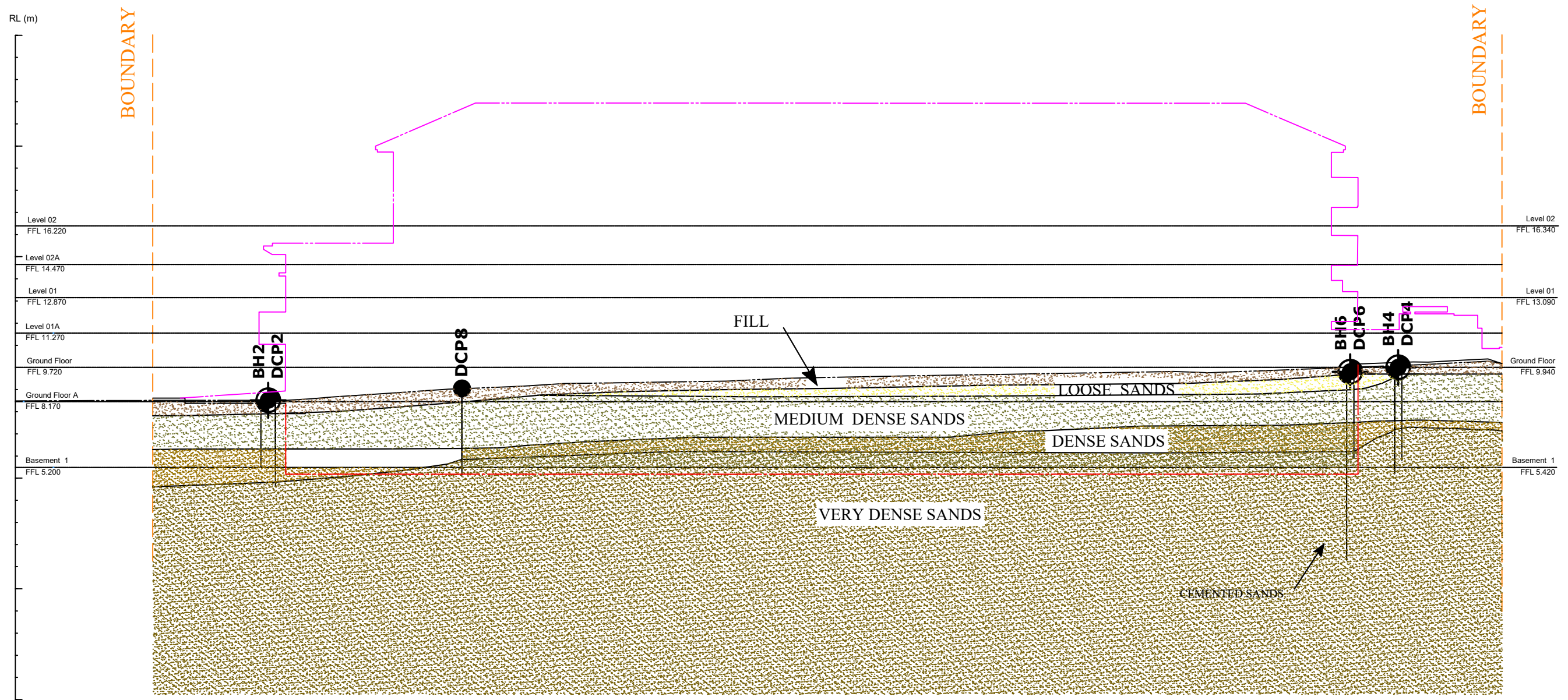
SCALE: 1:150
DRAWING: FIG 2
DATE: 06/02/2025

APPROVED BY: TMC
DRAWN BY: TS
PROJECT: 2021-073

PREPARED FOR:
TRIO INDUSTRIES

ADDRESS:
140-142 OCEAN STREET, NARABEEN

B ————— B'



SECTION B FIGURE 3.



