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REPORT ON GEOTECHNICAL SITE INVESTIGATION

for

PROPOSED ALTERATIONS AND ADDITIONS

at

24 NORMA ROAD, PALM BEACH, NSW

Prepared For

Edwina Withers

Project No.: 2021-218

February, 2023

Document Revision Record

Issue No	Date	Details of Revisions
0	8th February, 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	24 Norma Road, Palm Beach, NSW

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 3rd November 2020_ 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: Report on Geotechnical Site Investigation for Proposed Alterations and Additions at 24 Norma Road, Palm Beach, NSW

Report Date: 08/02/2023 **Project No.:** 2021-218

Author: M. Lujan and T. Crozier

Author's Company/Organisation: Crozier Geotechnical Consultants

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

Site Survey Plan by Sydney Surveyors Pty Ltd, Ref No.: 17652/1A, Date: 15/6/2021 and Sheet 1 of 1.
DA Architectural Drawings – by Justin Long Design Pty Ltd, Date: 16.01.23, Drawn by: FS and Drawings by: A00, 3D1, A01 to A16.

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
10197

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 __24 Norma Road, Palm Beach, NSW ___________

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: Report on Geotechnical Site Investigation for Proposed Alterations and Additions at 24 Norma Road, Palm Beach, NSW
Report Date: 08/02/2023 **Project No.:** 2021-218
Author: M. Lujan and T. Crozier
Author's Company/Organisation: Crozier Geotechnical Consultants

Please mark appropriate box

- ■ Comprehensive site mapping conducted ___28th September 2021________ (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 28th September 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 .... (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)**......................

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

Company... **Crozier Geotechnical Consultants**

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GEOTECHNICAL REPORT FOR PROPOSED ALTERATIONS & ADDITIONS AT 24 NORMA ROAD, PALM BEACH, NSW

1. INTRODUCTION:

This report details the results of a geotechnical investigation carried out for proposed alterations and additions at 24 Norma Road, Palm Beach, NSW. The investigation was undertaken by Crozier Geotechnical Consultants (CGC) at the written request of Justin Long Design Pty Ltd on behalf of the client Edwina Withers.

The site is situated on the low northern side of the road within steep to very steep north dipping topography. The site is currently occupied by a one to two storey masonry dwelling with a swimming pool, a slightly raised (street level) front garage and overgrown vegetation and several trees at the rear of the site.

It is understood that the proposed works involve extensive alterations and additions including the extension of an existing Lower Ground Floor Level (LGFL) towards the south and landscaping works at the front of the site. Bulk excavation down to approximately 2.50m depth will be required for the LGFL extension, whilst the landscaping works will require an excavation of approximately 1.50m depth.

The site is located within the H1 (highest category) landslip hazard zone as identified within Northern Beaches (Pittwater) Councils Geotechnical Risk Management Policy for Pittwater. As such the site requires an assessment for landslip hazards and risks to ensure the property achieves and can maintain the 'Acceptable' Risk Management criteria of Councils Policy.

This report includes a description of site and subsurface conditions, site plan, geological section, a geotechnical assessment of ground conditions, a Risk Assessment and provides recommendations for preliminary design and construction ensuring stability is maintained for a design life of 50 years.

The investigation and reporting were undertaken as per the Proposal P21-478, Dated: 8th September 2021.

The investigation comprised:

a) DBYD plan review for service mains with test locations clearance by accredited locator contractor.
b) A detailed geotechnical inspection and mapping of the site and adjacent properties by a Geotechnical Engineer.
c) Drilling of three boreholes using hand tools along with six Dynamic Cone Penetrometer (DCP) testing to investigate the subsurface geology, depth to bedrock and identification of a water table.
d) All fieldwork was supervised by an experienced Geotechnical Engineer.

The following plans and drawings were supplied and relied upon for proposal, investigation and assessment:

- DA Architectural Drawings – by Justin Long Design Pty Ltd, Date: 16.01.23, Drawn by: FS and Drawings by: A00, 3D1, A01 to A16.
- Survey Drawing – by Sydney Surveyors Pty Ltd, Ref No.: 17652/1A, Date: 15/6/2021 and Sheet 1 of 1.

2. PROPOSED WORKS:

It is understood that the proposed works comprise extensive alterations and additions to the existing site, including the extension of the existing Lower Ground Floor Level (LGFL) south, construction of an essentially new three storey dwelling and landscaping works within the front of the site.

The proposed LGFL will require bulk excavation down to a maximum depth of 2.50m reducing north to nil. The proposed landscaping works within the front of the site will require excavation down to 1.50m depth. Detail depth and distances of the proposed excavation are described in Section 5.3.2 of this report.

3. SITE FEATURES:

3.1. Description:

The site is a rectangular shaped block located on the low northern side of Norma Road. It has a front south boundary of 15.85m, an east side boundary of 39.20m, a west side boundary of 39.18m and rear north boundary of 17.035m as referenced from the provided survey plan.

The Ground Surface Level (GSL) within the site reduces from a high of approximately RL 74.72m at the south-western corner of the block to a low of approximately RL 60.00m within the northern end of the block.

The southern half of the site is gently north dipping and contains an east-west striking cliff face (approximately 4m high) through the centre of the site with the northern side of the site very steeply north dipping. The southern portion of the site contains the site-structures, whilst the northern portion of the site contains overgrown vegetation.

An aerial photograph of the site and its surrounds is provided below, as sourced from NSW Government Six Map spatial data system, as Photograph-1. The front of the site at the time of investigation is provided in Photograph-2.

Photograph-1: Aerial photo of site and surrounds

Photograph-2: Front of the site. View looking north.

3.2. Geology:

Reference to the Sydney 1: 100,000 Geological Series sheet (9130) indicates that the site is located on the boundary between the Newport Formation (Rnn) of the Upper Narrabeen Group and the overlying Hawkesbury Sandstone (Rh). Hawkesbury Sandstone is of Triassic Age and the rock unit typically comprises medium to coarse grained quartz sandstone with minor lenses of shale and laminate and forms a capping to the ridges in this area. The Newport Formation (Upper Narrabeen Group) is slightly older and typically comprises interbedded laminite, shale and quartz to lithic quartz sandstones and pink clay pellet sandstones. This unit underlies the Hawkesbury Sandstone and is expected below the majority of the site based on our previous experience within the area and the outcropping sandstone units.

Sydney 1:100 000 Geological Sheet

4. FIELD WORK:

4.1. Methods:

The field investigation comprised a walk over inspection and mapping of the site and adjacent properties on the 28th September 2021 by a Geotechnical Engineer. It included a photographic record of site conditions as well as geological/geomorphological mapping of the site and adjacent land with examination of outcrops, vegetation and existing structures. It also included the drilling of three boreholes (BH1 to BH3) using a hand auger due to site access limitations.

Dynamic Cone Penetrometer (DCP) testing was carried out from ground surface adjacent to the boreholes and at selected separate locations 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 confirm depths to bedrock.

Explanatory notes are included in Appendix: 1. Mapping information and test locations are shown on Figure: 1, along with detailed log sheets in Appendix: 2. Geological model/sections are provided as Figure: 2 and Figure 3, Appendix 2.

