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GEOTECHNICAL INVESTIGATION REPORT

for

PROPOSED NEW RESIDENTIAL DEVELOPMENT

at

1 – 5 RICKARD ROAD, NORTH NARRABEEN, NSW

Prepared For

ALDA Properties

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GEOTECHNICAL REPORT FOR PROPOSED NEW RESIDENTIAL DEVELOPMENT
1-5 RICKARD ROAD, NORTH NARABEEN, NSW

1. INTRODUCTION:

This report details the results of a geotechnical investigation carried out for a proposed new residential development at 1-5 Rickard Road, North Narrabeen, NSW. The investigation was undertaken by Crozier Geotechnical Consultants (CGC) at the request of the client ALDA Properties.

It is understood that the proposed works involve demolition of existing site structures and construction of a four storey residential unit building (Class 2). The structure will be formed across the majority of the site, extending to the western and southern boundaries. The proposed structure will be formed at approximate natural ground surface level, with the ground floor comprising a carpark level. Therefore, it is anticipated that only isolated excavation will be required for footings and deep bulk excavation is not anticipated.

The site is not located within the H1 landslip hazard zone of the Geotechnical Risk Management Policy for Pittwater, and based on our understanding of the proposed works it will not invoke the policy, however it is expected that geotechnical assessment will be required for DA submission.

The site is also classified under Northern Beaches Council's Local Environmental Plan (LEP) 2014 as being within 'Class 3' Acid Sulfate Soils (ASS) hazard zone. As such, a preliminary assessment is required as part of the Development Application to determine if the proposed works will require an Acid Sulfate Soils Management Plan.

This report is provided for DA submission and includes a description of site and sub-surface conditions including groundwater, soil logs and in-site test results, a geotechnical assessment of the proposed works, assessment of landslide hazards, site plan and recommendations for the design of works.

The investigation and reporting were undertaken as per Proposal No.: P23-554.1, Dated: 16th April 2024.

The investigation comprised:

a) Onsite service location and clearing of borehole locations by an accredited contractor.
b) Detailed geotechnical inspection and mapping of the site and adjacent properties with a photographic record and identification of geotechnical conditions and hazards related to the existing site and proposed works;
c) Drilling of four boreholes using a restricted access drill rig along with four Dynamic Cone Penetrometer (DCP) tests across the site

The following plans and drawings were supplied for the proposal, investigation and reporting:

- Architectural Drawings – Gartner Trovato Architecture, Project No.: 2315, Drawing No.: DA00 – DA16, Revision: A, Dated: 09/07/2024
- Survey Drawing – Stutchbury Jacques Pty Ltd, Reference No.: 11883/23, Dated: 10/08/2023

2. SITE FEATURES:

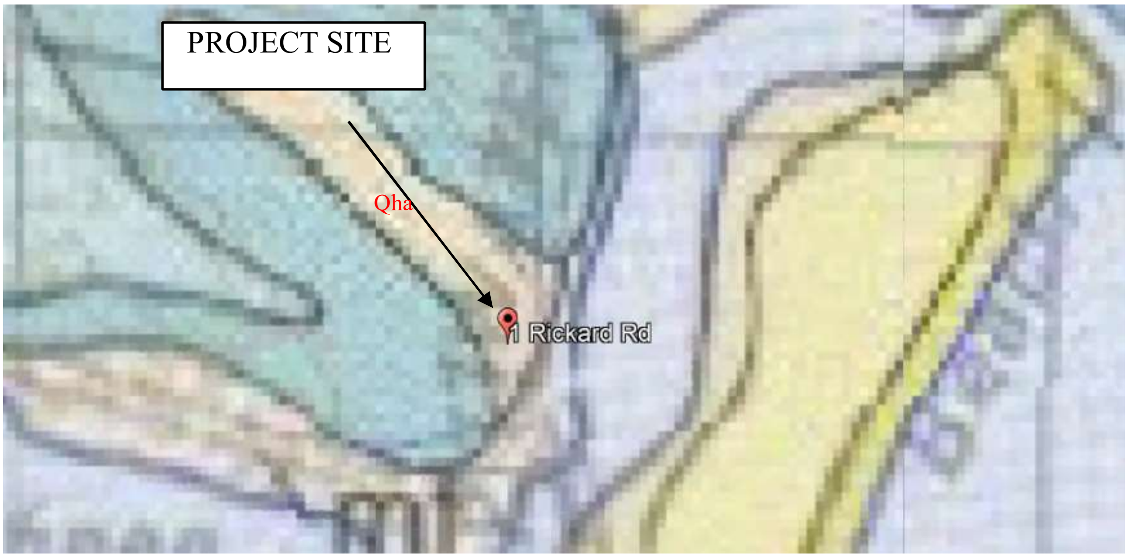
2.1. Description:

The site comprises the three separate properties of No. 1, No. 3 and No. 5 Rickard Road (Lot 7 – 9/DP16212). The overall site is a broadly trapezoidal shaped block situated on the southern side of Rickard Road and is bounded to the east by Minarto Lane. The site is situated within relatively flat topography with site levels varying between approximately RL 2.30 and RL 1.90. The site currently contains three fibro/weatherboard single storey dwellings situated towards the front northern boundary of the three individual properties with each property also featuring ancillary metal shed structures towards their rear southern boundaries. An aerial photograph of the site and its surrounds with boundary designations is provided below (Photograph 1), as sourced from NSW Government Six Map spatial data system.

Photograph 1: Aerial photo of site and surrounds

2.2. Geology:

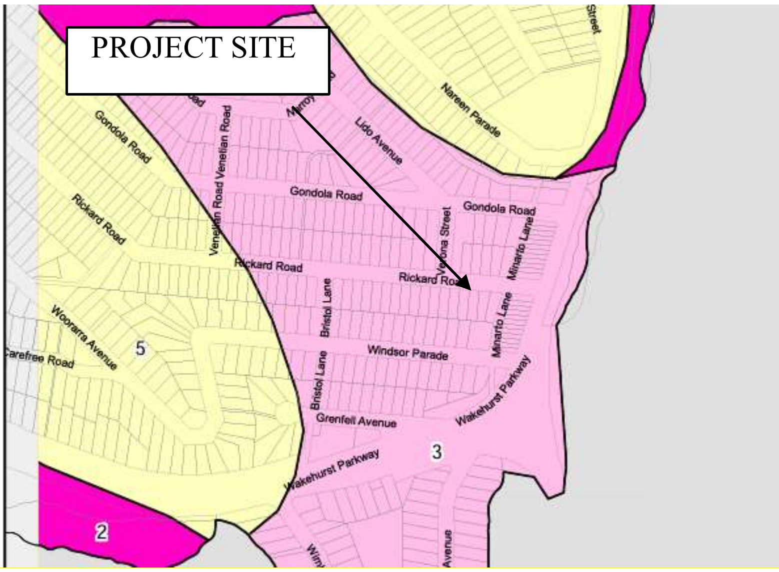
Reference to the Sydney 1:100,000 Geological Series sheet 9130 indicates that the site is underlain by Quaternary Sands (Qha) of alluvial origin associated with the deposition of sediment associated with the nearby Nareen Creek which typically comprise silty to peaty quartz sand silt and clay. An extract from the Sydney 1:100, 000 Geological Series sheet is provided below.