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

LEGEND					
BH DCP	AUGER / DYNAMIC CONE PENETROMETER LOCATION	PROPERTY BOUNDARY	PROPOSED STRUCTURE	MEDIUM DENSE SAND	FILL
DCP	DYNAMIC CONE PENETROMETER	PROPOSED EXCAVATION	LOOSE SAND	DENSE SAND	VERY DENSE SAND
				A — A' SECTION LINE	

SCALE: 1:100
DRAWING: FIG 3
DATE: 06/02/2025
APPROVED BY: TMC
DRAWN BY: TS
PROJECT: 2021-073

PREPARED FOR: TRIO INDUSTRIES
ADDRESS: 140-142 OCEAN STREET, NARABEEN

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		In Situ Testing	
			Type	Tests	Type	Results
0.00		FILL/TOPSOIL: Brown, moist, silty sand topsoil trace rootlets				
0.60			D	0.50 0.60		
	SP	SAND: Medium dense, orange brown, medium grained,				
			D	1.00 1.10		
			D	1.50 1.60		
2.10		...yellow brown	D	2.00 2.10		
			D	2.40 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						
0.15		FILL: Medium to coarse grained gravel with silty sand				
0.50	SP	SAND: Loose, orange brown, medium grained, moist, sand ...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)	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							
0.10		FILL: Medium to coarse gravel with silty sand ...brown, silty sand					
0.30		SAND: Medium dense, orange brown, medium grained, moist, sand		0.50			
			D	0.60			
				1.00			
			D	1.10			
1.50		...yellow brown		1.50			
			D	1.60			
				2.00			
			D	2.10			
2.40		...dense, pale brown, trace shell fragment and fine quartz gravel		2.50			
			D	2.60			
2.80		...very dense		3.00			
			D	3.10			
				3.50			
			D	3.60			
				4.00			
			D	4.10			
				4.50			
			D	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	
			Type	Tests	Type	Results
0.00						
		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

BOREHOLE LOG

CLIENT: Trio Industries

DATE: 14/10/2024

BORE No.: 6

PROJECT: Construction of Class 2 residential development

PROJECT No.: 2021-073.1

SHEET: 1 of 2

LOCATION: 140-142 Ocean Street, Narrabeen

SURFACE LEVEL: RL 9.74m

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		TOPSOIL: Dark brown, medium grained, moist, silty sand				
0.10	SP	SAND: Loose, brown, medium-coarse grained, moist, sand				
0.50		...orange brown		0.50		
0.70		...medium dense	D	0.70		
1.00		...light brown				
2.00						
2.50		...dense	D	2.20 2.40		
2.90		...pale brown				
3.00						
3.60		...very dense				
4.00						
5.00		...trace shell				

RIG: Dingo - restricted access drill rig

DRILLER: AC

METHOD: Solid stem spiral flighted auger with tungsten carbide bit

LOGGED: JC

GROUND WATER OBSERVATIONS: Not encountered

REMARKS:

CHECKED: BT

BOREHOLE LOG

CLIENT: Trio Industries

DATE: 14/10/2024

BORE No.: 6

PROJECT: Construction of Class 2 Residential Development

PROJECT No.: 2021-073.1

SHEET: 2 of 2

LOCATION: 140-142 Ocean Street, Narrabeen

SURFACE LEVEL: RL 9.74m

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						
5.80		...light brown, weakly cemented sand	D	5.20 5.50 5.60 5.90		
6.00						
6.50		...coarse grained, weakly cemented sand trace clay				
7.00		...increased moisture content		7.00		
8.00			D	7.30		
8.50			D	8.20 8.50		
9.00		Borehole Terminated at 8.5m depth within very dense to cemented sand				

RIG: Dingo - restricted access drill rig

DRILLER: AC

METHOD: Solid stem spiral flighted auger with tungsten carbide bit

LOGGED: JC

GROUND WATER OBSERVATIONS: Not encountered

REMARKS:

CHECKED: BT

BOREHOLE LOG

CLIENT: Trio Industries

DATE: 14/10/2024

BORE No.: 7

PROJECT: Construction of Class 2 residential development

PROJECT No.: 2021-073.1

SHEET: 1 of 2

LOCATION: 140-142 Ocean Street, Narrabeen

SURFACE LEVEL: RL 9.60m

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						
0.05		Concrete slab				
0.08		Aggregate				
0.20		TOPSOIL: Dark brown, medium-coarse grained, moist, sand with silt				
	SP	SAND: Very loose, dark brown to brown, medium-coarse grained, moist, sand				
1.00		...medium dense, brown to orange brown				
2.00						
2.20		...light brown				
3.00		...dense				
3.10		...very dense				
				3.60		
			D			
4.00				4.00		
4.50		...increased moisture content				
4.90		...pale brown, coarse grained, sand trace shells				
5.00						

RIG: Dingo - restricted access drill rig

DRILLER: AC

METHOD: Solid stem spiral flighted auger with tungsten carbide bit

LOGGED: JC

GROUND WATER OBSERVATIONS: Not encountered

REMARKS: 50mm concrete slab on 20-30mm aggregate cored through to start borehole

CHECKED: BT

BOREHOLE LOG

CLIENT: Trio Industries

DATE: 14/10/2024

BORE No.: 7

PROJECT: Construction of Class 2 residential development

PROJECT No.: 2021-073.1

SHEET: 2 of 2

LOCATION: 140-142 Ocean Street, Narrabeen

SURFACE LEVEL: RL 9.60m

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						
6.00		...light brown, coarse grained				
7.00						
8.00		...weakly cemented sand				
8.50			D	8.20 8.50		
		Borehole termination within sand/weakly cemented sand @ 8.50m depth				
9.00						

RIG: Dingo - restricted access drill rig

DRILLER: AC

METHOD: Solid stem spiral flighted auger with tungsten carbide bit

LOGGED: JC

GROUND WATER OBSERVATIONS: Not encountered

REMARKS: 50mm concrete slab on 20-30mm aggregate cored through to start borehole CHECKED: BT

DYNAMIC PENETROMETER TEST SHEET

CLIENT: Trio Industries Pty Ltd

DATE: 01/04/2021 & 14/10/2024

PROJECT: Demolition of existing house and construction of new apartment block

PROJECT No.: 2021-073

LOCATION: 142 Ocean Street, Narrabeen

SHEET: 1 of 2

Depth (m)	Test Location								
	DCP1	DCP2	DCP3	DCP4	DCP5	DCP6	DCP6a	DCP7	DCP8
0.00 - 0.10	0	0	--	5	1	-	1	-	1
0.10 - 0.20	1	1	2	2	1	-	2	-	2
0.20 - 0.30	1	1	2	4	1	-	2	-	1
0.30 - 0.40	0	2	2	3	1	-	2	1	1
0.40 - 0.50	1	2	4	3	2	-	2	1	1
0.50 - 0.60	2	3	3	4	2	-	2	1	2
0.60 - 0.70	2	4	4	4	3	-	2	2	3
0.70 - 0.80	2	4	3	3	4	-	3	2	3
0.80 - 0.90	3	3	3	3	5	-	3	2	3
0.90 - 1.00	3	3	4	3	6	-	2	2	3
1.00 - 1.10	3	4	3	3	5	-	3	3	4
1.10 - 1.20	2	3	3	4	5	-	4	3	4
1.20 - 1.30	3	3	4	4	5	-	3	3	4
1.30 - 1.40	4	2	3	4	5	-	3	3	3
1.40 - 1.50	3	2	4	4	5	-	3	3	4
1.50 - 1.60	4	3	3	4	5	-	3	4	4
1.60 - 1.70	5	3	3	3	5	-	3	3	4
1.70 - 1.80	4	2	3	4	6	-	3	3	5
1.80 - 1.90	4	3	2	3	6	-	4	3	5
1.90 - 2.00	4	3	3	4	7	-	3	3	4
2.00 - 2.10	5	2	2	4	6	-	4	3	4
2.10 - 2.20	4	3	2	5	6	-	5	4	4
2.20 - 2.30	5	2	3	7	5	-	5	4	3
2.30 - 2.40	6	2	3	7	5	-	6	4	3
2.40 - 2.50	6	2	3	8	5	-	7	3	4
2.50 - 2.60	6	1	2	9	5	4	8	3	6
2.60 - 2.70	5	2	4	8	5	6	8	3	7
2.70 - 2.80	6	1	8	10	4	6	9	6	7
2.80 - 2.90	6	2	7	14	5	8	9	6	6
2.90 - 3.00	5	2	9	14	5	7	9	7	8