4.2. Field Observations:

The western front of the site contains a brick paved driveway leading to a rendered garage (GFL 74.65m). The garage is supported by a 1.70m high rendered retaining wall along the northern and eastern sides. The eastern front of the site contains a lower stone paved patio (RL 73.00m) with retained gardens along the southern side supported by approximately 1.0m to 1.5m high sandstone block retaining walls. Signs of cracking or underlying geotechnical movement were not observed at the front of the site.

The southern portion of the site is broadly occupied by a one to two storey rendered brick residence that extends east and west with approximately 0.7m (Photograph-3) and 1.0m (Photograph-4) wide concrete pathways along each boundary. Signs of cracking, ground movement or geotechnical issues were not observed within the side pathways and external walls of the site-dwelling.

Photograph-3: Pathway along the eastern side of the site-dwelling. View looking north.

Photograph-4: Pathway long the western side of the site-dwelling. View looking north.

Photograph-5: Front site patio. View looking east.

To the rear of the site-dwelling is a swimming pool with timber decking. The timber deck and concrete pool are supported by brick piers and concrete piers onto the crest of a sandstone bedrock cliff face outcrop. The cliff face is approximately 4m to 5m high and is characterised as fine to medium grained, low to medium strength and contains sub-horizontal bedding defects (Photograph-8). Signs of water leakage in the pool, unfavourable defects, ground movement or underlying geotechnical issues were not identified in the observed sandstone cliff face and above structures.

Photograph-6: Brick piers supporting the timber deck. View looking south.

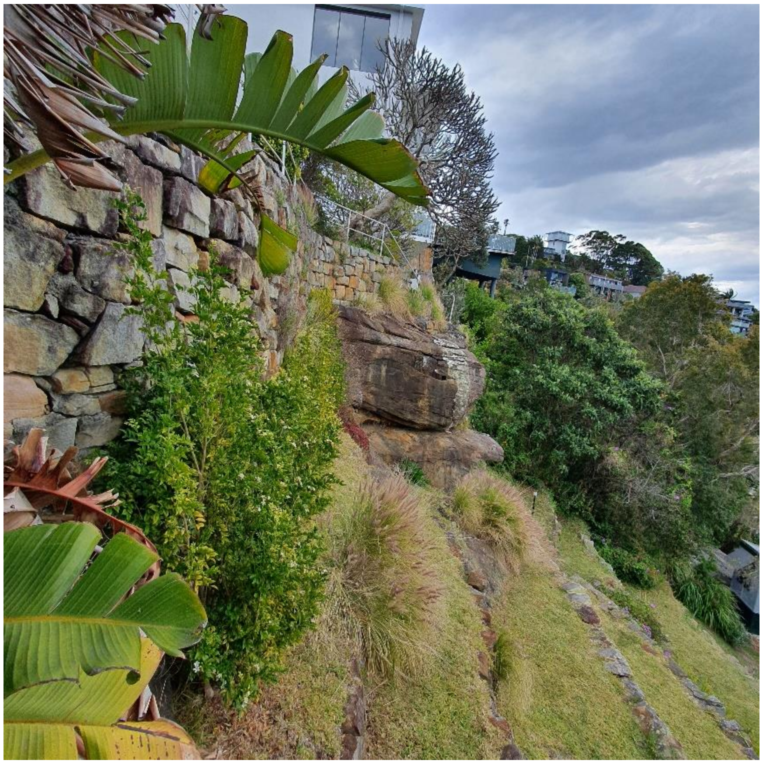
Photograph-7: Concrete piers supporting the pool. View looking up south-east.

Photograph-8: Sandstone bedrock cliff face below the pool displaying sub-horizontal bedding defects and minor undercutting. View looking south.

The neighbouring property to the east (No.26 Norma Road) is currently occupied by a two to three storey brick residence located within the southern portion of the block. The southern front of the property contains a carport within the western side and a concrete carpark within the eastern side. To the rear of the property dwelling the Ground Surface Level (GSL) drops approximately 4m and exposes the east-west striking sandstone cliff face through the centre of the property (Photograph-9). The neighbouring property is at similar GSL to the site along the common boundary. The property dwelling and carport are approximately 2.5m east from the common boundary. The northern half of the property contains overgrown vegetation. Signs of cracking, ground movement or underlying geotechnical issues were not encountered on the observed structures and appeared in good condition.

Photograph-9: Sandstone bedrock cliff. View looking down east to the neighbouring property.

The neighbouring property to the west (No.22 Norma Road) is currently occupied by a two to three storey brick residence with a balcony to the rear located within the southern portion of the block. The southern front of the property contains a concrete carpark with a balcony above within the eastern side and a grass lawn within the western side. The ground to the rear of the property dwelling is supported by a dry stacked sandstone block wall retaining wall (Photograph-10) which appears to be party founded on the crest of the sandstone bedrock cliff face. The ground to the rear of the sandstone bedrock cliff face comprises terraced gardens. The neighbouring property is at similar GSL to the site along the common boundary. The neighbouring house extends east to approximately 1.5m from the common boundary. Signs of cracking, ground movement or underlying geotechnical issues were not encountered on the observed structures and appeared in good condition.



Photograph-10: Sandstone bedrock cliff and retaining wall. View looking west to the neighbouring property.

The neighbouring property to the north (No. 308 Whale Beach Road) contains a three storey rendered brick dwelling with a front concrete driveway and retained gardens within the northern half of the block and a garden with dense vegetation near the rear boundary within the southern portion of the block. The garden is located directly adjacent to the common boundary and the property dwelling is located approximately 20.0m form the common boundary. The site contains a similar ground surface level to the site along the common boundary, however it steeply north dipping. Signs of ground movement, cracking within the structure or underlying geotechnical issues were not observed within the neighbouring property and appeared in good condition.

The neighbouring buildings and properties were only inspected from within the site or from the road reserve however the visible aspects did not show any significant signs of large scale slope instability or other major geotechnical concerns which would impact the site.

4.3. Field Testing:

The boreholes (BH1 – BH3) were drilled to varying depths between 1.0m (BH3) and 1.35m (BH2) with refusal encountered within very stiff clay and sandstone bedrock, respectively. BH1 was discontinued due to a cobble that had fallen into the borehole during the drilling process.

Dynamic Cone Penetrometer (DCP) tests were carried out to varying depths between 0.30m (DCP2a/2b) and 1.35m (DCP2) with refusal encountered on interpreted sandstone bedrock.

For a detailed description at test locations the individual BH/DCP log sheets should be consulted. Based on the borehole logs and DCP test results, the sub-surface conditions at the project site can be summarized as follows:

- **FILL** – this layer was encountered within all test locations to a maximum depth of 0.70m (BH1). It was classified as loose, dark brown, fine to medium grained, moist, silty sand with some sandstone gravel.
- **SANDY CLAY** – this layer was encountered below the fill to a maximum depth of 1.35m (BH2, RL 70.05m). It was classified as generally stiff/very stiff and hard below 0.90m depth within BH2 and BH1; orange mottled brown, medium plasticity, moist/wet below 1.30m depth within BH2 and moist within all other tested locations; sandy clay.
- **SANDSTONE BEDROCK** – this unit was encountered exposed in the form of a cliff face across the center of the site and was encountered at varying depths between 0.30m (DCP2a/2b) and 1.35m (DCP2) below surface. Based on the tactile assessment, it was classified as fine to medium grained, low to medium strength with sub-horizontal bedding defects.