Extract 1: Sydney (9130 Geology Series Map): 1: 100000 – Geology underlying the site

2.3 Acid Sulfate Soils

Reference to the Pittwater Council LEP 2014, section 7.1, Acid sulfate soils map Sheet_ 019(Shown below as Extract 2), indicates that the site is situated within “Class 3” land. Subclause (2) stipulates that for “Class 3”, development consent is required for the carrying out of any works more than 1.00m below the natural ground surface and/or by which the water table is likely to be lowered more than 1.00m within the site or adjacent Class 1 – Class 3 land. However, subclause (4) outlines that development consent is not required if (a) a preliminary assessment of the proposed works prepared in accordance with the Acid Sulfate Soils Manual indicates that an acid sulfate soils management plan is not required.



Extract 2: Pittwater Council LEP 2014, Acid Sulfate Soils Map, Sheet_011

3. FIELD WORK:

3.1. Methods:

The field investigation was conducted on the 11th of June 2024 and comprised a walk over inspection and mapping of the site and adjacent properties by a Geotechnical Engineer. It included a photographic record of site conditions as well as geological/geomorphological mapping of the site and adjacent land with examination of soil slopes, existing structures and neighbouring properties. It also included the drilling of four boreholes (BH1-BH4) using a restricted access drill rig employing solid stem spiral flighted augers with a tungsten carbide bit.

DCP testing was carried out during the initial investigation from ground surface adjacent to the boreholes in accordance with AS1289.6.3.2 – 1997, “Determination of the penetration resistance of a soil – 9kg Dynamic Cone Penetrometer” to estimate near surface ground conditions.

Geotechnical logging of the subsurface conditions was undertaken by a Geotechnical Engineer by inspection of disturbed soil recovered from the augers. Logging was undertaken in accordance with AS1726:2017 ‘Geotechnical Site Investigations’.

Explanatory notes are included in Appendix: 1. Mapping information and test locations are shown on Figure: 1, along with detailed Borehole Log sheets and Dynamic Penetrometer Test Sheet in Appendix: 2. A geological model/section is provided as Figure: 2, Appendix: 2.

3.2. Field Observations:

The site is situated on the southern side of Rickard Road and the western side of Minarto Lane within relatively flat and low lying topography. Rickard Road and Minarto Lane both comprise relatively flat bituminous sealed pavements with Rickard Road separated from the site by a concrete kerb, gutter pedestrian pavement and nature strip whilst Minarto lane abuts the site boundary. Signs of minor cracking and settlement were observed within the roadway however this is considered to be characteristic of sandy soils foundations as opposed to being indicative of a large scale geotechnical concern.

No. 1 Rickard Road comprises the easternmost of the three individual properties which make up the site. It contains a single storey fibro/weatherboard dwelling situated towards the northern boundary with Rickard Road. The dwelling is anticipated to be of approximately 60 years construction age and, although showing some signs of deterioration, did not exhibit any signs of excessive settlement or cracking to indicate any impending geotechnical concern. The rear portion of No. 1 Rickard Road is accessed from Minarto Lane and features vacant grass area with some small metal shed structures and miscellaneous building/automotive material.

No. 3 Rickard Road comprises a single storey fibro/weatherboard dwelling, also considered to be of approximately 60 years construction age situated towards the front northern boundary. This dwelling showed some signs of deterioration however did not exhibit any signs of excessive settlement or cracking to indicate any impending geotechnical concern.

No. 5 Rickard Road comprises an irregular shaped block that extends around the rear southern edge of No. 3 Rickard Road. It comprises a single storey fibro/weatherboard dwelling situated towards the front boundary with Rickard Road as well as multiple ancillary shed/storage and workshop structures situated in the rear portion of the property. The dwelling is anticipated to be of approximately 60 years construction age and, although showing some signs of deterioration, did not exhibit any signs of excessive settlement or cracking to indicate any impending geotechnical concern

The neighbouring property to the west (No. 7 Rickard Road) comprises a single storey weatherboard/fibro dwelling situated towards the front boundary as well as a masonry warehouse structure towards the rear southern boundary which also abuts the shared boundary with the site. The visible aspects of the structures appeared to be in good condition with no signs of excessive settlement or cracking to indicate any impending geotechnical concern.

Two separate properties share a common boundary with the site to the south (No. 2 and No. 6 Windsor Parade), No. 2 Windsor parade which comprises the easternmost of these two properties contains a masonry warehouse structure which abuts the shared boundary whilst No. 6 Windsor Parade comprises a single storey weatherboard/fibro dwelling as well as a masonry warehouse/storage structure which appears to abut the shared boundary in parts. The visible aspect of the neighbouring structures did not indicate any impending geotechnical concern.

3.3. Ground Conditions:

The boreholes (BH1 – BH4) were drilled across site broadly within the envelope of proposed works. The boreholes encountered fill soils from existing ground surface levels to a maximum depth of 0.30m. Underlying the topsoil/fill alluvial quaternary sands were encountered which extended to the maximum borehole depth of 2.50m.

DCP tests were carried out from the ground surface adjacent to the boreholes with all extending to depths of approximately 2.90m prior to termination, generally within medium dense sands.

Based on the borehole logs and DCP test results, the subsurface conditions at the site can be classified as follows:

- **TOPSOIL/FILL** – This layer was encountered in all boreholes and extended from ground level to a maximum depth of 0.30m (BH1). The material typically comprised loose, dark brown silty sand with building refuse, roots and drainage aggregate.
- **ALLUVIAL SOILS –** This layer was encountered underlying the topsoil/fill in all test locations. It was initially intersected as a brown/yellow fine to medium grained medium dense sand with trace silt and shell fragments. The alluvial soils varied in composition with depth featuring zones of increasing silt, sand and organic matter content. Density generally varied with depth with some zones of increased density intersected however broadly speaking, the soils remained medium dense for the whole investigation range.

A freestanding ground water table was intersected in all boreholes broadly below 1.20m depth (≈RL0.80) and is anticipated to vary approximately ±0.50m with tidal fluctuations with larger rises anticipated during and following significant rainfall events.

3.4. Laboratory Testing

3.4.1 Acid Sulfate Soils Testing

Soil samples collected from the boreholes were sent to a NATA accredited laboratory for chemical testing (Envirolab).

Eight samples were tested at Envirolab via the pH, pHFOX methods with four samples analysed by using the Chromium method to provide quantitative data on ASS based on the recommendations of the Acid Sulfate Soils Laboratory Methods Guidelines, Version.2.1, June 2004 and National Acid Sulfate Soils Guidance (June 2018). The results are summarised in Table 1 and Table 2 below and the certificates of analysis are included in appendix 3.

Table 1: Summary of Laboratory Test Results (pH and pH_{FOX})

Borehole:	Depth (m)	pH	pH_{FOX}	Reaction Rate
BH1	0.50	9.6	6.5	Medium
BH1	1.00	9.6	6.8	Medium
BH1	2.00	7.6	1.8	Medium
BH1	2.50	7.5	2.2	Medium
BH4	1.00	9.5	6.3	Medium
BH4	1.50	8.2	4.0	Medium
BH4	2.00	8.5	5.0	Medium
BH4	2.50	7.8	2.1	Medium

Table 2: Chromium Suite Laboratory Test Results +%S w/w yellow indicates exceedance of action criteria

Borehole:	Depth (m)	pH (KCL)	Titratable Actual Acidity %w/w S	Chromium Reducible Sulfur – Scr) % w/w	Net Acidity * moles H^+/t	Calculated Liming Rate (kg CaCO3/t)
BH1	1.00	9.6	<0.01	0.006	<5	<0.75
BH1	2.50	7.0	<0.01	0.22	110	8
BH4	1.50	7.0	<0.01	0.02	<5	<0.75
BH4	2.00	7.9	<0.01	<0.005	<5	<0.75

Acid Sulfate Soils in NSW are assessed in accordance with the ASSMAC and the National Acid Sulfate Soils Guidance (Australian Government Initiative June 2018) which provide action criteria for assessing the results of laboratory testing quantifying the acid producing effects based on the sum of existing plus potential acidity. These action criteria are presented in the table below.

