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REPORT ON GEOTECHNICAL INVESTIGATION

for

PROPOSED ALTERATIONS AND ADDITIONS

at

106 PRINCE ALFRED PARADE, NEWPORT, NSW

Prepared For

Peter Easter

Project No.: 2021-092.1

December, 2023

Document Revision Record

Issue No	Date	Details of Revisions
0	12th December 2023	Original issue

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER

FORM NO. 1 – To be submitted with Development Application

Development Application for____

Name of Applicant

Address of site ___ 106 Prince Alfred Parade, Newport_________

Declaration made by geotechnical engineer or engineering geologist or coastal engineer (where applicable) as part of a geotechnical report

I, __***Troy Crozier***______ *on behalf of* ___***Crozier Geotechnical Consultants*** ____

on this the 13 December 2023 certify that I am a ~~geotechnical engineer or~~ engineering geologist ~~or coastal engineer~~ as defined by the Geotechnical Risk Management Policy for Pittwater - 2009 and I am authorised by the above ~~organisation/~~company to issue this document and to certify that the ~~organisation/~~company has a current professional indemnity policy of at least $2million.

I:

☐ have prepared the detailed Geotechnical Report referenced below in accordance with the Australia Geomechanics Society's Landslide Risk Management Guidelines (AGS 2007) and the Geotechnical Risk Management Policy for Pittwater - 2009

☐ am willing to technically verify that the detailed Geotechnical Report referenced below has been prepared in accordance with the Australian Geomechanics Society's Landslide Risk Management Guidelines (AGS 2007) and the Geotechnical Risk Management Policy for Pittwater - 2009

☐ have examined the site and the proposed development in detail and have carried out a risk assessment in accordance with Section 6.0 of the Geotechnical Risk Management Policy for Pittwater - 2009. I confirm that the results of the risk assessment for the proposed development are in compliance with the Geotechnical Risk Management Policy for Pittwater - 2009 and further detailed geotechnical reporting is not required for the subject site.

■ have examined the site and the proposed development/alteration in detail and I am of the opinion that the Development Application only involves Minor Development/Alteration that does not require a Geotechnical Report or Risk Assessment and hence my Report is in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009 requirements.

☐ have examined the site and the proposed development/alteration is separate from and is not affected by a Geotechnical Hazard and does not require a Geotechnical Report or Risk Assessment and hence my Report is in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009 requirements.

☐ have provided the coastal process and coastal forces analysis for inclusion in the Geotechnical Report

Geotechnical Report Details:

Report Title: Geotechnical Investigation for Proposed Inclinator

Report Date: 13 December 2023 **Project No.:** 2021-092.1

Author: K.Nicholson and T. Crozier

Author's Company/Organisation: Crozier Geotechnical Consultants

Documentation which relate to or are relied upon in report preparation:

Structural Drawing – PR King and Son, Plan No.: 3422/1, Dated: 2 December 2022.

Survey Drawing – Chadwick Cheng Consulting Surveyors, Drawing Ref.: 40157/D-MGA, Dated: 22/02/2021

Geotechnical Investigation for Proposed Alterations and Additions, Report Reference 2021-092, Dated: 26th May 2021

I am aware that the above Geotechnical Report, prepared for the abovementioned site is to be submitted in support of a Development Application for this site and will be relied on by Pittwater Council as the basis for ensuring that the Geotechnical Risk Management aspects of the proposed development have been adequately addressed to achieve an "Acceptable Risk Management" level for the life of the structure, taken as at least 100 years unless otherwise stated and justified in the Report and that reasonable and practical measures have been identified to remove foreseeable risk.

Signature ....

Name ...**Troy Crozier**..............................

Chartered Professional Status: **RPGeo (AIG)**..............

Membership No. ...**10197**..............................

Company... **Crozier Geotechnical Consultants**

REGISTERED PROFESSIONAL GEOSCIENTIST
AUSTRALIAN INSTITUTE OF GEOSCIENTISTS
TROY CROZIER
10,197

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER

FORM NO. 1(a) - Checklist of Requirements For Geotechnical Risk Management Report for Development Application

Development Application for ____

Name of Applicant

Address of site _106 Prince Alfred Parade, Newport _ ______________________

The following checklist covers the minimum requirements to be addressed in a Geotechnical Risk Management Geotechnical Report. This checklist is to accompany the Geotechnical Report and its certification (Form No. 1).

Geotechnical Report Details:

Report Title: Geotechnical Investigation for Proposed Inclinator
Report Date: 13 December 2023 **Project No.:** 2021-092.1
Author: K.Nicholson and T. Crozier
Author's Company/Organisation: Crozier Geotechnical Consultants

Please mark appropriate box

- ■ Comprehensive site mapping conducted __27th April 2021 and 24 November 2023 (date)
- ☐ Mapping details presented on contoured site plan with geomorphic mapping to a minimum scale of 1:200 (as appropriate)
- ■ Subsurface investigation required
  - ☐ No Justification ... .
  - ■ Yes Date conducted 27 April 2021............
- ■ Geotechnical model developed and reported as an inferred subsurface type-section
- ☐ Geotechnical hazards identified
  - ☐ Above the site
  - ☐ On the site
  - ☐ Below the site
  - ☐ Beside the site
- ☐ Geotechnical hazards described and reported
- ☐ Risk assessment conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
  - ☐ Consequence analysis
  - ☐ Frequency analysis
- ☐ Risk calculation
- ☐ Risk assessment for property conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
- ☐ Risk assessment for loss of life conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
- ■ Assessed risks have been compared to "Acceptable Risk Management" criteria as defined in the Geotechnical Risk Management Policy for Pittwater - 2009
- ■ Opinion has been provided that the design can achieve the "Acceptable Risk Management" criteria provided that the specified conditions are achieved.
- ■ Design Life Adopted:
  - ☐ 100 years
  - ■ Other ......50 years............................ (specify)
- ■ Geotechnical Conditions to be applied to all four phases as described in the Geotechnical Risk Management Policy for Pittwater - 2009 have been specified
- ■ Additional action to remove risk where reasonable and practical have been identified and included in the report.
- ☐ Risk assessment within Bushfire Asset Protection Zone.

I am aware that Pittwater Council will rely on the Geotechnical Report, to which this checklist applies, as the basis for ensuring that the geotechnical risk management aspects of the proposal have been adequately addressed to achieve an "Acceptable Risk Management" level for the life of the structure, taken as at least 100 years unless otherwise stated, and justified in the Report and that reasonable and practical measures have been identified to remove foreseeable risk.

Signature ....

Name ...**Troy Crozier**..

Chartered Professional Status...**RPGeo (AIG)**.......TROY CROZIER 10,197

Membership No. ...**10197**..

Company... **Crozier Geotechnical Consultants**

TABLE OF CONTENTS

APPENDICES

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GEOTECHNICAL INVESTIGATION FOR PROPOSED INCLINATOR AT 106 PRINCE ALFRED PARADE, NEWPORT, NSW

1. INTRODUCTION:

This report details the results of a geotechnical assessment carried out for a proposed inclinator at 106 Prince Alfred Parade, Newport, NSW. The assessment was undertaken by Crozier Geotechnical Consultants (CGC) at the written request of Erik Smithson Architecture on behalf of the client, Teresa Easter.

The site is located within the H1 (highest category) landslip hazard zone as identified within Northern Beaches Councils precinct (Geotechnical Risk Management Policy for Pittwater - 2009). To meet the Councils Policy requirements for land classified as H1 a detailed Geotechnical Report which meets the requirements of Paragraph 6.5 of that policy is required for submission with the Development Application. The report must include a landslide risk assessment of the site and proposed works, plans, geological sections and provide recommendations for construction and to ensure stability is maintained for a design life of 100 years.