A free standing ground water table was not encountered in the investigation, however groundwater seepage was encountered at 1.30m depth (RL 70.10m) within BH2 at the bedrock and soil interface. No signs of ground water were observed after the retrieval of the DCP rods (except DPC2).

5. COMMENTS:

5.1. Geotechnical Assessment:

The site investigation identified the presence fill, underlaid by residual sandy clay interpreted to a maximum depth of 1.35m depth, overlying sandstone bedrock. A free standing groundwater table was not encountered within the site and is not expected due to the site location, however minor seepage was encountered at the bedrock and soil interface.

The project site contains no existing landslip hazards and there were no hazards identified within the neighbouring properties that could impact the site. However, the excavation for the LGFL could induce small scale instability.

The proposed works comprise extensive alterations and additions within the site-dwelling. This will include the extension of the existing LGFL to the south to result in the effective construction of a new three storey dwelling and minor landscaping works within the front of the site. Bulk excavation down to a maximum of 2.50m depth reducing north to nil will be required for the proposed new LGFL and excavation down to 1.50m depth will be required for the construction of a new courtyard at the front of the site extending to the front south boundary and southern side of the eastern site boundary. It is anticipated that the excavation will intersect through fill/sandy clay and sandstone bedrock at the base of the LGFL excavation.

Based on the proposed excavation and distance to the site boundaries the safe batter slopes as recommended in Section 5.3.2 of this report are marginally achievable. However, it is recommended that the stability of the batter slopes of the LGFL excavation with respect to the side boundaries be assessed by an experienced geotechnical consultant at site mark out and following excavation to the bedrock surface. Where pre-excavation support is not implemented it is recommended that the construction of the retaining structure be constructed immediately post the soil excavation.

Where medium to high strength bedrock with no poorly oriented defects is encountered, it will likely be free standing and can be excavated near vertically without the need for additional support measures. Where defects are encountered in this rock then support may be required (i.e. rock bolts) to maintain stability. Confirmation of rock strength/conditions prior to excavation will require cored boreholes, drilled (to at least 1.0m below Bulk Excavation Level, BEL) to confirm the sub-surface conditions (i.e. if any weak zones of rock are identified) prior to final structural design. In addition, regular detail geotechnical inspection during excavation works (every 1.5m depth interval) will be required with potential stop/hold points to allow support installation if determined necessary.

The fill, sandy clay and extremely to very low strength bedrock can be excavated using conventional earthmoving equipment, however low to high strength bedrock will require the use of the rock breaking equipment (e.g. rock hammers). The use of rock hammers can create ground vibrations which could damage the neighbouring structures including nearby services (e.g. sewer within the northern portion of the site).

Care will be required during the demolition, construction and excavation works to ensure the neighbouring properties, structures and services are not adversely impacted by ground vibrations. Small scale equipment (i.e. rock hammer <250kg) along with rock saw and a good excavation methodology can be used to maintain low vibration levels and avoid the need for full time vibration monitoring. However, this will result in slow excavation progress and it is anticipated that larger scale rock hammers will be preferred. As such Crozier Geotechnical Consultants (CGC) should be consulted regarding the size and type of demolition/excavation equipment proposed and demolition/excavation methodology prior to works.

It is recommended that all new footings extend through the fill and residual soil units and bear onto/within the bedrock of similar strengths to reduce the potential risk of differential settlement. Preliminary allowable bearing pressures appropriate for the bedrock encountered underlying the site are provided in Section 5.3.1.

Provided that the recommendations of this report are implemented in the design and construction phases the proposed works are considered suitable for the site and may be completed with negligible impact to the neighbouring properties.

5.2. Site Specific Risk Assessment:

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

A. Landslip (earth slide <3m^3) from LGFL excavation
B. Landslip (rock topple/slide <2m^3) from the LGFL excavation
C. Landslip (earth slide <2m^3) from landscape excavation
D. Landslip (boulder roll <3m^3) from LGFL excavation

A qualitative assessment of risk to life and property related to this hazard is presented in Table A and B, Appendix: 3, and is based on methods outlined in Appendix: C of the Australian Geomechanics Society (AGS) Guidelines for Landslide Risk Management 2007. AGS terms and their descriptions are provided in Appendix: 4.

The Risk to Life from Hazard A was estimated to up to **4.31×10^{-7}** for persons within neighbouring properties, whilst the Risk to Property was considered to be **'Low'**.

The Risk to Life from Hazard B was estimated to up to **2.34 x 10^{-8}** for persons within neighbouring properties, whilst the Risk to Property was considered to be **'Moderate'**.

The Risk to Life from Hazard C was estimated to up to **7.81 x 10^{-8}** for persons within neighbouring properties, whilst the Risk to Property was considered to be **'Very Low'**.

The Risk to Life from Hazard D was estimated to up to **8.98 x 10^{-7}** for persons within neighbouring properties, whilst the Risk to Property was considered to be **'Moderate'**.

The Risk to Property for Hazard B and D are considered to be 'Unacceptable'. However, the assessments were based on excavations with no support or planning. Provided further the recommendations of this report are implemented including installation of an engineer designed retaining wall prior to bulk excavation or in stages during excavation, the likelihood of any failure becomes 'Rare' and as such the consequences reduce and risk becomes within 'Acceptable' levels when assessed against the criteria of the AGS. As such the project is considered suitable for the site provided the recommendations of this report are implemented.

5.3. Design & Construction Recommendations:

Design and the construction recommendations are tabulated below:

5.3.1. New Footings:	
Site Classification as per AS2870 – 2011 for new footing design	- Class 'A' for footings on bedrock
Type of Footing	Strip/Pad, Slab at base of excavation, or piers
Sub-grade material and Maximum Allowable Bearing Capacity	- Very Low Strength Sandstone: 800kPa - Low Strength Sandstone: 1000kPa - Medium Strength Sandstone: 2000kPa*
Site sub-soil classification as per *Structural design actions AS1170.4 – 2007, Part 4: Earthquake actions in Australia*	B_e – Rock Site
Remarks: All footings 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.	

5.3.2. Excavation:

Lower Ground Floor Level Extension Excavation

Table 1: Property Separation Distances

Boundary	Adjacent Property	Structure	Bulk Excavation Depth (m bgl)	Separation Distances (m)	
				Boundary (m)	Structure
North	Not Applicable				
South	Not Applicable				
East	No. 26 Norma Road	Pathway, Dwelling	2.50m decreasing north to nil	0.70m	Pathway directly adjacent to the boundary; Dwelling another 2.5m east.
West	No. 22 Norma Road	Pathway, Dwelling		1.0m	Pathway directly adjacent to the boundary; Dwelling another 1.5m west.