Action Criteria Based on ASS Analysis for Three Broad Texture Categories

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

The samples below 2.50m in BH1 subjected to Chromium testing, did have potential net acidity and chromium reducible sulfur values that exceed the Action Criteria for both <1000 tonnes and >1000 tonnes disturbed, and the sample is therefore considered to be PASS and therefore will require management and treatment (if disturbed) to neutralise the net acidity.

As such, based on the testing results and the proposed works an Acid Sulphate Soils Management Plan will be required for the proposed works.

4. COMMENTS:

4.1. Geotechnical Assessment:

The site investigation identified the presence of a relatively thin layer of topsoil/fill overlying alluvial sandy soils which extended to the maximum investigation depth of 2.90m (≈RL-1.00). The alluvial soils varied in composition with depth however generally remained medium dense. A freestanding groundwater table was intersected in all test locations below 1.20m depth (≈RL0.80) and is anticipated to vary approximately ±0.50m with tidal fluctuations with larger rises anticipated during and following significant rainfall events.

It is understood that the proposed works involve demolition of existing site structures and construction of a four storey residential unit building (Class 2). The structure will be formed across the majority of the site, extending to the western and southern boundaries. The proposed structure will be formed at approximate natural ground surface level, with the ground floor comprising a carpark level. Therefore, it is anticipated that isolated excavation will be required for footings only and deep bulk excavation is not anticipated.

It is expected that the structure will require deep pile footings for foundation support. All piers will be required to extend below the water table, intersected broadly below 1.20m depth across site (≈RL 0.80). As such open bored piers will not be feasible with CFA methods (or similar) required.

Driven style support systems (i.e. sheet piling, concrete/timber piles) are not suitable for use on this site due to ground vibration compaction in the adjacent sands and subsequent risk of damage to nearby structures. Also, care will need to be exercised during demolition of any existing structures and large scale breakers should be avoided to prevent damage to neighbouring structures.

A preliminary estimation of pile capacity at various levels as per AS2159 for a bored pile was undertaken using the above parameters. A design geotechnical reduction factor of $\phi_g = 0.52$ was determined suitable based on the level of testing expected prior to and during the project.

The results of this assessment suggests that for 10mm elastic settlement the following factored compressive pile loads are suitable for 450mm diameter piles:

- Pile footings founded at least 6.0m depth within medium dense sand: 250kN;
- Pile footings founded at least 8.0m depth within medium dense sand: 335kN;

Consolidation settlement is very difficult to estimate with the existing level of testing, however based on the proposed loads, estimated elastic settlement and the primarily sandy soils, it is considered that consolidation settlement over time will be minimal (<15mm).

Further investigation and analysis is recommended following demolition of structures and determination of anticipated footing loads including CPT testing to below proposed foundation levels to confirm continuity of assumed strata.

All new footings should be founded off material of similar strength in order to avoid differential settlement.

All new footings must be inspected by an experienced geotechnical professional before concrete or steel are placed to verify their bearing capacity and the in-situ nature of the founding strata. This is mandatory to allow them to be ‘certified’ at the end of the project. If continual flight auger (CFA) methods are chosen then geotechnical inspection of the founding conditions is not possible as it is an essentially “blind” method and further testing and investigation is required to confirm founding conditions across the site with geotechnical inspection to confirm contractors quality control.

The site is situated within ‘Class 3’ Acid Sulfate Soils hazard zone and based on the laboratory test results from the samples taken within BH1 and BH4, net acidity and chromium reducible sulphur values exceeded the guidelines for the Action Criteria. Therefore, it is considered that an Acid Sulphate Soils Management Plan (ASSMP) is required for the development. A preliminary ASSMP is provided in Appendix 3. It is recommended that further investigation and testing be undertaken upon demolition of site structures to better define the extent of PASS soils.

The inspection and assessment identified no obvious credible existing geotechnical hazards within the site or adjacent properties. The site shows no signs of any instability or problematic ground movement including as a result of moisture changes. No obvious surface stormwater flow or excess seepage/wet areas were identified.

The proposed works are considered suitable for the site and may be completed with negligible impact to 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 isolated boreholes and DCP testing. This test equipment 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 subsequent preliminary design of the proposed works.

4.2. Site Specific Risk Assessment:

Based on our site investigation we have identified no geological/geotechnical landslip hazards which need to be considered in relation to the existing site and the proposed works.

Therefore, risk to both life and property levels are considered to be ‘Acceptable’ against the AGS Guidelines. As such the project is considered suitable for the site provided the recommendations of this report are implemented.

4.3. Design & Construction Recommendations:

Design and construction recommendations are tabulated below:

4.3.1. New Footings:	
Site Classification as per AS2870 – 2011 for new footing design	Class ‘S’ due to prevalence of silt and clay within alluvial deposits
Type of Footing	Strip/Pad/Piles
Sub-grade material and Maximum Allowable Bearing Capacity for shallow footings above water table	Medium dense alluvial soils: - 150kPa (Strip and pad footings)

Sub grade and material maximum allowable bearing capacity for pier footings with embedment >3m below exiting ground surface/ development levels	Medium dense alluvial soils (Geotechnical reduction factor of $\phi_g = 0.52$: - 900kPa (Piles, end bearing) - 4kPa (Piles, skin friction)
Site sub-soil classification as per *Structural design actions AS1170.4 – 2007, Part 4: Earthquake actions in Australia*	C_e – Shallow Soil site (interpreted)
Remarks: All footings for the proposed structure should be founded off material of similar strength to prevent differential settlement. All new footings must be inspected by an experienced geotechnical professional before concrete or steel are placed to verify their bearing capacity and the in-situ nature of the founding strata. This is mandatory to allow them to be 'certified' at the end of the project. If Screw Piles are utilised CGC cannot certify their insitu end bearing with them typically being 'Self Certifying' pending contractor.	

4.2.2. Drainage and Hydrogeology		
Groundwater Table or Seepage identified in Investigation		Yes – freestanding groundwater table encountered broadly 1.20m below existing ground levels (RL 0.80)
Excavation likely to intersect	Water Table	No
	Seepage	Negligible
Site Location and Topography		On the northern side of the road within relatively flat topography
Impact of development on local hydrogeology		Negligible, provided the recommendations of this report are implemented which includes secant pile walls where excavation blow the water table is required/likely to ensure de-watering is maintained within site perimeter. Further analysis is required for monitoring program
Onsite Stormwater Disposal		Not possible
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.		

4.4. Conditions Relating to Design and Construction Monitoring:

To comply with Councils conditions and to enable us to complete Forms: 2b and 3 required as part of construction, building and post-construction certificate requirements of the Councils Geotechnical Risk Management Policy 2009, it will be necessary for Crozier Geotechnical Consultants to:

1. Review and approve the structural design drawings for compliance with the recommendations of this report prior to construction,
2. Inspection of site during drilling for pier footings
3. Inspect all new footings and earthworks to confirm compliance to design assumptions with respect to allowable bearing pressure, basal cleanness and the stability prior to the placement of steel or concrete,
4. Inspect completed works to ensure construction activity has not created any new hazards and that all retention and stormwater control systems are completed.