Based on our understanding of the proposed development, Council and project requirements, a Fee Proposal (P23-444, Dated: 10 November 2023) was submitted and subsequently accepted by the client. In addition to the walkover inspection, the assessment was partially based on the results of a previous investigation undertaken within the site which comprised:

a) On-site service location by accredited underground service locator.
b) A detailed geotechnical inspection and mapping of the site and adjacent properties by a Senior Engineering Geologist.
c) Drilling of three auger boreholes using hand tools along with three Dynamic Cone Penetrometer (DCP) tests to investigate the subsurface conditions.

This report contains the results of the nominated scope of works and includes a site description and geological setting, details of investigation methodology, detailed geotechnical/geological field observations, borehole/test pit logs, in situ test results, test location plan and a geological cross section.

This report provides recommendations for Council use in assessment of the Development Application and to assist in the preliminary structural design of the development and includes:

- Assessment of potential/existing landslide hazards in accordance with AGS guidelines.
- Assessment of the impacts of the development
- Measures to protect adjacent properties during construction and following completion of the development.
- Structural design parameters on new footings, stability, support measures.
- Construction considerations including recommended plant and equipment

The following documents have been supplied and relied on in regard to the request:

- Structural Drawing – PR King and Son, Plan No.: 3422/1, Dated: 2 December 2022.
- Survey Drawing – Chadwick Cheng Consulting Surveyors, Drawing Ref.: 40157/D-MGA, Dated: 22/02/2021

1.1 Proposed Development:

It is understood that the proposed works involve the installation of a new inclinator which will extend along the eastern side boundary between RL 3.43m and RL 17.88m. The proposed inclinator will be supported via approximately 12 pad footings. No major bulk excavation is anticipated as part of the proposed works.

2. SITE FEATURES:

2.1. Site Description:

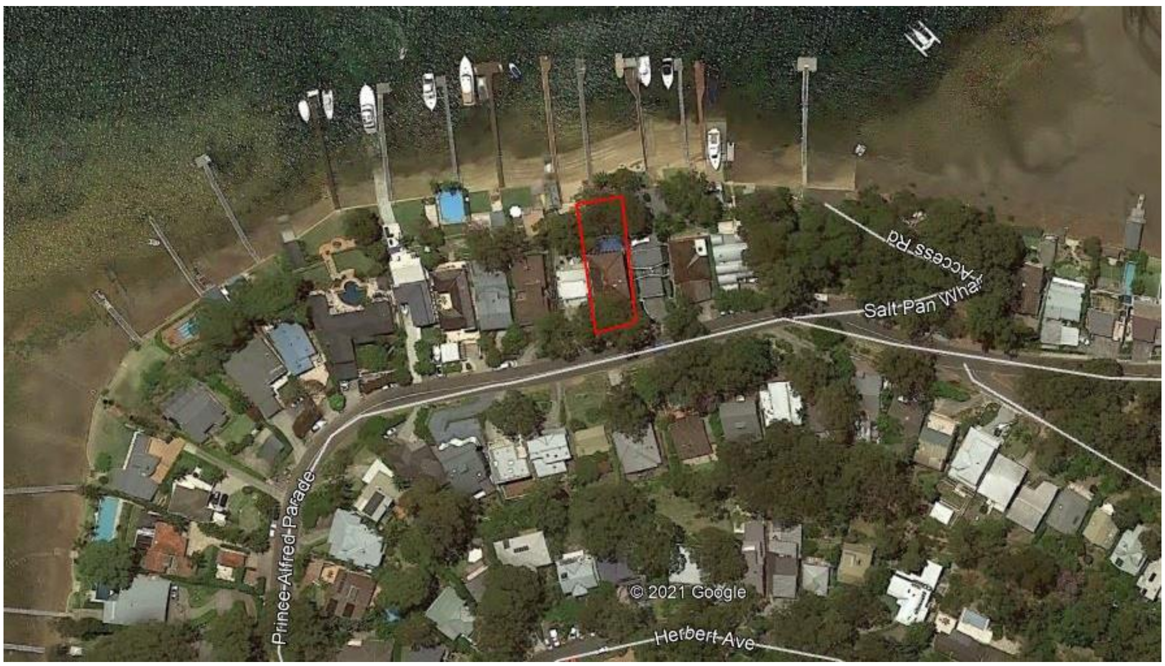
The site is trapezoidal in shape and covers an area of approximately 582m^2 in plan as referenced from the provided survey drawing. It is located on the low north side of the road within steeply north dipping topography. The elevation varies between a high of RL17.0m adjacent to the south west corner and a low of RL2.0m near the north boundary of the site. It has north, east south and west boundaries of approximately 13.0m, 42.7m, 44.5m and 13.5m respectively as determined from the survey plan provided and defined by the mean high-water mark.

The front of the site contains a steeply inclined driveway accessed from Prince Alfred Parade easement to the south, low flagstone retaining walls up to approximately 1.0m in height, a carport and front garden.

The site residence comprises a two to three storey rendered structure with an indoor pool within the northern end.

The rear (north) of the site is accessed via concrete steps located to the west of the residence and contains terrace gardens supported by flagstone retaining walls up to approximately 1.5m in height and a boatshed/jetty adjacent to the foreshore.

An aerial view of the site and surrounding properties is provided in Photograph 1, obtained from Google Earth.



Photograph 1: Aerial view of the site (outlined red) and immediate surrounds

The site is bordered to the north, east, south and west by Salt Pan Cove, No.108 Prince Alfred Parade, Prince Alfred Parade easement and No.104 Prince Alfred Parade respectively.

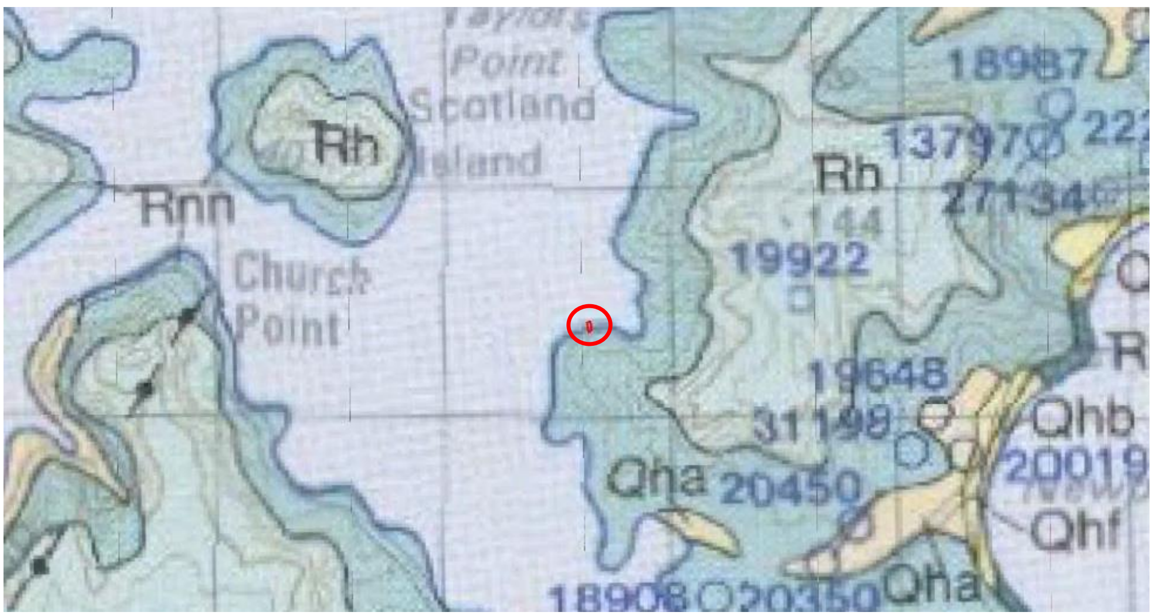
No.108 contains a two to three storey residential rendered dwelling with access driveway and front and rear gardens. The house structure is approximately 3.0m from the shared boundary. The property is at a similar level to the site immediately adjacent to the shared boundary and shares similar topography.