Front Landscape Excavation

Table 1: Property Separation Distances

Boundary	Adjacent Property	Structure	Bulk Excavation Depth (m bgl)	Separation Distances (m)	
				Boundary (m)	Structure
North	Not Applicable				
West	Not Applicable				
East	No. 26 Norma Road	Dense vegetation, Carport	1.50m	0.0m	Dense vegetation directly adjacent to the boundary, carport a further 2.0m east.
South	Norma Road	Road Pavement	1.50m	0.0m	Road Pavement is located a further 5.0m south.

Type of Material to be Excavated	Layers of fill/sandy clay ≤1.25m
	Sandstone bedrock below 0.30m depth (DCP2a/2b) and the sandy clay

Guidelines for batter slopes for general information are tabulated below:

Material	Safe Batter Slope (H:V)	
	Short Term/ Temporary	Long Term/ Permanent
Fill & Sandy Clay	1.5:1.0	2.0:1.0
Clay/Sandy Clay and ELS bedrock	1.0:1.0	2.0:1.0
Very Low to Low strength or fractured bedrock	0.5:1.0	1.5:1.0*
Medium Strength (MS), defect free bedrock	Vertical	Vertical

*Dependent on assessment by engineering geologist.

Remarks: Seepage at the bedrock surface or along defects in the soil/rock can also reduce the stability of batter slopes and invoke the need to implement additional support measures. Where safe batter slopes are not implemented the stability of the excavation cannot be guaranteed until the installation of permanent support measures. This should also be considered with respect to safe working conditions.

Equipment for Excavation	Fill and natural soils	Excavator with bucket
	ELS/VLS bedrock	Excavator with bucket and ripper
	LS-HS bedrock	Rock hammer and saw

ELS – extremely low strength, VLS – very low strength, LS – low strength, MS – medium strength, HS- high strength

Remarks:

Based on previous testing of ground vibrations created by various rock excavation equipment within medium strength bedrock, to maintain a vibration level below 5mm/s PPV the below hammer weights and buffer distances are required:

Buffer Distance from Structure	Maximum Hammer Weight
2.0m	200kg
4.0m	500kg
5.0m	800kg
8.0m	1000kg

Onsite calibration will provide accurate vibration levels to the site specific conditions and will generally allow for larger excavation machinery or smaller buffers to be used. Calibration of rock excavation machinery should be carried out prior to commencement of rock excavation works where ≥250kg rock hammers are proposed for use.

Rock sawing of the excavation perimeter is recommended as it has several advantages. It often reduces the need for rock bolting as the cut faces generally remain more stable and require a lower level of rock support than hammer cut excavations, ground vibrations from rock saws are minimal, the saw cuts will provide a slight increase in buffer distance for use of rock hammers whilst also reducing deflection of separated rock across boundaries.

The strength of bedrock below the maximum depth achieved during the investigation is unconfirmed and if required for detailed assessment and contract costing requires cored boreholes using specialist restricted access drilling equipment unless demolition of existing structures can occur prior to final design.

Excavation of soils to ELS will not create excessive vibrations provided it is undertaken with medium scale (<20 tonne excavator) excavation equipment in a sensible manner.

Recommended Vibration Limits	Road Reserve = 5mm/s Adjacent residential dwellings= 5mm/s

(Maximum Peak Particle Velocity (PPV))	Sydney water sewer asset within the site: A maximum Peak Particle Velocity (PPV) of 10mm/s for continuous vibrations should be adopted and A maximum PPV of 20mm/s for intermittent vibrations should be adopted.
Recommended Vibration Limits (Maximum Peak Particle Velocity (PPV))	Yes, recommended for any rock hammer >250kg weight
Full time vibration Monitoring Required	Pending proposed equipment and vibration calibration testing results
Geotechnical Inspection Requirement	Yes, recommended that these inspections be undertaken as per below mentioned sequence: • For assessment of excavation of batter slopes, • Any excavation where unsupported at every 1.50m depth interval, • At completion of the excavation, • During construction of new footings.
Dilapidation Surveys Requirement	Recommended on neighbouring structures or parts thereof within 10m of the excavation perimeter prior to site work to allow assessment of the recommended vibration limit and protect the client against spurious claims of damage.
Remarks: Water ingress into exposed excavations can result in erosion and stability concerns in both soil and rock portions. Drainage measures will need to be in place during excavation works to divert any surface flow away from the excavation crest and any batter slope.	

5.3.3. Retaining Structures:	
Required	New retaining structures will be required as part of the works.
Types	The safe batter slopes are marginally achievable along all sides of the LGFL excavation. However, the construction of support should be considered immediately after the excavation. Therefore, inspection by a geotechnical consultant to assess the stability of the batters and assess support needs is critical. The construction of steel reinforced concrete walls or conventional gravity walls where temporary batters are achievable and support post to excavation is required.

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

Material	Unit Weight (kN/m3)	Long Term (Drained)	Earth Pressure Coefficients		Passive Earth Pressure Coefficient *
			Active (Ka)	At Rest (K_0)	
Fill	18	ϕ' = 25°	0.35	0.52	N/A
Clay (Very stiff to hard)	20	ϕ' = 35°	0.27	0.50	N/A
ELS to VLS bedrock	22	ϕ' = 38°	0.15	0.20	200 kPa
LS to MS bedrock	23	ϕ' = 40°	0.05	0.10	400kPa

Remarks: In suggesting these parameters it is assumed that the retaining walls will be fully drained with suitable subsoil drains provided at the rear of the wall footings. If this is not done, then the walls should be designed to support full hydrostatic pressure in addition to pressures due to the soil backfill. It is suggested that the retaining walls should be back filled with free-draining granular material (preferably not recycled concrete) which is only lightly compacted in order to minimize horizontal stresses.

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

5.3.4. Drainage and Hydrogeology		
Groundwater Table or Seepage identified in Investigation		Groundwater not encountered and not expected within the site. Seepage was encountered at 1.30m depth (RL 70.10m) within BH2.
Excavation likely to intersect	Water Table	No
	Seepage	Minor (<2L/min), within the soil and rock face
Site Location and Topography		Low northern side of the road, within steeply north dipping topography.
Impact of development on local hydrogeology		Negligible
Onsite Stormwater Disposal		Only possible via engineering designed dispersion system.
Remarks: All new structure gutters, down pipes and stormwater intercept trenches should be connected to a stormwater system design by a Hydraulic Engineer which preferably discharges to the Council's stormwater system off site.		

5.4. 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 the structural design drawings for compliance with the recommendations of this report prior to construction,
2. Inspection of site and works as per Section 5.3 of this report
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.

5.5. 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.

6. CONCLUSION:

The site investigation identified the presence fill underlaid by residual clay, overlying sandstone bedrock. Based on the tactile assessment the sandstone bedrock was classified as low to medium strength. The presence of a free-standing groundwater table was not encountered or expected within the site due to the site location, however minor seepage was encountered at the bedrock and soil interface.

It is anticipated that the proposed alterations and additions require excavation will intersect through soil and sandstone bedrock at the base of the LGFL extension excavation.

The excavation of sandstone bedrock of at least low strength will require the use of a rock hammer and saws. It is recommended that a small scale rock hammer (≤250kg) along with a rock saw be utilized to maintain low ground vibrations. Where a heavier rock hammer is proposed then vibration calibration test will be required prior to the bulk rock excavation to assess the need for full time vibration monitoring. CGC should be consulted to assess the excavation equipment and methodology prior to the start of the excavation.