The client and builder should make themselves familiar with the Councils Geotechnical Policy and the requirements spelled out in this report for inspections during the construction phase. Crozier Geotechnical Consultants cannot sign Form: 3 of the Policy if it has not been called to site to undertake the required inspections.

4.5. Design Life of Structure:

We have interpreted the design life requirements specified within Council's Risk Management Policy to refer to structural elements designed to support the existing structures, control stormwater and maintain the risk of instability within acceptable limits. Specific structures and features that may affect the maintenance and stability of the site in relation to the proposed and existing development are considered to comprise:

- stormwater and subsoil drainage systems,
- retaining walls and instability,
- maintenance of trees/vegetation on this and adjacent properties.

Man-made features should be designed and maintained for a design life consistent with surrounding structures (as per AS2870 – 2011 (100 years)). It will be necessary for the structural and geotechnical engineers to incorporate appropriate design and inspection procedures during the construction period. Additionally, the property owner should adopt and implement a maintenance and inspection program.

If this maintenance and inspection schedule are not maintained the design life of the property cannot be attained. A recommended program is given in Table: C in Appendix: 3 and should also include the following guidelines.

- The conditions on the block don't change from those present at the time this report was prepared, except for the changes due to this development.
- There is no change to the property due to an extraordinary event external to this site

- The property is maintained in good order and in accordance with the guidelines set out in;
    a) CSIRO sheet BTF 18
    b) Australian Geomechanics "Landslide Risk Management" Volume 42, March 2007.
    c) AS 2870 – 2011, Australian Standard for Residential Slabs and Footings

Where changes to site conditions are identified during the maintenance and inspection program, reference should be made to relevant professionals (e.g. structural engineer, geotechnical engineer or Council). Where the property owner has any lack of understanding or concerns about the implementation of any component of the maintenance and inspection program the relevant engineer should be contacted for advice or to complete the component. It is assumed that Council will control development on neighbouring properties, carry out regular inspections and maintenance of the road verge, stormwater systems and large trees on public land adjacent to the site so as to ensure that stability conditions do not deteriorate with potential increase in risk level to the site.

Also, individual Government Departments will maintain public utilities in the form of power lines, water and sewer mains to ensure they don't leak and increase either the local groundwater level or landslide potential.

5. CONCLUSION:

The site investigation identified the presence of a relatively shallow layer of fill soils from existing ground surface levels overlying alluvial sands soils which extended to the maximum investigation range of 2.90m (RL1.00) generally remaining medium dense. A freestanding ground water table was intersected in all test locations broadly below 1.20m depth below existing ground levels, corresponding to RL0.80m.

It is understood that the proposed works involve demolition of existing site structures and construction of a four storey residential unit building (Class 2). The structure will be formed across the majority of the site, extending to the western and southern boundaries. The proposed structure will be formed at approximate natural ground surface level, with the ground floor comprising a carpark level. Therefore, it is anticipated that isolated excavation will be required for footings only and deep bulk excavation is not anticipated.

All new footings will need to bear within materials of similar strength/density to minimise the risk of differential settlement.

Laboratory testing was conducted within both boreholes, which identified soils exhibiting characteristics inherent to Acid Sulfate Soils with net acidity value which exceeded the Action Criteria guidelines. The water table will likely be intersected within the envelope of proposed works as part of pier drilling works, therefore an Acid Sulfate Soils Management Plan (ASSMP) is required for the development.

The risks associated with the proposed development are considered to achieve and can be maintained within the ‘Acceptable’ Risk Management Criteria provided the recommendations of this report and any future geotechnical directive are implemented. As such the site is considered suitable for the proposed construction works provided that the recommendations outlined in this report are followed.

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Reviewed by:

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MIEAust., MAIG, RPGeo
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6. REFERENCES:

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3. C. W. Fetter 1995, “Applied Hydrology” by Prentice Hall. V. Gardiner & R. Dackombe 1983, “Geomorphological Field Manual” by George Allen & Unwin
4. Australian Standard AS 3798 – 2007, Guidelines on Earthworks for Commercial and Residential Developments.
5. Australian Standard AS 2870 – 2011, Residential Slabs and Footings – Construction
6. Australian Standard AS1170.4 – 2007, Part 4: Earthquake actions in Australia
7. Australian Standard AS 1726 – 2017, Geotechnical Site Investigations

Appendix 1

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NOTES RELATING TO THIS REPORT

Introduction

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

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

Description and classification Methods

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

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

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

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

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

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

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

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

Sampling

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

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

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

Drilling Methods

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

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

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

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

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

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

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

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

Standard Penetration Tests

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

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

The test results are reported in the following form.

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

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

Cone Penetrometer Testing and Interpretation

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

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

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

The information provided on the plotted results comprises: -

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

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

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

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

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

Q_c = (12 to 18) C_u

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

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

Dynamic Penetrometers

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

Two relatively similar tests are used.

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

Laboratory Testing

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

Borehole Logs

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

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

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

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

Ground Water

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

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

Engineering Reports

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

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

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

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

Site Anomalies

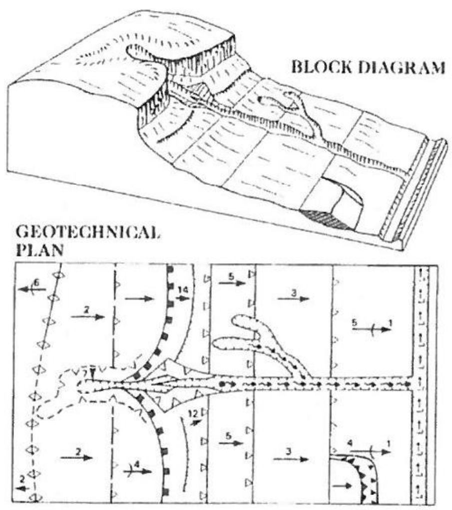
In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the Company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed than at some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

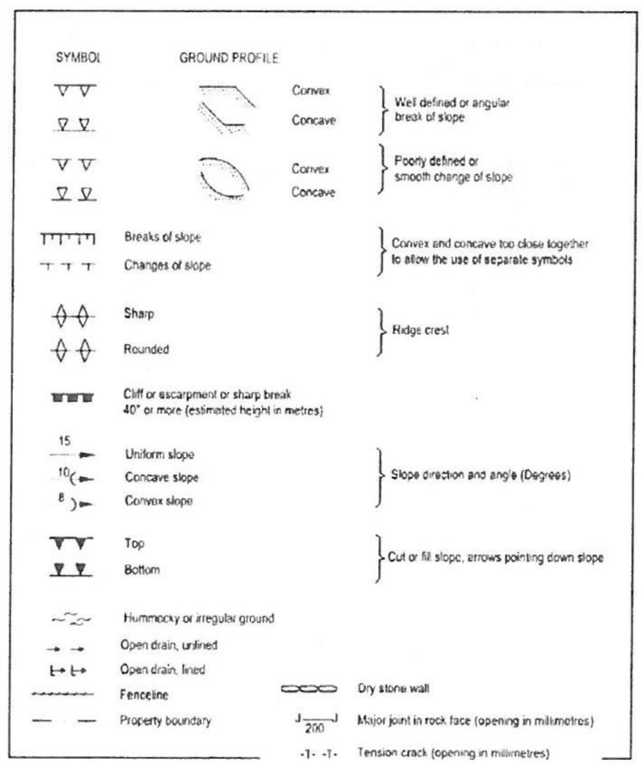
Reproduction of Information for Contractual Purposes