No.104 contains a two to three storey residential rendered dwelling currently undergoing renovation with access driveway and front and rear gardens. The house structure is approximately 3.0m from the shared boundary. The property is at a similar level to the site immediately adjacent to the shared boundary and has shares similar topography.

2.2. Geology:

Reference to the Sydney 1:100,000 Geological Series sheet indicates that the site is underlain by Newport Formation (Upper Narrabeen Group) rock which is of middle Triassic Age. The Newport Formation typically comprises interbedded laminite, shale and quartz to lithic quartz sandstones and pink clay pellet sandstones.

Narrabeen Group rocks are dominated by shales and thin siltstone beds and often form rounded convex ridge tops with moderate angle (<20°) side slopes. These side slopes can be either concave or convex depending on geology, internally they comprise interbedded shale and siltstone beds with close spaced bedding partings that have either close spaced vertical joints or in extreme cases large space convex joints. The shale often forms deeply weathered silty clay soil profiles (medium to high plasticity) with thin silty colluvial cover.
An extract of the relevant geological sheet is provided as Extract 1.



Extract 1: Extract from the Sydney Series 9130 Geology Sheet with the site (circled red).

3. FIELD WORK:

3.1. Methods:

The original field investigation comprised geotechnical inspection/mapping and a subsurface investigation which were both undertaken/supervised by a Senior Engineering Geologist on the 27th April 2021. An additional inspection of the site was also undertaken on the 24 November 2023.

The geotechnical mapping comprised a visual inspection of the site and adjacent properties to assess potential geotechnical issues relevant to the proposed development. It involved a photographic record of site conditions as well as geological/geomorphological mapping of the site and adjacent land with examination of soil slopes, vegetation and existing structures to assess the stability of the site.

The sub-surface investigation comprised the drilling of three boreholes (BH1 to BH3) using a hand auger to investigate sub-surface geology. A hand auger was used as access to the site for a conventional drilling rig was unavailable.

Soil samples were recovered from the auger for geotechnical logging purposes which was undertaken in accordance with AS1726:2017 'Geotechnical Site Investigations'.

Numerous (unsuccessful) attempts to advance the boreholes and DCP tests were undertaken at each location (two to three at each). These locations were at similar location to BH1 to BH3 and have not been included on the Test Location Plan.

DCP testing was carried out 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 soil conditions and depths to bedrock.

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 Ground Conditions:

For a description of the subsurface conditions encountered at the borehole locations, the Borehole Log Report and Dynamic Penetrometer Test Sheet should be consulted, however a very broad description is provided below:

- **Fill/Possible fill/Colluvium –** Possible fill/colluvium was encountered within all boreholes to the maximum depth achieved of 0.7m (BH2). The material comprised of a surface layer of topsoil underlain by orange-brown sandy clay with fine to coarse gravel and suspected cobbles. Within BH3 at the front of the site, the fill contained tile fragments and plastic. Due to the suspected cobbles, auger refusal was encountered within this material in all boreholes. Based on the results of the DCP testing it has been interpreted that fill likely extends to between approximately 0.8m and 1.0m depth and although not recovered from the boreholes, is probably underlain by clay soils grading to extremely low strength sandstone however this has not been confirmed.

- **Bedrock –** What has been interpreted as a minimum very low strength bedrock was encountered in DCP1 to DCP3 at depths of between 1.1m and 1.78m.

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

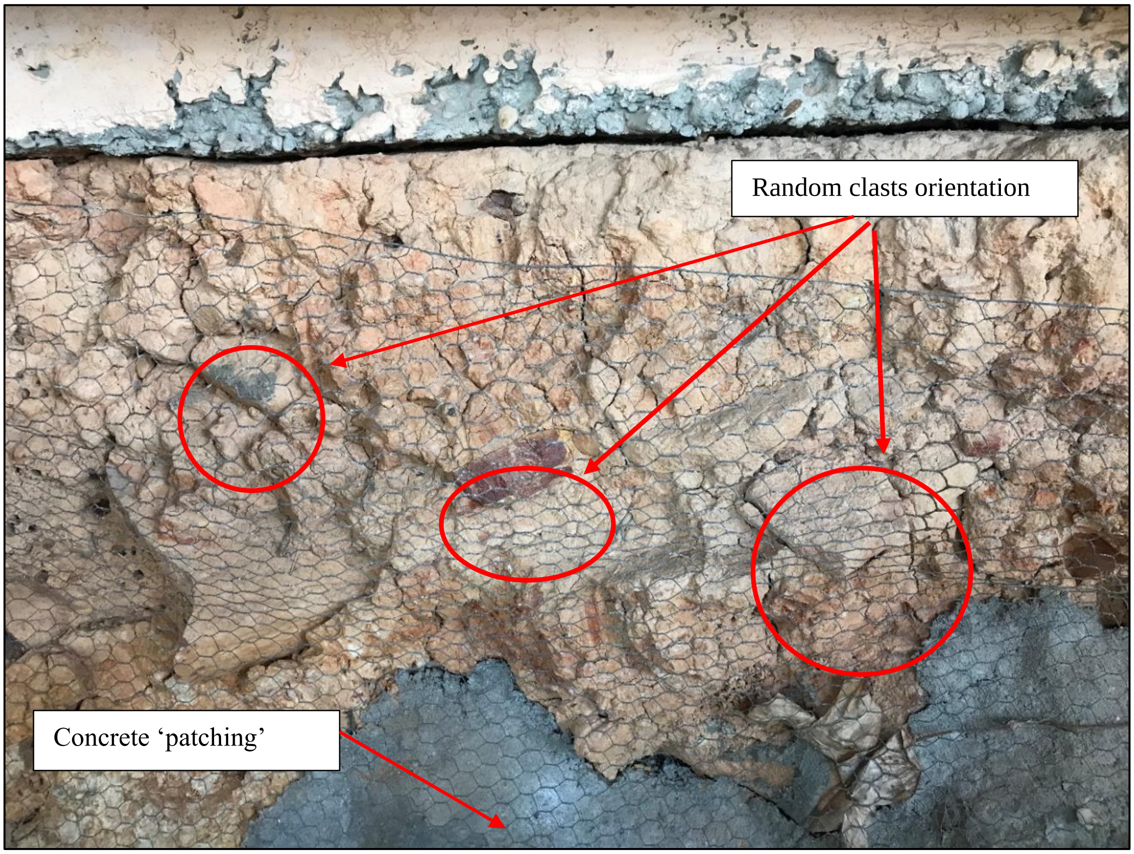
3.3 Site Stability:

No.106 Prince Alfred Parade lies to the north of the carriageway which comprises a gently east dipping asphalt pavement with concrete curbing and appears in good condition where it passes the site.

Bedrock outcrops were not observed within the roadway cutting, or in adjacent properties. In-situ bedrock may have been present at one location in the underfloor/basement storage area however it is not confirmed as the exposure observed was of limited dimensions.