The excavation of safe batter slopes appears marginally achievable with respect to the site boundaries; however it is recommended that an experienced geotechnical consultant inspect the stability of the batters along the sides of the LGFL excavation. It is recommended that the construction of support be considered immediately after the excavation otherwise pre-excavation support or temporary systems are recommended.

It is recommended that a core drilling investigation occur between the Lower GFL excavation and the side boundaries to at least 1.0m below the BEL along with geotechnical inspection at every 1.50m depth interval to assess if the excavation required support (e.g. rock bolts).

It is recommended that all the new footings be extended through the fill and soils and bear onto competent sandstone bedrock of similar bearing capacity.

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

Prepared by:
Marvin Lujan
Geotechnical Engineer

Reviewed by:
Troy Crozier
Principal
MIE Aust MAIG. RPGeo; 10197

7. REFERENCES:

1. Australian Geomechanics Society 2007, "Landslide Risk Assessment and Management", Australian Geomechanics Journal Vol. 42, No 1, March 2007.
2. Geological Society Engineering Group Working Party 1972, "The preparation of maps and plans in terms of engineering geology" Quarterly Journal Engineering Geology, Volume 5, Pages 295 - 382.
3. 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
5. V. Gardiner & R. Dackombe 1983, "Geomorphological Field Manual" by George Allen & Unwin.

Appendix 1

CROZIER GEOTECHNICAL CONSULTANTS

Crozier Geotechnical Consultants ABN: 96 113 453 624
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Brookvale NSW 2100 Email: info@croziergeotech.com.au
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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: -

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

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

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

Dynamic Penetrometers

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

Two relatively similar tests are used.

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

Laboratory Testing

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

Borehole Logs

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

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

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

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

Ground Water

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

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

Engineering Reports

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

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

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

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

Site Anomalies

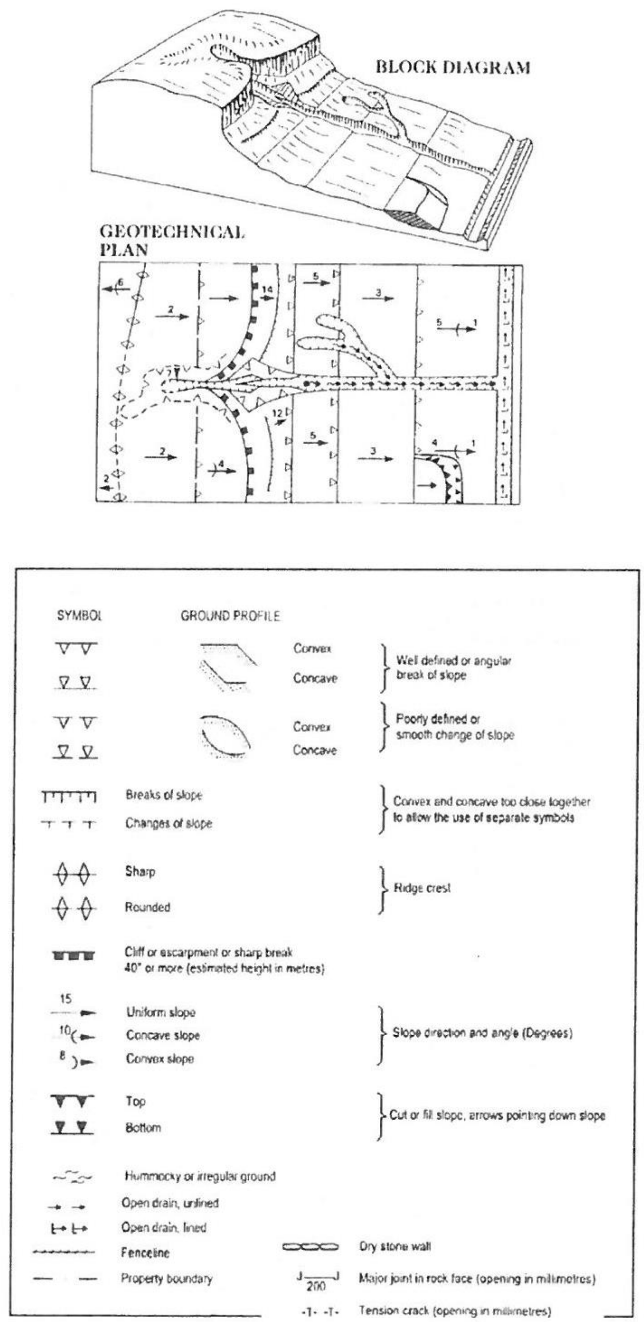
In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the Company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed than at some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