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

Site Inspection

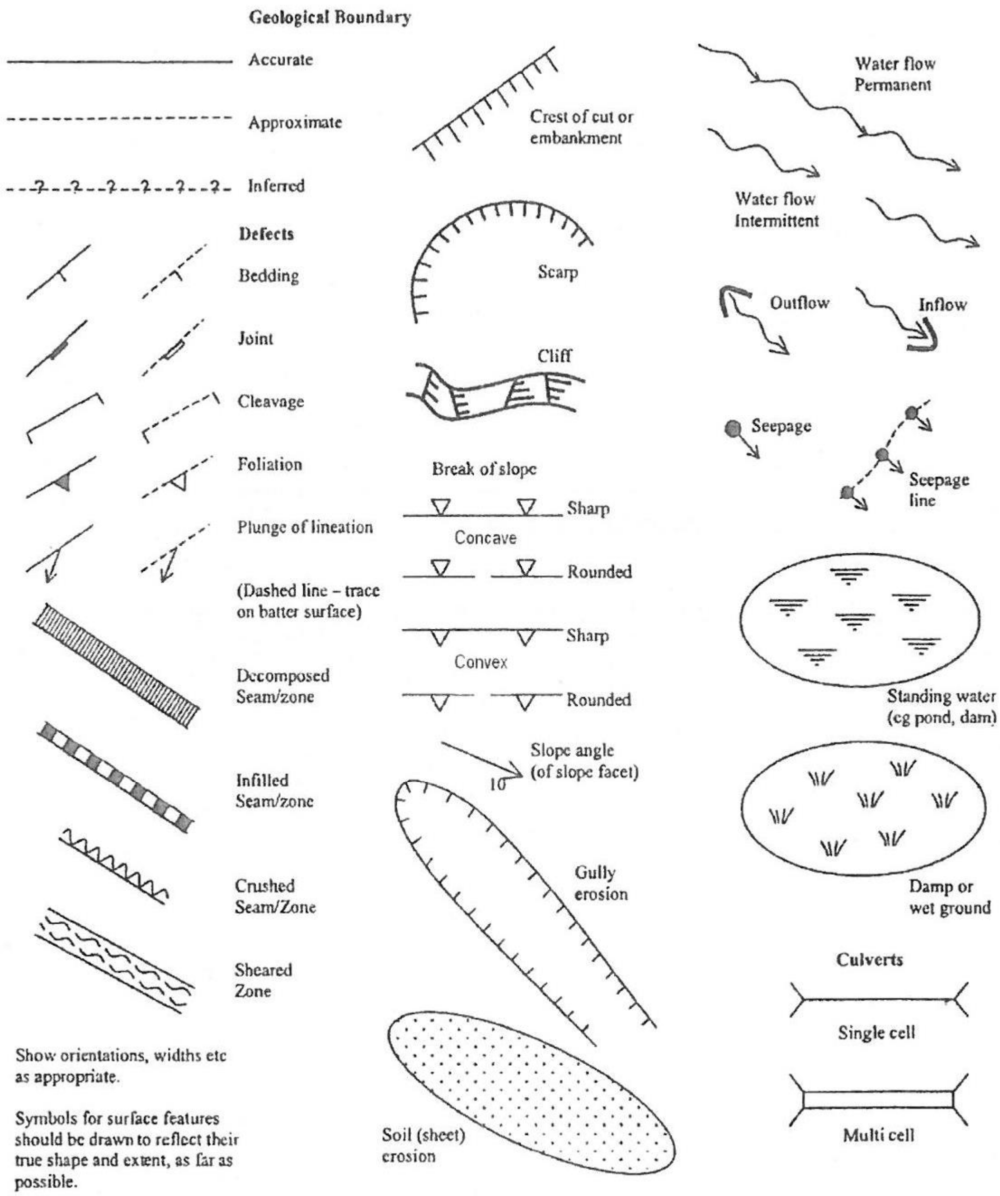
The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.





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

APPENDIX E - GEOLOGICAL AND GEOMORPHOLOGICAL MAPPING SYMBOLS AND TERMINOLOGY

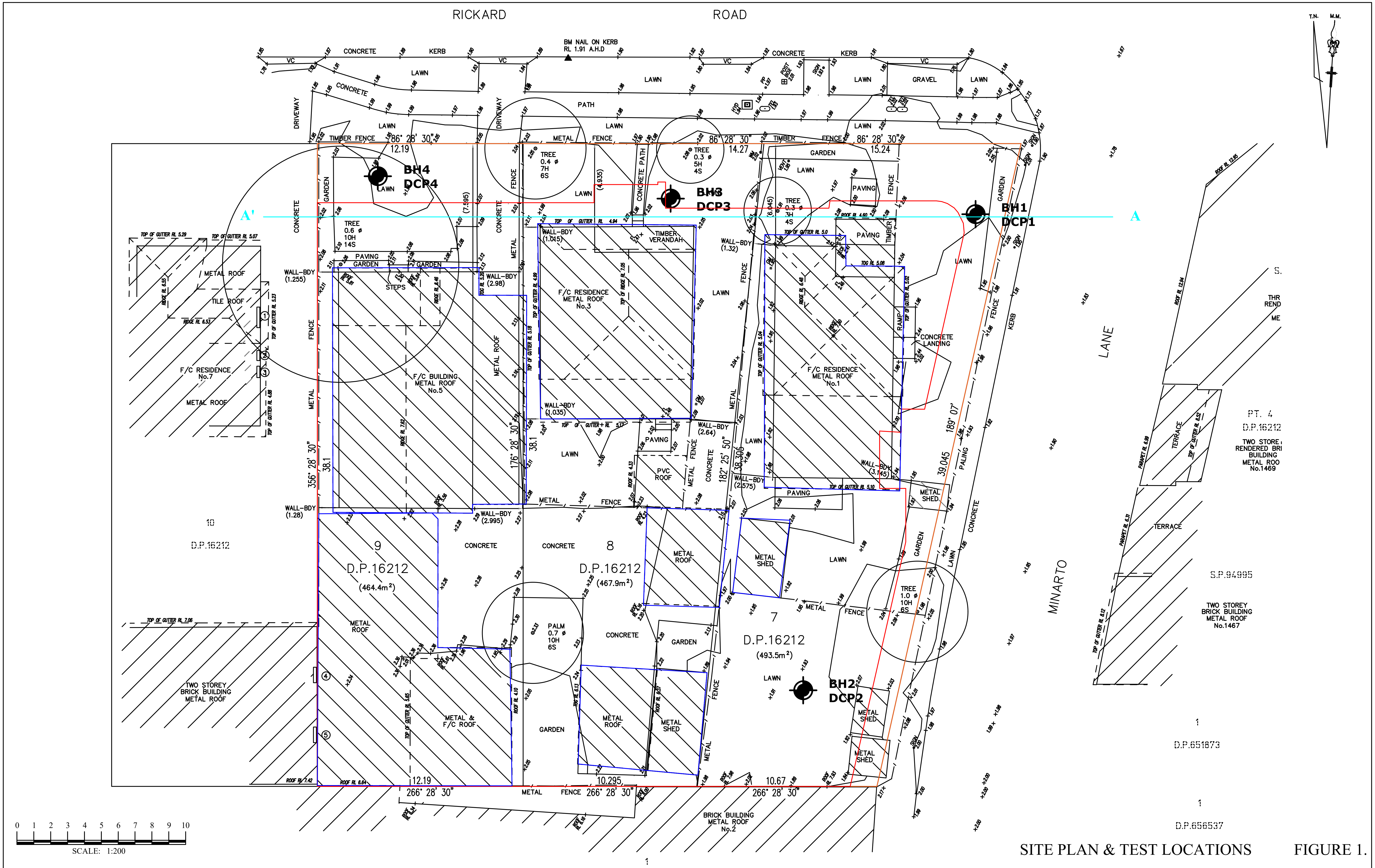


Show orientations, widths etc as appropriate.