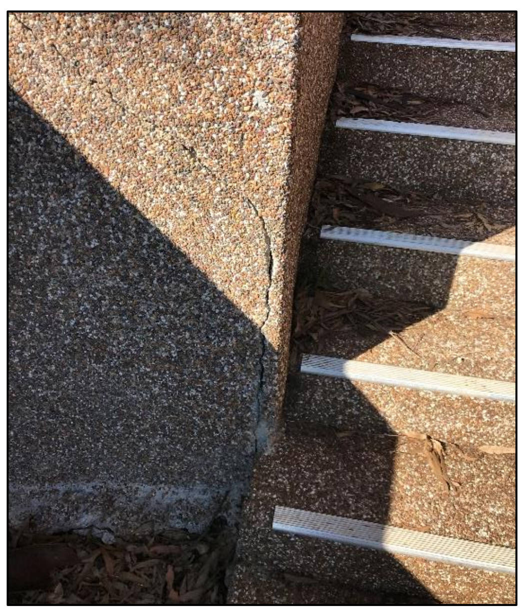
Within the north end of the site and below the pool surround/lower-level floor slab, soil was exposed and comprised orange-brown clay which contained subangular, medium to coarse gravel to cobble size clasts of sandstone (Photographs 2 and 3). The soil was overlain by what appeared to be a topsoil horizon and the clasts appeared randomly orientated within the clay matrix indicating that the deposit is likely to represent a colluvial soil/slope deposit.

Concrete patching was also observed in one small area at the base of the soil cutting adjacent to the pathway west of the residence. The concrete does not appear to be degraded/cracked and likely resembles original application.



Photograph 2: View of the soil exposed under north end of house

Photograph 3: View of the soil exposed under north end of the site house



Photograph 4: View of the cracking within the bin store at the front of the site

Signs of instability (cracking in the pavement/brickwork/render etc) where not observed within the roadway or within the site residence however some isolated cracking was observed within a bin storage structure near the front access to the site (see Photograph 4).

The concrete structure was unsupported downslope and it is considered the cracking observed is likely to be related to downslope creep of the colluvial soils observed underlying the north end of the residence rather than a deep-seated stability issue.

The site residence generally appeared in good condition with no evidence of cracking in the external walls observed.

Within the rear garden, low timber or flagstone (<1.5m) retaining walls have been constructed which do not appear to be in distress. Signs of hummocky ground, back scars, tilting trees or any other signs of potential instability were not observed in the rear garden of the property.

The properties to the east and west of the site (No.108 and No.104 respectively) did not appear to be displaying any signs of distress.

4. COMMENTS:

4.1 Ground Model

Based on the subsurface investigation it is anticipated that the ground conditions underlying the site will comprise an upper layer of fill/colluvial soils to approximately 1.0m-1.5m depth underlain by potentially residual clay soils/extremely weathered bedrock to between 1.1m (DCP2) and 1.78m (DCP3). It is anticipated that the bedrock may grade to low to medium strength near the front of the property however this is unconfirmed.

A groundwater table is not anticipated in footing excavations however local groundwater seepages on the competent sandstone bedrock surface are anticipated.

4.2. Geotechnical Assessment:

A significant landslip hazard was not identified during the previous investigation and assessment whilst the now proposed scope of works (inclinator) is such that a landslip hazard will not be created. Signs of potential downslope creep was observed in the bin storage structure at the front of the site and likely indicates that the structure is supported on colluvial/fill soils.

New footings supporting the inclinator should be founded in/off competent bedrock or residual soils to control differential movement and potential future downslope creep. Based on the results of DCP1 and DCP3, which were undertaken within the east of the site broadly within the location of the proposed inclinator alignment, it appears bedrock lies at a depth of between 1.37m and 1.78m below existing ground surface levels.

It is further understood that pad footings are proposed to support the inclinator. Should the depths to bedrock encountered in DCP1 and DCP3 be greater than practical to found pad footings on, bored piers should be adopted to control future creep movements. The requirement for piers could be reduced where footings found in residual soils not prone to downslope creep movements. However, the depth to residual soils was not determined during the investigation and would need to be assessed at the time of footing excavation for the inclinator pad footings which may introduce an element of risk to the design and construction phase of the inclinator installation.

4.3. Site Specific Risk Assessment:

Based on the limited scope of the work in terms of geotechnical risk it is considered that the proposed development will not impact global slope stability whilst there are no existing landslide hazards. As such, it is considered that the site achieves the 'Acceptable' risk management criteria and as such no further assessment or analysis is required

4.4. Design & Construction Recommendations:

Preliminary design and construction recommendations are tabulated below:

4.4.1. New Footings:	
Site Classification as per AS2870 – 2011 for new footing design	'P' due to colluvial soils & landslide potential.
Type of Footing	Strip/pad **or** piers where bedrock or residual clay is not exposed in shallow footing excavations.
Sub-grade material and Maximum Allowable Bearing Capacity	- Stiff Residual Clay: 100kPa - VLS bedrock: 800kPa
Site sub-soil classification as per *Structural design actions AS1170.4 – 2007, Part 4: Earthquake actions in Australia*	B_e – rock site
Remarks: 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.	

Individual footings should be founded within/on material of similar bearing and settlement characteristics to reduce the potential for differential settlement.

4.5. 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 and works as per Section 4.4 of this report
3. Inspect all new footings 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.

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.

4.6. 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 investigation identified that the ground conditions underlying the proposed inclinator location will likely comprise colluvial clay then potentially residual soils in turn underlain by bedrock at a maximum depth of 1.78m below existing site surface levels.

Footings should extend to either residual soils (at a depth unknown) or found within bedrock.

The proposed works are considered suitable for the site and may be completed with negligible impact to existing nearby structures within the site or on neighbouring properties provided the recommendations of this report and any future geotechnical directive are implemented.

The recommendations and conclusions in this report are based on a site walkover and the results of a subsurface investigation and will require confirmation during excavation. However, the results of the investigation provide a reasonable basis for the Development Application and preliminary design.

Prepared by:

Kieron Nicholson

Kieron Nicholson
Senior Engineering Geologist

Reviewed by:

Troy Crozier
Principal
MIE. Aust, CPEng
MAIG. RPGeo; 10197

6. 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. E. Hoek & J.W. Bray 1981, "Rock Slope Engineering" By The Institution of Mining and Metallurgy, London.
4. C. W. Fetter 1995, "Applied Hydrology" by Prentice Hall. V. Gardiner & R. Dackombe 1983, "Geomorphological Field Manual" by George Allen & Unwin.

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

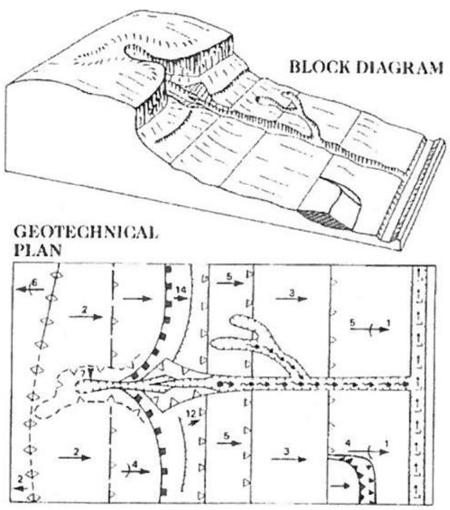
In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the Company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed than at some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