Reproduction of Information for Contractual Purposes

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

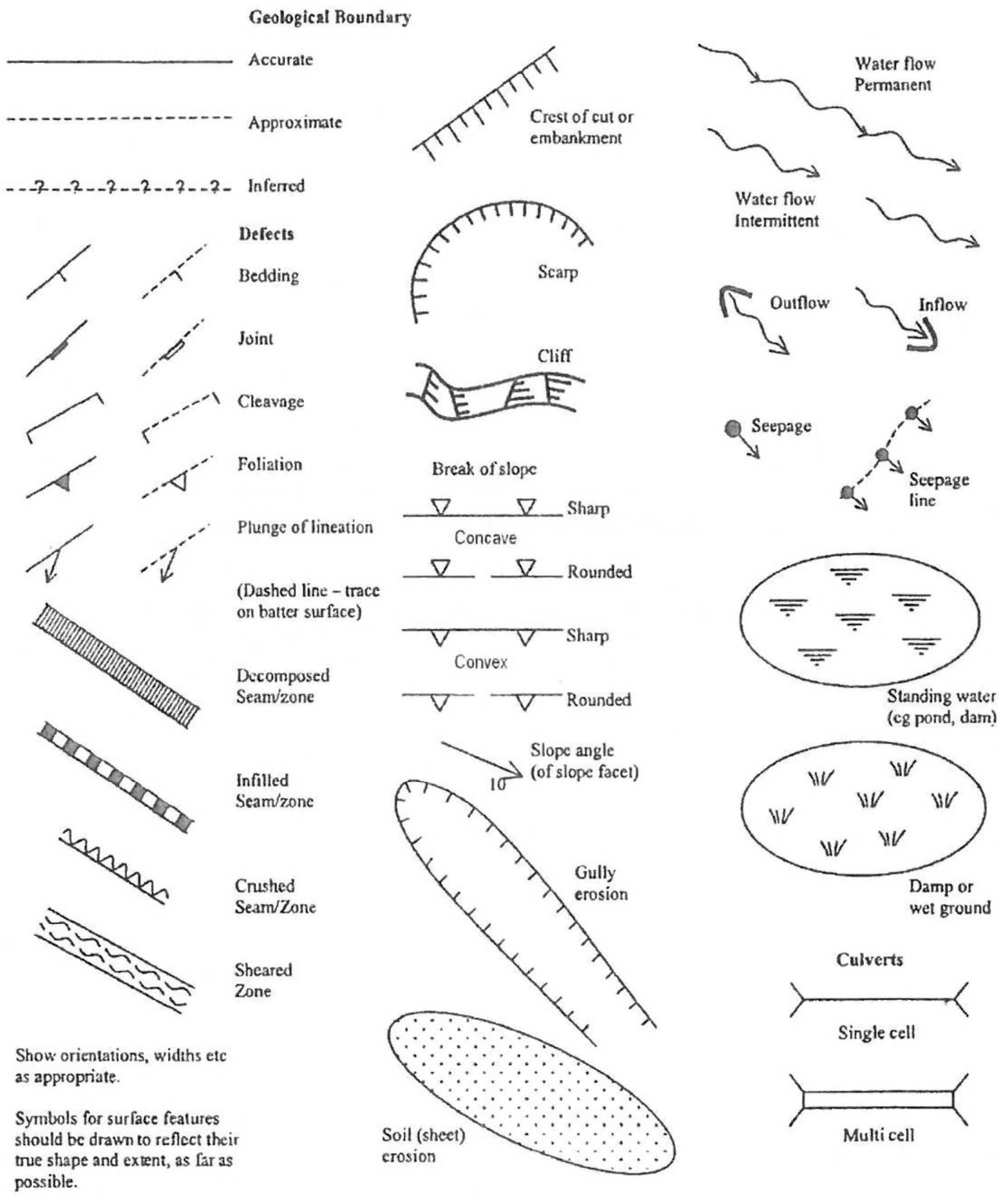
Site Inspection

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



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

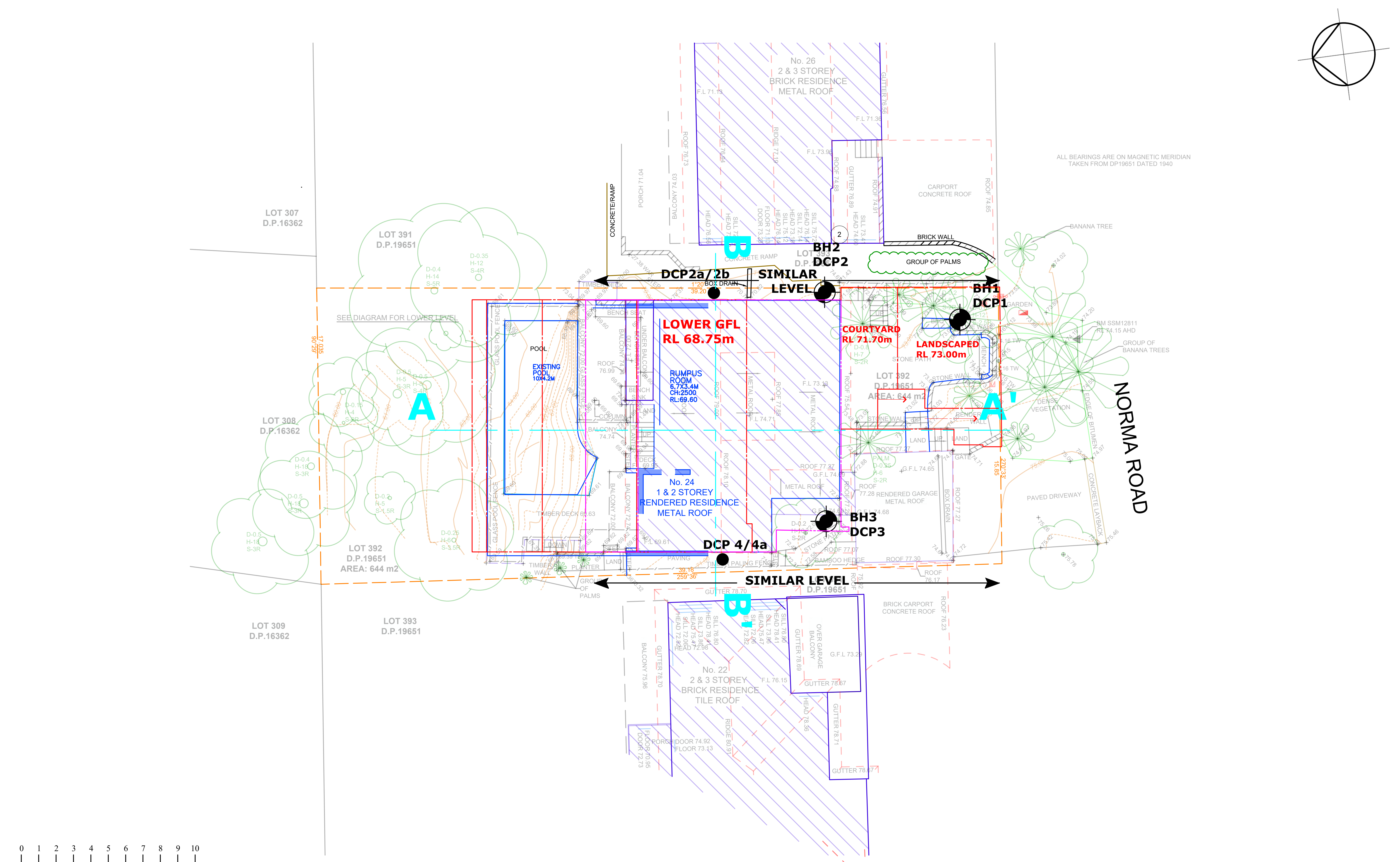
APPENDIX E - GEOLOGICAL AND GEOMORPHOLOGICAL MAPPING SYMBOLS AND TERMINOLOGY



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



SITE PLAN & TEST LOCATIONS FIGURE 1.

CROZIER
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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