Symbols for surface features should be drawn to reflect their true shape and extent, as far as possible.

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

Appendix 2



SITE PLAN & TEST LOCATIONS

FIGURE 1.

CROZIER GEOTECHNICAL CONSULTANTS
Crozier Geotechnical 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 PJC Geo-Engineering Pty Ltd

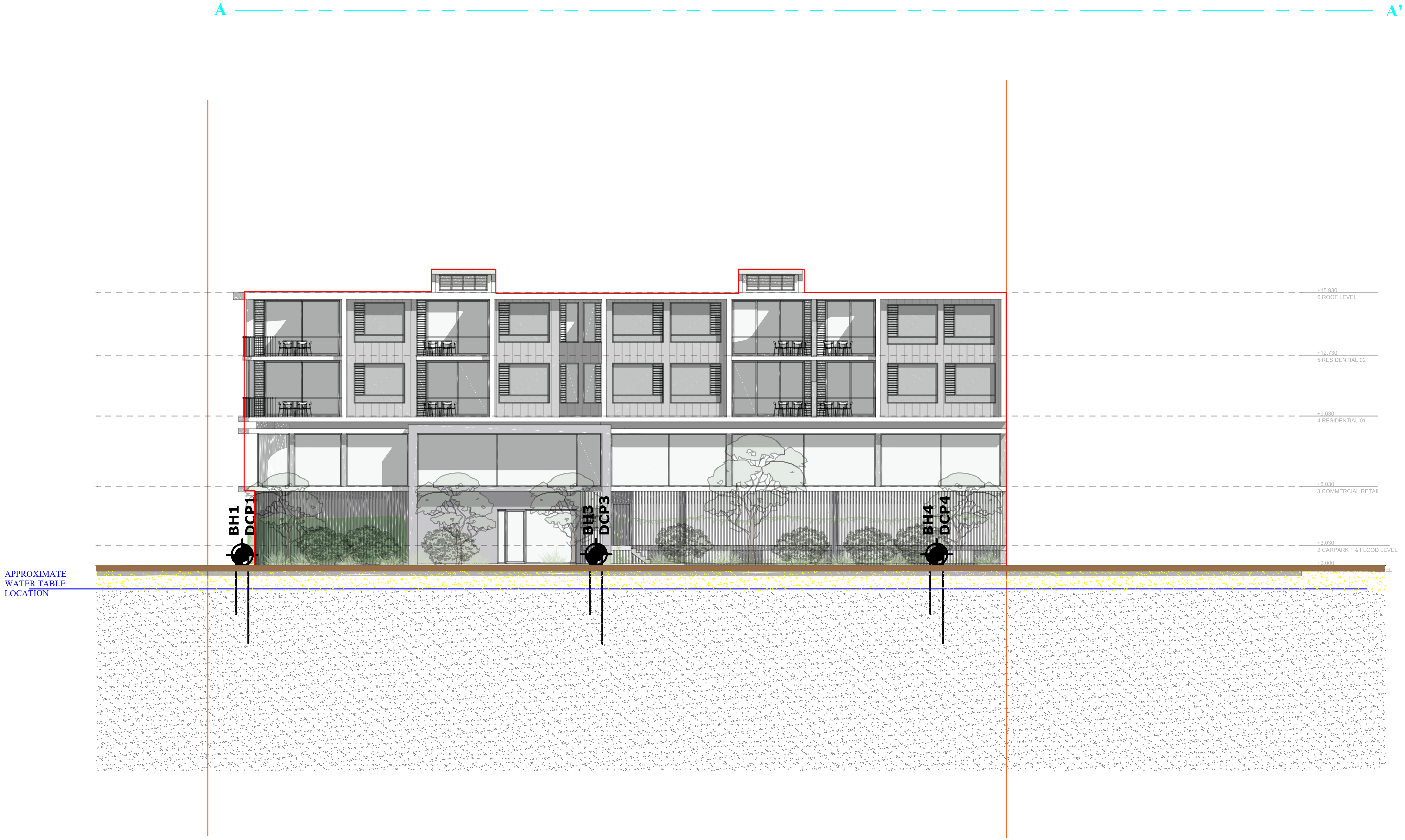
LEGEND

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

SCALE:	1:200 @ A3
DRAWING:	FIGURE 1
DATE:	06 /2024
APPROVED BY:	TMC
DRAWN BY:	JD
PROJECT:	2024-105

PREPARED FOR: ALDA Properties

ADDRESS: 1 - 5 Rickard Road, North Narrabeen



SECTION A: FIGURE 2

CROZIER
GEOTECHNICAL CONSULTANTS

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

LEGEND

PROPOSED WORKS | PROPERTY BOUNDARY | TOPSOIL/FILL | VERY LOOSE TO LOOSE ALLUVIAL SOILS | MEDIUM DENSE ALLUVIAL SOILS | BH DCP AUGER / DYNAMIC CONE PENETROMETER LOCATION | A —— A' SECTION LINE

SCALE:	1:200 @ A3
DRAWING:	FIGURE 2
DATE:	06 /2024
APPROVED BY:	TMC
DRAWN BY:	JD
PROJECT:	2024-105

PREPARED FOR:
ALDA Properties

ADDRESS:
1 - 5 Rickard Road, North Narrabeen

BOREHOLE LOG

CLIENT: ALDA Properties **DATE:** 11/06/2024 **BORE No.:** 1

PROJECT: New Residential Development **PROJECT No.:** 2024-105 **SHEET:** 1 of 1

LOCATION: 1 - 5 Rickard Road, North Narrabeen **SURFACE LEVEL:** RL 2.05

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/Fill: loose, grey/brown silty sand with roots				
0.20	SM	SAND: loose, yellow/brown, fine to medium grained, moist/dry				
			D	0.50 0.60		
1.00		… with trace silt	D	1.00 1.10		
1.20		… wet/saturated				
1.50		… brown, medium dense	D	1.50 1.60		
2.00		… grey/brown, silty sand	D	2.00 2.10		
			D	2.40 2.50		
2.50		End auger borehole @ target depth of 2.50m				

RIG: Dingo - Restricted Access Drill Rig DRILLER: AC

METHOD: Solid Stem Spiral Flighted Auger with Tungsten Carbide Bit LOGGED: JD

GROUND WATER OBSERVATIONS: Groundwater Table intersected below 1.20m depth

REMARKS: CHECKED: BT

BOREHOLE LOG

CLIENT: ALDA Properties | **DATE:** 11/06/2024 | **BORE No.:** 2

PROJECT: New Residential Development | **PROJECT No.:** 2024-105 | **SHEET:** 1 of 1