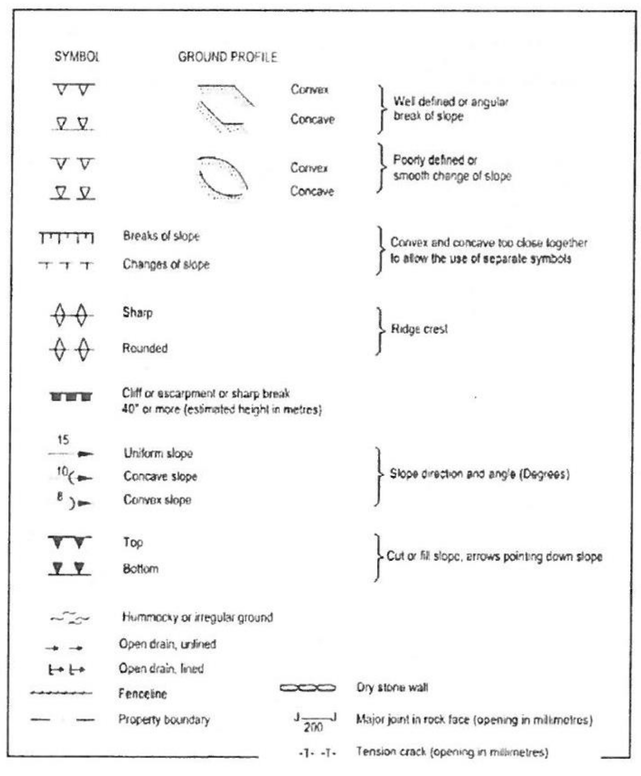
Reproduction of Information for Contractual Purposes

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

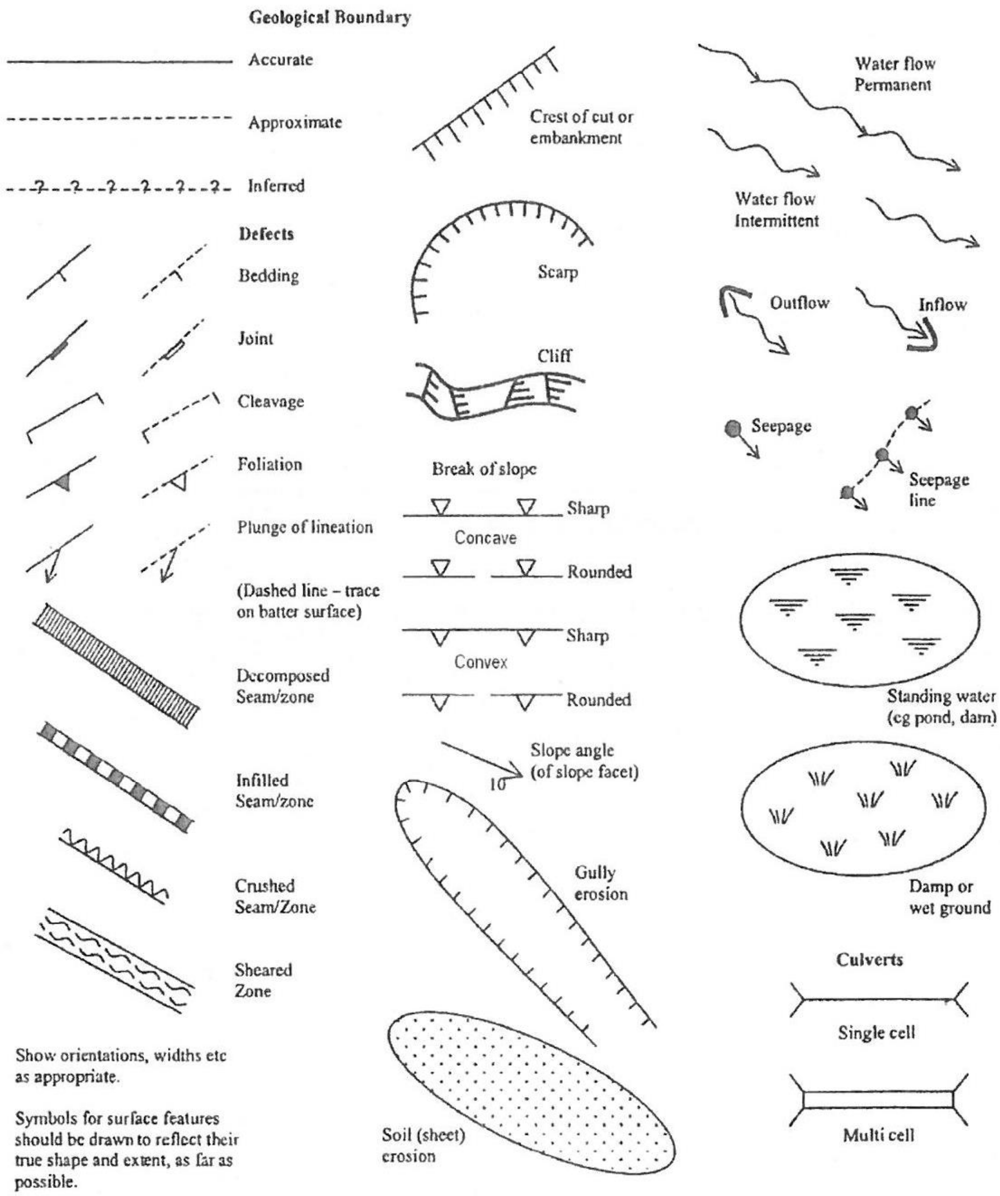
The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.