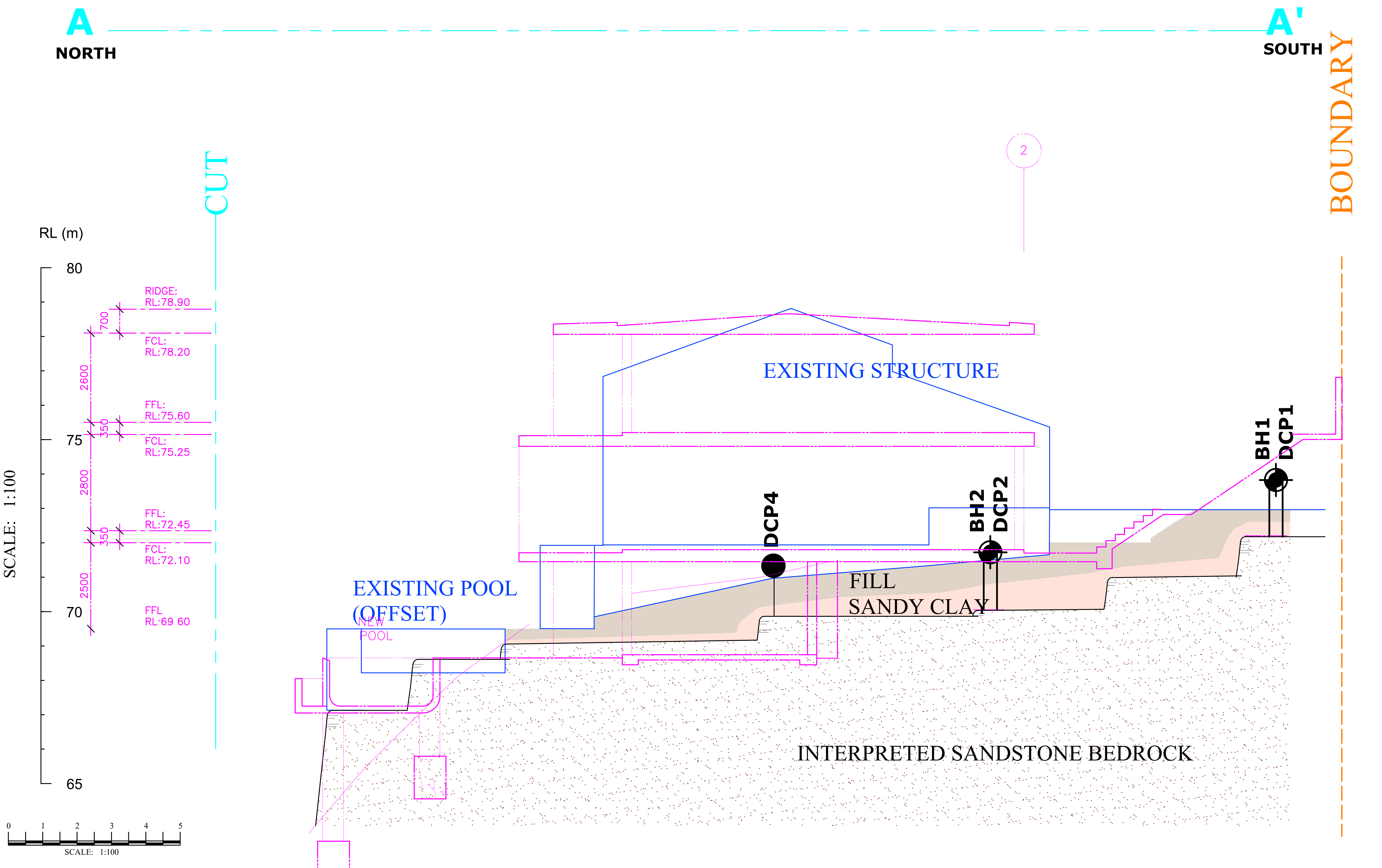
LEGEND

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

SCALE:	1:200 @ A3
DRAWING:	FIGURE 1
DATE:	24/01/2023
APPROVED BY:	TMC
DRAWN BY:	ML
PROJECT:	2021-218

PREPARED FOR:
EDWINA WITHERS

ADDRESS:
25 NORMA ROAD
PALM BEACH



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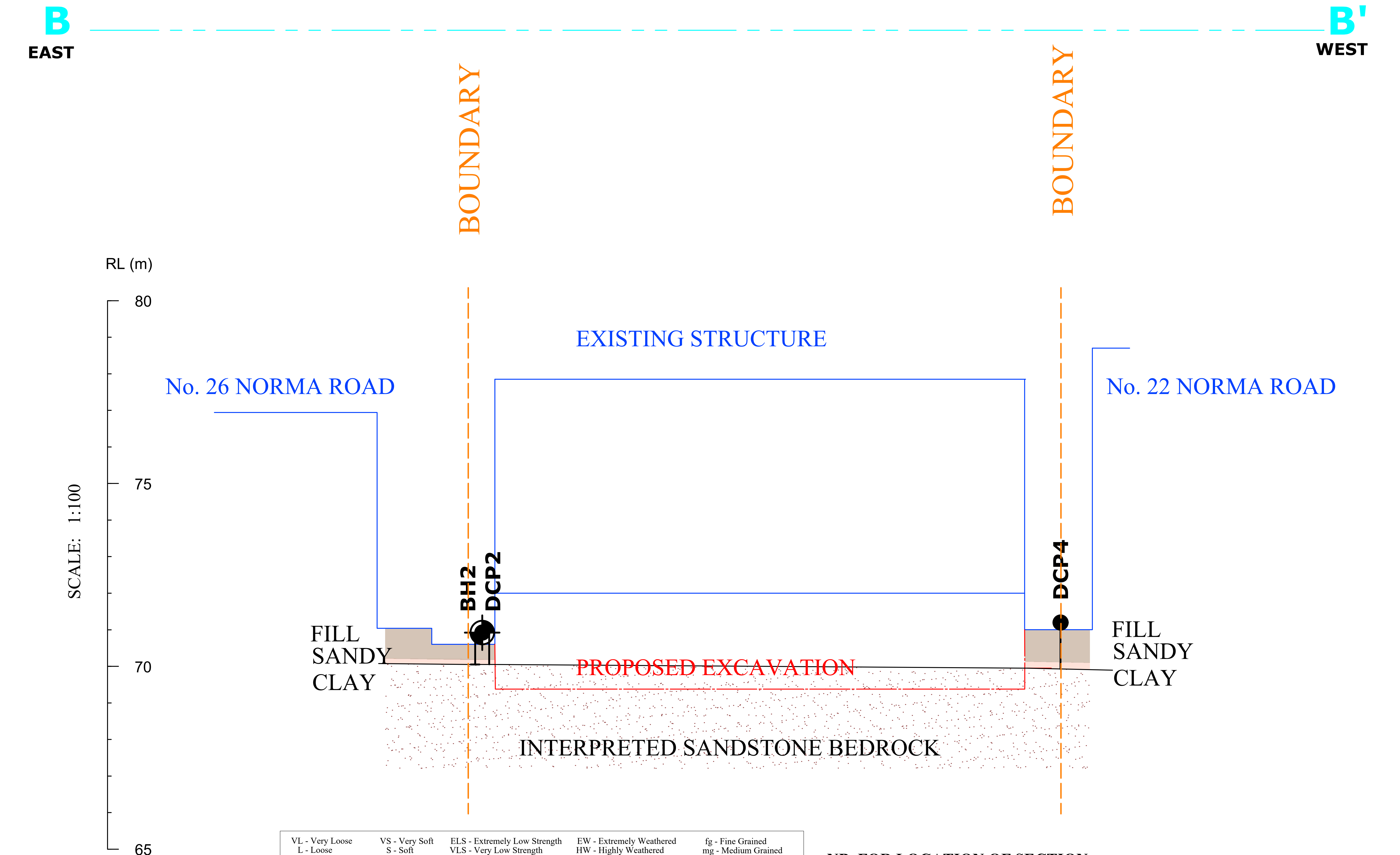
LEGEND

A — A'	CROSS-SECTION REFERENCE LINE
BH DCP	AUGER / DYNAMIC CONE PENETROMETER LOCATION
(sandy clay fill)	SANDY CLAY
(dashed orange line)	PROPERTY BOUNDARY
DCP	DYNAMIC CONE PENETROMETER
(soil/fill fill)	SOIL/FILL
(sandstone fill)	SANDSTONE BEDROCK

SCALE:	1:100 @ A3
DRAWING:	FIGURE 2
DATE:	24/01/2023
APPROVED BY:	TMC
DRAWN BY:	ML
PROJECT:	2021-218

PREPARED FOR:
EDWINA WITHERS

ADDRESS:
25 NORMA ROAD
PALM BEACH



0 1 2 3 4 5
SCALE: 1:100

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 3.