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 $\leq 6m^3$) at crest of excavation for basement level		Excavation to 4.8m depth through sandy soils	a) Building minimum of 8.6m from 4.8m deep excavation, impacted 5% b) Gardens minimum of 1.0m from $\leq 4.8m$ basement and driveway excavation, impacted 20% (excavation for the driveway grades from nil to 4.8m depth as setback distance from boundary is increased) c) Building a minimum of 5.6m from 4.8m deep excavation, impacted 20% d) Garage and driveway 6.0m from 3.3m excavation, impacted 5% e) Building 12.0m from 3.0m deep excavation, impacted 2% f) Road reserve 6.2m from 4.8m deep excavation, impacted 20%		a) Person in building 20hrs/day ave. b) Person in garden 1hr/day ave. c) Person in building 20hr/day ave. d) Person in garage or on driveway 2hrs/day ave. e) Person in building 20hrs/day ave. f) Person on public pathway 1hr/day ave.	a) Possible to not evacuate b) Possible to not evacuate c) Possible to not evacuate d) Possible to not evacuate e) Possible to not evacuate f) likely to evacuate	a) Person in building minor damage only b) Person in open space, possible buried c) Person in building minor damage only d) Person in open space, possible buried e) Person in building, minor damage only f) Person in open space, unlikely buried									
										Possible	Prob. of Impact	Impacted					
										a) Apartment building No.138 Ocean Street	0.001	0.20	0.05	0.8333	0.5	0.01	4.17E-08
										b) Northern gardens within No.138 Ocean Street	0.001	0.40	0.20	0.0417	0.5	0.50	8.33E-07
										c) Apartment building No.144 Ocean Street	0.001	0.30	0.20	0.8333	0.5	0.01	2.50E-07
										d) Garage and rear of driveway No. 59 Lagoon Street	0.001	0.20	0.05	0.0833	0.5	0.50	2.08E-07
										e) Apartment building No.53-55 Lagoon street	0.001	0.05	0.02	0.8333	0.5	0.01	4.17E-09
f) Road Reserve	0.001	0.40	0.20	0.0417	0.25	0.25	2.08E-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 (soil slide $\leq 6m^3$) at crest of excavation for basement level	a) Apartment building No.138 Ocean Street	Unlikely	The event might occur under very adverse circumstances 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
		b) Northern gardens within No.138 Ocean Street	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.	Moderate
		c) Apartment building 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.	Moderate
		d) 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
		e) Apartment building No.53-55 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
		f) 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.	Medium

* 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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Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

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.

Client Reference: 2021-073 Narrabeen, 142 Ocean St

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]

Client Reference: 2021-073 Narrabeen, 142 Ocean St

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]

Client Reference: 2021-073 Narrabeen, 142 Ocean St

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.

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.

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

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		100 years		The event will probably occur under adverse conditions over the design life.	LIKELY	B
10 ⁻³	5x10 ⁻³	1000 years	200 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10 ⁻⁴	5x10 ⁻⁴	10,000 years	2000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10 ⁻⁵	5x10 ⁻⁵	100,000 years	20,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10 ⁻⁶	5x10 ⁻⁶	1,000,000 years	200,000 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%		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%	40%	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%	10%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%	1%	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*

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

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.