LOCATION: 1 - 5 Rickard Road, North Narrabeen | **SURFACE LEVEL:** RL 2.00

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/Fill: loose, grey/brown silty sand with roots				
0.20	SM	SAND: loose, yellow, fine to medium grained, moist/dry with trace silt				
1.00		… yellow/brown				
1.20		… wet/ saturated, increase in silt				
1.30		… medium dense				
2.50		End auger borehole @ target depth of 2.50m				

RIG: Dingo - Restricted Access Drill Rig | DRILLER: AC

METHOD: Solid Stem Spiral Flighted Auger with Tungsten Carbide Bit | LOGGED: JD

GROUND WATER OBSERVATIONS: Groundwater Table intersected below 1.20m depth

REMARKS: | CHECKED: BT

BOREHOLE LOG

CLIENT: ALDA Properties | **DATE:** 11/06/2024 | **BORE No.:** 3

PROJECT: New Residential Development | **PROJECT No.:** 2024-105 | **SHEET:** 1 of 1

LOCATION: 1 - 5 Rickard Road, North Narrabeen | **SURFACE LEVEL:** RL 2.05

Depth (m)	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling Type	Sampling Tests	In Situ Testing Type	In Situ Testing Results
0.00		Topsoil/Fill: loose, grey/brown silty sand with roots				
0.20	SM	SAND: loose, yellow, fine to medium grained, moist/dry with trace silt				
1.00		… dark brown (organic)				
1.10		… medium dense, pale grey				
1.30		… grey, wet/saturated, increase in silt				
2.50		End auger borehole @ target depth of 2.50m				

RIG: Dingo - Restricted Access Drill Rig | DRILLER: AC

METHOD: Solid Stem Spiral Flighted Auger with Tungsten Carbide Bit | LOGGED: JD

GROUND WATER OBSERVATIONS: Groundwater Table intersected below 1.30m depth

REMARKS: | CHECKED: BT

BOREHOLE LOG

CLIENT: ALDA Properties | **DATE:** 11/06/2024 | **BORE No.:** 4

PROJECT: New Residential Development | **PROJECT No.:** 2024-105 | **SHEET:** 1 of 1

LOCATION: 1 - 5 Rickard Road, North Narrabeen | **SURFACE LEVEL:** RL 2.05

Depth (m)	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling Type	Sampling Tests	In Situ Testing Type	In Situ Testing Results
0.00		Topsoil/Fill: loose, grey/brown silty sand with roots				
0.20	SM	SAND: loose, yellow/brown, fine to medium grained, moist/dry with trace silt				
			D	0.50 0.60		
			D	1.00 1.10		
1.20		… grey/brown, wet/saturated				
1.30		… medum dense				
			D	1.50 1.60		
			D	2.00 2.10		
			D	2.40 2.50		
2.50		End auger borehole @ target depth of 2.50m				

RIG: Dingo - Restricted Access Drill Rig | DRILLER: AC

METHOD: Solid Stem Spiral Flighted Auger with Tungsten Carbide Bit | LOGGED: JD

GROUND WATER OBSERVATIONS: Groundwater Table intersected below 1.20m depth

REMARKS: | CHECKED: BT

DYNAMIC PENETROMETER TEST SHEET

CLIENT: ALDA Properties **DATE:** 11/06/2024

PROJECT: New Residential Development **PROJECT No.:** 2024-105

LOCATION: 1 - 5 Rickard Road, North Narrabeen **SHEET:** 1 of 1

	Test Location									
Depth (m)	1	2	3	4						
0.00 - 0.10	-	-	-	-						
0.10 - 0.20	3	1	1	1						
0.20 - 0.30	4	1	2	1						
0.30 - 0.40	5	2	1	2						
0.40 - 0.50	3	1	2	1						
0.50 - 0.60	4	3	2	2						
0.60 - 0.70	3	2	3	2						
0.70 - 0.80	3	2	2	2						
0.80 - 0.90	2	3	2	2						
0.90 - 1.00	1	3	2	1						
1.00 - 1.10	0	1	1	2						
1.10 - 1.20	2	2	2	2						
1.20 - 1.30	1	2	2	1						
1.30 - 1.40	1	3	2	2						
1.40 - 1.50	1	2	2	2						
1.50 - 1.60	3	4	4	3						
1.60 - 1.70	3	6	5	4						
1.70 - 1.80	4	5	5	5						
1.80 - 1.90	4	5	6	4						
1.90 - 2.00	4	5	5	5						
2.00 - 2.10	4	5	6	4						
2.10 - 2.20	5	6	5	4						
2.20 - 2.30	5	5	7	4						
2.30 - 2.40	4	4	6	3						
2.40 - 2.50	2	3	5	3						
2.50 - 2.60	3	3	2	3						
2.60 - 2.70	2	3	2	5						
2.70 - 2.80	5	3	3	6						
2.80 - 2.90	5	4	6	6						
2.90 - 3.00										
3.00 - 3.10										
3.10 - 3.20										
3.20 - 3.30										
3.30 - 3.40										
3.40 - 3.50										
3.50 - 3.60										
3.60 - 3.70										
3.70 - 3.80										
3.80 - 3.90										
3.90 - 4.00										

TEST METHOD: AS 1289. F3.2, CONE PENETROMETER
AS 1289. F3.3, PERTH SAND PENETROMETER

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

Appendix 3

CROZIER
GEOTECHNICAL CONSULTANTS

Crozier Geotechnical Consultants | ABN: 96 113 453 624
Unit 12/ 42-46 Wattle Road | Phone: (02) 9939 1882
Brookvale NSW 2100 | Email: info@croziergeotech.com.au
Crozier Geotechnical Consultants a division of PJC Geo-Engineering Pty Ltd

Date: 10th July *2024*

Potential Acid Sulphate Soils (PASS) Management Plan:

1. Soil Neutralisation:

Where the disturbance of the PASS is unavoidable, neutralisation of the excavated soils with Calcium Carbonate (CaCO3) in the form of finely crushed limestone or 'Aglime' is required. The volume of lime required is calculated based on the acidity of the soil and its total oxidisable sulphur content along with the neutralising value (NV) of the agent and volume of soil disturbed. (Tabled 5.1, 6.1 and 6.2 in ASS Manual-1998, and provided in Table 3 in this report). Neutralising material should be applied to counteract the ASS and PASS at a 'safety factor' of 1.5 to 2.0.

2. Neutralising acidic dewatering effluent:

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

A staged treatment plan is provided below for use on all PASS soils excavated on this site. It is recommended that experienced ASS contractors be engaged to undertake all management of ASS on this site.

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

2. The soils should then be treated with natural lime via mechanical mixing at regular intervals during excavation. Based on the results of the Chromium Suite testing (BH1 and BH4) it is considered that a value of 10 kg of lime per tonne of soil to be treated will be required. If during bulk excavation or pile drilling the mixing of the non-acid sulphate soils from surface with the PASS soils below 1.00m

depth may result in a lower value of lime being suitable. However, this would need to be confirmed via onsite testing during the excavation and pier drilling process. If this further testing is not undertaken then the above recommended liming rate should be maintained.

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

Regards,

Troy Crozier
Principal

CROZIER
GEOTECHNICAL CONSULTANTS

Appendix 4

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 354242

Client Details

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

Sample Details

Your Reference	**2024-105, North Narrabeen, 1-5 Rickard Road**
Number of Samples	8 Soil
Date samples received	19/06/2024
Date completed instructions received	19/06/2024

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.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	26/06/2024
Date of Issue	26/06/2024

NATA Accreditation Number 2901. This document shall not be reproduced except in full.