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

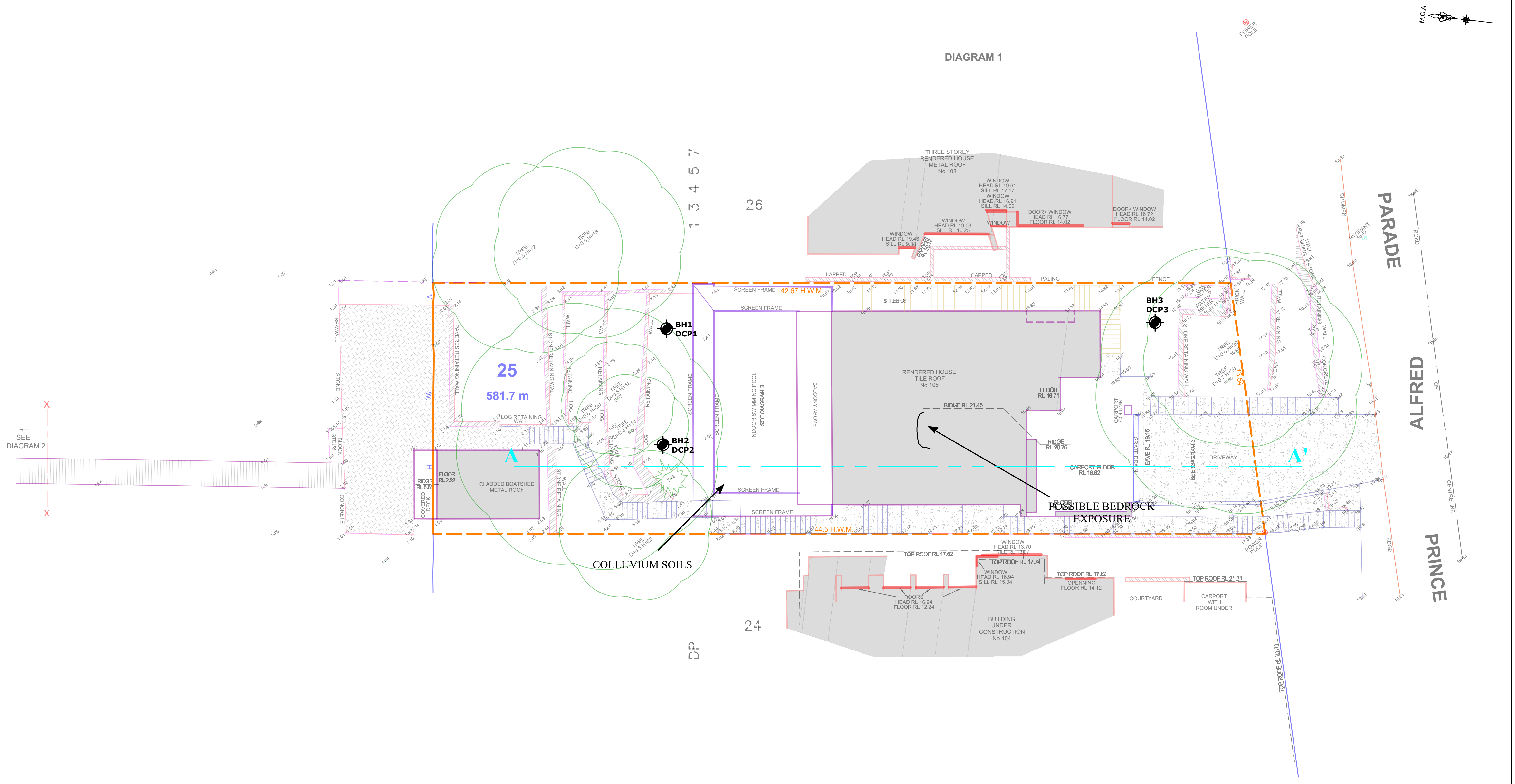
APPENDIX E - GEOLOGICAL AND GEOMORPHOLOGICAL MAPPING SYMBOLS AND TERMINOLOGY



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

CROZIER
GEOTECHNICAL CONSULTANTS

Appendix 2



0 1 2 3 4 5 6 7 8 9 10

SCALE: 1:200

SITE PLAN

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

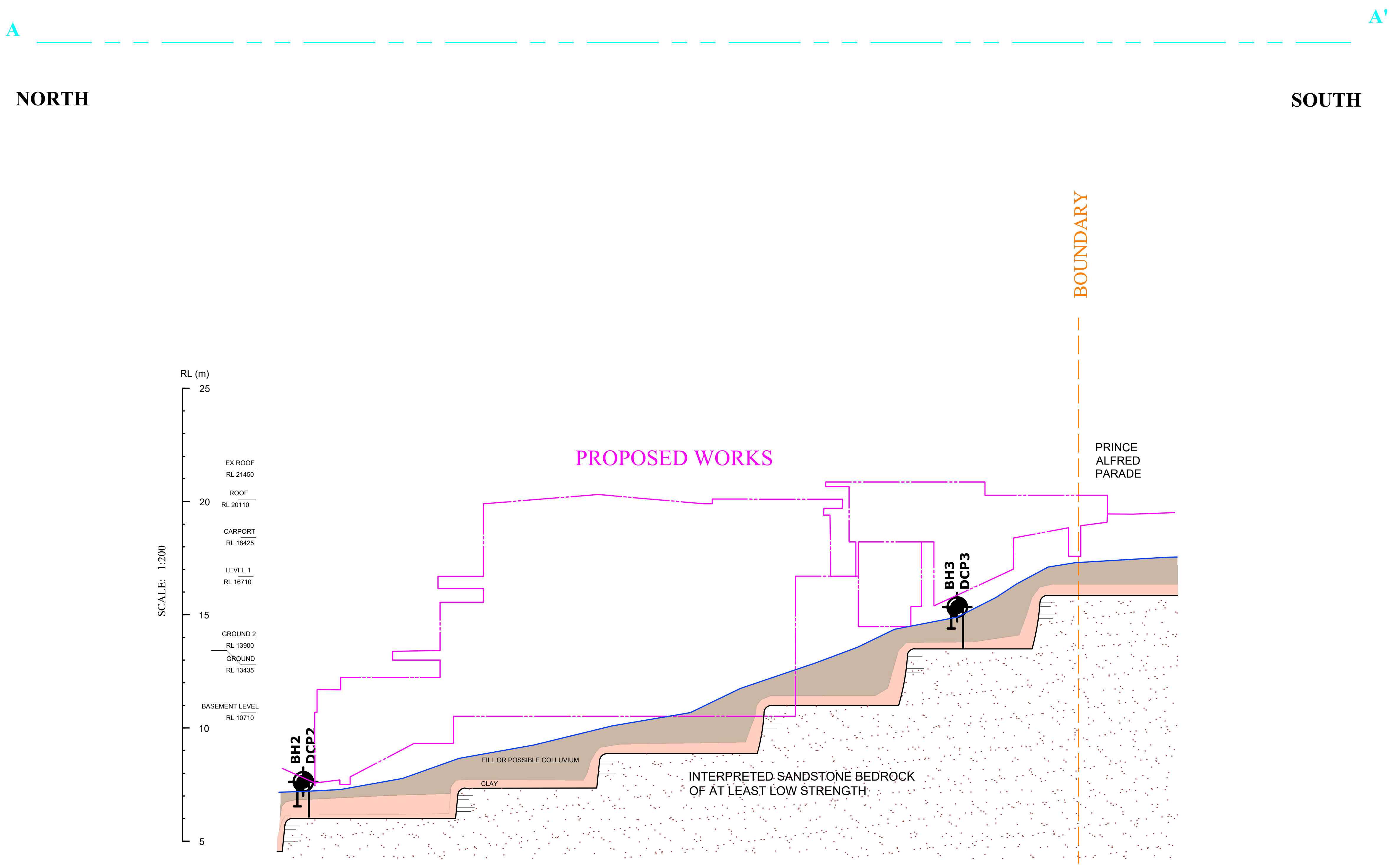
BH DCP — AUGER / DYNAMIC CONE PENETROMETER LOCATION	EXISTING STRUCTURE
SITE BOUNDARY	PROPOSED ADDITION

SCALE:	1:200 @ A3
DRAWING:	FIGURE 1
DATE:	26/05/2021
APPROVED BY:	KN
DRAWN BY:	ML
PROJECT:	2021-092

PREPARED FOR:

PETER EASTER

ADDRESS:
106 PRINCE ALFRED PARADE, NEWPORT, NSW



0 1 2 3 4 5 6 7 8 9 10

SCALE: 1:200

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

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

GEOLOGICAL MODEL FIGURE 2.

CROZIER
GEOTECHNICAL CONSULTANTS

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

LEGEND

- BH DCP — AUGER / DYNAMIC CONE PENETROMETER LOCATION
- EXISTING STRUCTURE
- PROPOSED STRUCTURE
- FILL
- GEOLOGICAL BOUNDARY
- A — A' CROSS-SECTION REFERENCE LINE
- PROPERTY BOUNDARY
- CLAY
- SANDSTONE BEDROCK

SCALE: 1:200 @ A3
DRAWING: FIGURE 2
DATE: 26/05/2021

APPROVED BY: KN
DRAWN BY: ML
PROJECT: 2021-092

PREPARED FOR:
PETER EASTER

ADDRESS:
106 PRINCE ALFRED PARADE,
NEWPORT, NSW

BOREHOLE LOG

CLIENT: Teresa Easter | **DATE:** 17/05/2021 | **BORE No.:** 1

PROJECT: Alterations and additions | **PROJECT No.:** 2021-092.1 | **SHEET:** 1 of 1

LOCATION: 106 Prince Alfred Pde Newport 2106 | **SURFACE LEVEL:** RL7.2m

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 - brown, silt-sand with rootlets				
0.20	CI	CLAY: Very stiff, orange brown sandy clay with fine to mdium grained gravel and cobbles (Possible fill/colluvium)				
0.50						
		Hand auger refusal @ 0.70m on possible fill/colluvium				
1.00						
2.00						

RIG: Not applicable

METHOD: Hand auger

GROUND WATER OBSERVATIONS: None

REMARKS:

DRILLER: JD

LOGGED: KN

CHECKED:

BOREHOLE LOG

CLIENT: Teresa Easter **DATE:** 17/05/2021 **BORE No.:** 2

PROJECT: Alterations and additions **PROJECT No.:** 2021-092.1 **SHEET:** 1 of 1

LOCATION: 106 Prince Alfred Pde Newport 2106 **SURFACE LEVEL:** RL7.2m

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 - brown, silt-sand with rootlets				
0.20	CI	CLAY: Very stiff, orange brown sandy clay with fine to mdium grained gravel and cobbles (Possible fill/colluvium)				
0.50						
0.65		Hand auger refusal @ 0.65m on possible fill/colluvium				
1.00						
2.00						

RIG: Not applicable DRILLER: JD

METHOD: Hand auger LOGGED: KN

GROUND WATER OBSERVATIONS: None

REMARKS: CHECKED:

BOREHOLE LOG

CLIENT: Teresa Easter **DATE:** 17/05/2021 **BORE No.:** 3

PROJECT: Alterations and additions **PROJECT No.:** 2021-092.1 **SHEET:** 1 of 1

LOCATION: 106 Prince Alfred Pde Newport 2106 **SURFACE LEVEL:** RL14.9m

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 - brown, silty sand with glass plastic, cobbles and rootlets				
0.50		Hand auger refusal 0.45m depth in filll				
1.00						
2.00						

RIG: Not applicable DRILLER: JD

METHOD: Hand auger LOGGED: KN

GROUND WATER OBSERVATIONS: None

REMARKS: CHECKED:

DYNAMIC PENETROMETER TEST SHEET

CLIENT: Teresa Easter **DATE:** 17/05/2021

PROJECT: Alterations and additions **PROJECT No.:** 2021-092.1

LOCATION: 106 Prince Alfred Pde Newport 2106 **SHEET:** 1 of 1

	Test Location							
Depth (m)	1	2	3					
0.00 - 0.10	1	-	2					
0.10 - 0.20	1	2	3					
0.20 - 0.30	2	3	3					
0.30 - 0.40	7	4	14					
0.40 - 0.50	5	4	15					
0.50 - 0.60	5	4	6					
0.60 - 0.70	6	4	5					
0.70 - 0.80	4	19	6					
0.80 - 0.90	20	9	15					
0.90 - 1.00	6	9	22					
1.00 - 1.10	7	15 Refusal (Bounce) @ 1.1m	21					
1.10 - 1.20	7		11					
1.20 - 1.30	7		21					
1.30 - 1.40	7		19 Refusal (Bounce) @ 1.37m					
1.40 - 1.50	16							
1.50 - 1.60	8							
1.60 - 1.70	12							
1.70 - 1.80	12 Refusal (Bounce) @ 1.78m							

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

REMARKS:

CROZIER
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Appendix 3

APPENDIX A

DEFINITION OF TERMS

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		**Implied Indicative Landslide Recurrence Interval**		**Description**	**Descriptor**	**Level**
Indicative Value	**Notional Boundary**					
10^{-1}	$5x10^{-2}$	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}		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%		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%	100%	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

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

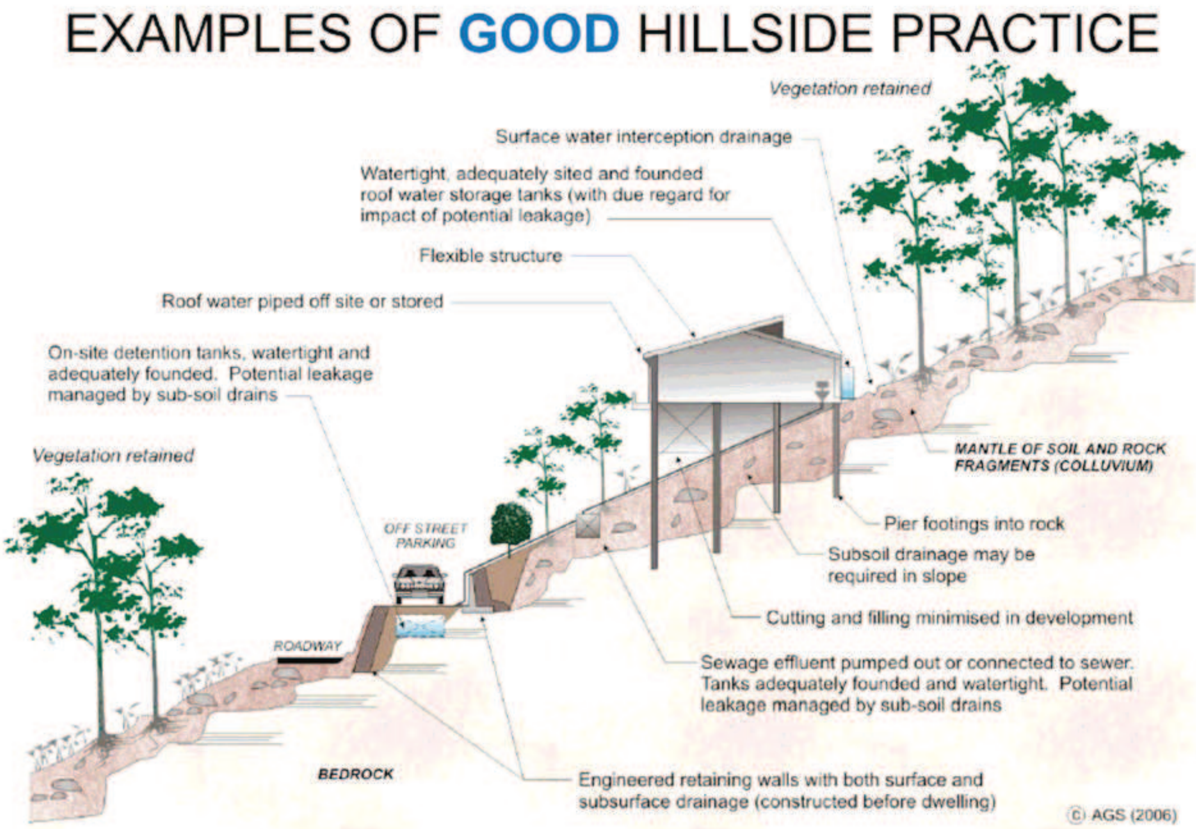
Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
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.

Appendix 4

APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

	GOOD ENGINEERING PRACTICE	*POOR ENGINEERING PRACTICE*
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical practitioner at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
PLANNING		
SITE PLANNING	Having obtained geotechnical advice, plan the development with the risk arising from the identified hazards and consequences in mind.	Plan development without regard for the Risk.
DESIGN AND CONSTRUCTION		
HOUSE DESIGN	Use flexible structures which incorporate properly designed brickwork, timber or steel frames, timber or panel cladding. Consider use of split levels. Use decks for recreational areas where appropriate.	Floor plans which require extensive cutting and filling. Movement intolerant structures.
SITE CLEARING	Retain natural vegetation wherever practicable.	Indiscriminately clear the site.
ACCESS & DRIVEWAYS	Satisfy requirements below for cuts, fills, retaining walls and drainage. Council specifications for grades may need to be modified. Driveways and parking areas may need to be fully supported on piers.	Excavate and fill for site access before geotechnical advice.
EARTHWORKS	Retain natural contours wherever possible.	Indiscriminatory bulk earthworks.
CUTS	Minimise depth. Support with engineered retaining walls or batter to appropriate slope. Provide drainage measures and erosion control.	Large scale cuts and benching. Unsupported cuts. Ignore drainage requirements
FILLS	Minimise height. Strip vegetation and topsoil and key into natural slopes prior to filling. Use clean fill materials and compact to engineering standards. Batter to appropriate slope or support with engineered retaining wall. Provide surface drainage and appropriate subsurface drainage.	Loose or poorly compacted fill, which if it fails, may flow a considerable distance including onto property below. Block natural drainage lines. Fill over existing vegetation and topsoil. Include stumps, trees, vegetation, topsoil, boulders, building rubble etc in fill.
ROCK OUTCROPS & BOULDERS	Remove or stabilise boulders which may have unacceptable risk. Support rock faces where necessary.	Disturb or undercut detached blocks or boulders.
RETAINING WALLS	Engineer design to resist applied soil and water forces. Found on rock where practicable. Provide subsurface drainage within wall backfill and surface drainage on slope above. Construct wall as soon as possible after cut/fill operation.	Construct a structurally inadequate wall such as sandstone flagging, brick or unreinforced blockwork. Lack of subsurface drains and weepholes.
FOOTINGS	Found within rock where practicable. Use rows of piers or strip footings oriented up and down slope. Design for lateral creep pressures if necessary. Backfill footing excavations to exclude ingress of surface water.	Found on topsoil, loose fill, detached boulders or undercut cliffs.
SWIMMING POOLS	Engineer designed. Support on piers to rock where practicable. Provide with under-drainage and gravity drain outlet where practicable. Design for high soil pressures which may develop on uphill side whilst there may be little or no lateral support on downhill side.	
DRAINAGE SURFACE	Provide at tops of cut and fill slopes. Discharge to street drainage or natural water courses. Provide general falls to prevent blockage by siltation and incorporate silt traps. Line to minimise infiltration and make flexible where possible. Special structures to dissipate energy at changes of slope and/or direction.	Discharge at top of fills and cuts. Allow water to pond on bench areas.
SUBSURFACE	Provide filter around subsurface drain. Provide drain behind retaining walls. Use flexible pipelines with access for maintenance. Prevent inflow of surface water.	Discharge roof runoff into absorption trenches.
SEPTIC & SULLAGE	Usually requires pump-out or mains sewer systems; absorption trenches may be possible in some areas if risk is acceptable. Storage tanks should be water-tight and adequately founded.	Discharge sullage directly onto and into slopes. Use absorption trenches without consideration of landslide risk.
EROSION CONTROL & LANDSCAPING	Control erosion as this may lead to instability. Revegetate cleared area.	Failure to observe earthworks and drainage recommendations when landscaping.
DRAWINGS AND SITE VISITS DURING CONSTRUCTION		
DRAWINGS	Building Application drawings should be viewed by geotechnical consultant	
SITE VISITS	Site Visits by consultant may be appropriate during construction/	
INSPECTION AND MAINTENANCE BY OWNER		
OWNER'S RESPONSIBILITY	Clean drainage systems; repair broken joints in drains and leaks in supply pipes. Where structural distress is evident see advice. If seepage observed, determine causes or seek advice on consequences.	


EXAMPLES OF GOOD HILLSIDE PRACTICE
Vegetation retained
Surface water interception drainage
Watertight, adequately sited and founded roof water storage tanks (with due regard for impact of potential leakage)
Flexible structure
Roof water piped off site or stored
On-site detention tanks, watertight and adequately founded. Potential leakage managed by sub-soil drains
Vegetation retained
OFF STREET PARKING
ROADWAY
MANTLE OF SOIL AND ROCK FRAGMENTS (COLLUVIUM)
Pier footings into rock
Subsoil drainage may be required in slope
Cutting and filling minimised in development
Sewage effluent pumped out or connected to sewer. Tanks adequately founded and watertight. Potential leakage managed by sub-soil drains
BEDROCK
Engineered retaining walls with both surface and subsurface drainage (constructed before dwelling)
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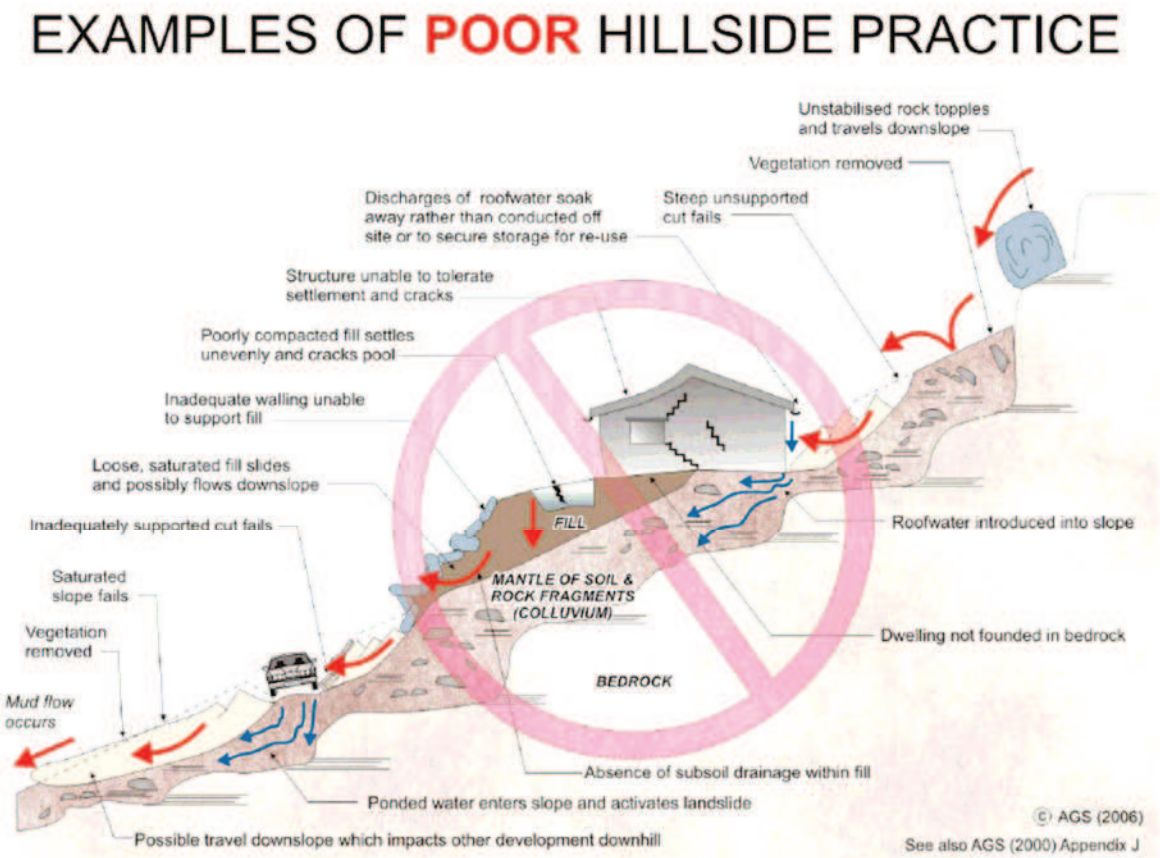
EXAMPLES OF POOR HILLSIDE PRACTICE
Unstabilised rock topples and travels downslope
Vegetation removed
Discharges of roofwater soak away rather than conducted off site or to secure storage for re-use
Steep unsupported cut fails
Structure unable to tolerate settlement and cracks
Poorly compacted fill settles unevenly and cracks pool
Inadequate walling unable to support fill
Loose, saturated fill slides and possibly flows downslope
Inadequately supported cut fails
FILL
Roofwater introduced into slope
Saturated slope fails
MANTLE OF SOIL & ROCK FRAGMENTS (COLLUVIUM)
Vegetation removed
Dwelling not founded in bedrock
Mud flow occurs
BEDROCK
Absence of subsoil drainage within fill
Ponded water enters slope and activates landslide
Possible travel downslope which impacts other development downhill
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See also AGS (2000) Appendix J