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

Results Approved By
Jenny He, Senior Chemist

Authorised By
Nancy Zhang, Laboratory Manager

sPOCAS field test						
Our Reference		354242-1	354242-2	354242-3	354242-4	354242-5
Your Reference	UNITS	2024-105 BH1 0.50m	2024-105 BH1 1.00m	2024-105 BH1 2.00m	2024-105 BH1 2.50m	2024-105 BH4 1.00m
Date Sampled		11/06/2024	11/06/2024	11/06/2024	11/06/2024	11/06/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	19/06/2024	19/06/2024	19/06/2024	19/06/2024	19/06/2024
Date analysed	-	21/06/2024	21/06/2024	21/06/2024	21/06/2024	21/06/2024
pH_F (field pH test)	pH Units	9.6	9.6	7.6	7.5	9.5
pH_{FOX} (field peroxide test)	pH Units	6.5	6.8	1.8	2.2	6.3
Reaction Rate*	-	Medium reaction	Medium reaction	Medium reaction	Medium reaction	Medium reaction

sPOCAS field test				
Our Reference		354242-6	354242-7	354242-8
Your Reference	UNITS	2024-105 BH4 1.50m	2024-105 BH4 2.00m	2024-105 BH4 2.50m
Date Sampled		11/06/2024	11/06/2024	11/06/2024
Type of sample		Soil	Soil	Soil
Date prepared	-	19/06/2024	19/06/2024	19/06/2024
Date analysed	-	21/06/2024	21/06/2024	21/06/2024
pH_F (field pH test)	pH Units	8.2	8.5	7.8
pH_{FOX} (field peroxide test)	pH Units	4.0	5.0	2.1
Reaction Rate*	-	Medium reaction	Medium reaction	Medium reaction

Chromium Suite					
Our Reference		354242-2	354242-4	354242-6	354242-7
Your Reference	UNITS	2024-105 BH1 1.00m	2024-105 BH1 2.50m	2024-105 BH4 1.50m	2024-105 BH4 2.00m
Date Sampled		11/06/2024	11/06/2024	11/06/2024	11/06/2024
Type of sample		Soil	Soil	Soil	Soil
Date prepared	-	19/06/2024	19/06/2024	19/06/2024	19/06/2024
Date analysed	-	20/06/2024	20/06/2024	20/06/2024	20/06/2024
pH_{kcl}	pH units	9.6	7.0	7.0	7.9
s-TAA pH 6.5	%w/w S	<0.01	<0.01	<0.01	<0.01
TAA pH 6.5	moles H^+/t	<5	<5	<5	<5
Chromium Reducible Sulfur	%w/w	0.006	0.22	0.02	<0.005
a-Chromium Reducible Sulfur	moles H^+/t	4	140	12	<3
S_{HCl}	%w/w S	[NT]	[NT]	[NT]	[NT]
S_{KCl}	%w/w S	[NT]	[NT]	[NT]	[NT]
S_{NAS}	%w/w S	[NT]	[NT]	[NT]	[NT]
ANC_{BT}	% $CaCO_3$	13	0.25	0.25	0.30
s-ANC_{BT}	%w/w S	4.1	0.08	0.08	0.1
s-Net Acidity	%w/w S	<0.005	0.17	<0.005	<0.005
a-Net Acidity	moles H^+/t	<5	110	<5	<5
Liming rate	kg $CaCO_3$/t	<0.75	8.0	<0.75	<0.75
a-Net Acidity without ANCE	moles H^+/t	<5	140	12	<5
Liming rate without ANCE	kg $CaCO_3$/t	<0.75	11	0.90	<0.75
s-Net Acidity without ANCE	%w/w S	0.0060	0.22	0.019	<0.005

Method ID	Methodology Summary
Inorg-063	pH- measured using pH meter and electrode. Soil is oxidised with Hydrogen Peroxide or extracted with water. 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-068	Chromium Reducible Sulfur - Hydrogen Sulfide is quantified by iodometric titration after distillation to determine potential acidity. Net acidity including ANC has a safety factor of 1.5 applied. Neutralising value (NV) of 100% is assumed for liming rate. The recommendation that the SHCL concentration be multiplied by a factor of 2 to ensure retained acidity is not underestimated, has not been applied in the SHCL result. However, it has been applied in the SNAS calculation: SNAS % = (SHCL-SKCL)x2

QUALITY CONTROL: sPOCAS field test					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			19/06/2024	[NT]	[NT]	[NT]	[NT]	19/06/2024	[NT]
Date analysed	-			21/06/2024	[NT]	[NT]	[NT]	[NT]	21/06/2024	[NT]
pH_F (field pH test)	pH Units		Inorg-063	[NT]	[NT]	[NT]	[NT]	[NT]	100	[NT]
pH_{FOX} (field peroxide test)	pH Units		Inorg-063	[NT]	[NT]	[NT]	[NT]	[NT]	100	[NT]

QUALITY CONTROL: Chromium Suite					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			19/06/2024	[NT]	[NT]	[NT]	[NT]	19/06/2024	[NT]
Date analysed	-			20/06/2024	[NT]	[NT]	[NT]	[NT]	20/06/2024	[NT]
pH $_{kcl}$	pH units		Inorg-068	[NT]	[NT]	[NT]	[NT]	[NT]	96	[NT]
s-TAA pH 6.5	%w/w S	0.01	Inorg-068	<0.01	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
TAA pH 6.5	moles H^+/t	5	Inorg-068	<5	[NT]	[NT]	[NT]	[NT]	94	[NT]
Chromium Reducible Sulfur	%w/w	0.005	Inorg-068	<0.005	[NT]	[NT]	[NT]	[NT]	96	[NT]
a-Chromium Reducible Sulfur	moles H^+/t	3	Inorg-068	<3	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
S_{HCl}	%w/w S	0.005	Inorg-068	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
S_{KCl}	%w/w S	0.005	Inorg-068	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
S_{NAS}	%w/w S	0.005	Inorg-068	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
ANC_{BT}	% $CaCO_3$	0.05	Inorg-068	<0.05	[NT]	[NT]	[NT]	[NT]	100	[NT]
s-ANC_{BT}	%w/w S	0.05	Inorg-068	<0.05	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
s-Net Acidity	%w/w S	0.005	Inorg-068	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
a-Net Acidity	moles H^+/t	5	Inorg-068	<5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Liming rate	kg $CaCO_3$/t	0.75	Inorg-068	<0.75	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
a-Net Acidity without ANCE	moles H^+/t	5	Inorg-068	<5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Liming rate without ANCE	kg $CaCO_3$/t	0.75	Inorg-068	<0.75	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
s-Net Acidity without ANCE	%w/w S	0.005	Inorg-068	<0.005	[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.

Where matrix spike recoveries fall below the lower limit of the acceptance criteria (e.g. for non-labile or standard Organics <60%), positive result(s) in the parent sample will subsequently have a higher than typical estimated uncertainty (MU estimates supplied on request) and in these circumstances the sample result is likely biased significantly low.

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.

Report Comments

Samples were out of the recommended holding time for this analysis.

CROZIER
GEOTECHNICAL CONSULTANTS

Appendix 5

APPENDIX A

DEFINITION OF TERMS

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

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

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

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

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

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

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

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

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

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

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

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

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

RISK LEVEL IMPLICATIONS

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

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