CROZIER
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Fax: (02) 9939 1883

LEGEND

A — A'	CROSS-SECTION REFERENCE LINE
BH DCP	AUGER / DYNAMIC CONE PENETROMETER LOCATION
	SANDY CLAY
	PROPERTY BOUNDARY
DCP	DYNAMIC CONE PENETROMETER
	SOIL/FILL
	SANDSTONE BEDROCK

SCALE:	1:100 @ A3
DRAWING:	FIGURE 3
DATE:	24/01/2023
APPROVED BY:	TMC
DRAWN BY:	ML
PROJECT:	2021-218

PREPARED FOR:
EDWINA WITHERS

ADDRESS:
25 NORMA ROAD
PALM BEACH

BOREHOLE LOG

CLIENT: Edwina Withers **DATE:** 28/09/2021 **BORE No.:** BH1

PROJECT: Extensive alterations and additions **PROJECT No.:** 2021-218 **SHEET:** 1 of 1

LOCATION: 24 Norma Road, Palm Beach, NSW **SURFACE LEVEL (RL):** 73.5 m

Depth (m)	RL (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, dark brown, fine to medium grained, moist, silty sand with some sandstone gravel				
0.70	72.80	CL/CI	SANDY CLAY: Very stiff, orange, low to medium plasticity, moist, sandy clay				
0.90	72.60		… pale orange mottled orange red				
1.00			… hard, becoming pale yellow mottled orange with bands of extremely weathered bedrock				
1.10	72.40		HAND AUGER DISCONTINUED at 1.10m depth due to a cobble that has fallen into the borehole				
2.00							

RIG: None DRILLER: AC

METHOD: Hand Tools LOGGED: ML

GROUND WATER OBSERVATIONS: None

REMARKS: CHECKED: TMC

BOREHOLE LOG

CLIENT: Edwina Withers | **DATE:** 28/09/2021 | **BORE No.:** BH2

PROJECT: Extensive alterations and additions | **PROJECT No.:** 2021-218 | **SHEET:** 1 of 1

LOCATION: 24 Norma Road, Palm Beach, NSW | **SURFACE LEVEL (RL):** 71.4 m

Depth (m)	RL (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, dark brown, fine to medium grained, moist/wet, silty sand with some sandstone gravel				
0.40	71.00				0.40		
		CI	SANDY CLAY: Firm, orange mottled brown, medium plasticity, moist/wet, sandy clay	D			
0.50	70.90		… orange red motled pale grey, moist		0.50		
0.60			… very stiff				
0.70	70.70		… pale grey mottled orange red				
0.90			… hard				
1.00							
1.30	70.10		… minor seepage at 1.30m depth				
1.35	70.05						
			HAND AUGER REFUSAL at 1.35m depth on sandstone bedrock				
2.00							

RIG: None | DRILLER: AC

METHOD: Hand Tools | LOGGED: ML

GROUND WATER OBSERVATIONS: Seepage encountered at 1.30m depth

REMARKS: | CHECKED: TMC

BOREHOLE LOG

CLIENT: Edwina Withers **DATE:** 28/09/2021 **BORE No.:** BH3

PROJECT: Extensive alterations and additions **PROJECT No.:** 2021-218 **SHEET:** 1 of 1

LOCATION: 24 Norma Road, Palm Beach, NSW **SURFACE LEVEL (RL):** 72.7 m

Depth (m)	RL (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, brown/light brown, fine to medium grained, moist, silty sand with some sandstone gravel				
0.50	72.20		SANDY CLAY: Stiff, orange brown, medium plasticity, moist, sandy clay				
0.70	72.00		… becoming pale orange mottled brown				
0.80	71.90		… very stiff, moist/dry	D	0.80		
0.90	71.80		… with bands of extremely weathered bedrock		0.90		
1.00	**71.70**		HAND AUGER REFUSAL at 1.0m depth on very stiff clay				
2.00							

RIG: None DRILLER: AC

METHOD: Hand Tools LOGGED: ML

GROUND WATER OBSERVATIONS: None

REMARKS: CHECKED: TMC

DYNAMIC PENETROMETER TEST SHEET

CLIENT: Edwina Withers **DATE:** 29/07/2020

PROJECT: Extensive alterations and additions **PROJECT No.:** 2021-218

LOCATION: 24 Norma Road Palm Beach, NSW **SHEET:** 1 of 1

	Test Location						
Depth (m)	DCP1 (RL 73.5m)	DCP2 (RL 71.4m)	DCP2a (RL 70.6m)	DCP2b (RL 70.6m)	DCP3 (RL 72.7m)	DCP4 (RL 71.0m)	
0.00 - 0.10	2	--	--	--	3	--	
0.10 - 0.20	2	1	--	--	7	--	
0.20 - 0.30	3	1	2 Ref. (B) @ 0.30m depth	3 Ref. (B) @0.30m depth	11	--	
0.30 - 0.40	8	0			14	3	
0.40 - 0.50	8	2			3	1	
0.50 - 0.60	6	3			4	9	
0.60 - 0.70	5	5			5	7	
0.70 - 0.80	6	5			4	10	
0.80 - 0.90	6	5			6	3	
0.90 - 1.00	7	9			6	6	
1.00 - 1.10	8	18			7	5 Ref. (B) @ 1.05m depth	
1.10 - 1.20	6	17			6		
1.20 - 1.30	12 Ref. (B) @1.30m depth	12			11 Ref. (B) @ 1.25m depth		
1.30 - 1.40		13 Ref. (B) @ 1.35m depth					
1.40 - 1.50							
1.50 - 1.60							
1.60 - 1.70							
1.70 - 1.80							
1.80 - 1.90							
1.90 - 2.00							
2.00 - 2.10							
2.10 - 2.20							
2.20 - 2.30							
2.30 - 2.40							
2.40 - 2.50							

TEST METHOD: AS 1289. F3.2, CONE PENETROMETER

REMARKS:

(B) Test hammer bouncing upon refusal on solid object

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

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Appendix 3

TABLE : A

Landslide risk assessment for Risk to life

HAZARD	Description	Impacting	Likelihood of Slide	Spatial Impact of Slide		Occupancy	Evacuation	Vulnerability	Risk to Life
A	Landslip (earth slide <$3m^3$) from the Lower GFL excavation		Appears down to 1.0m depth of soil, excavation down to 2.50m depth	a) Pathway ≤0.70m from the excavation, impact 5% b) Pathway ≤1.00m from the excavation, impact 5% c) Dwelling ≤2.50m from the excavation, impact 3%		a) Person on the pathway, 1hr/day avge. b) Person on the pathway, 1hr/day avge. c) Person in the house, 23hrs/day avge.	a) Likely to not evacuate b) Likely to not evacuate c) Almost certain to not evacuate	a) Person in open space, likely impacted by fall b) Person in open space, likely impacted by fall c) Person in the building, unlikely impacted by landslip	
			Possible	**Prob. of Impact**	**Impacted**				
		a) No. 26 Norma Road (pathway)	0.001	0.25	0.05	0.04	0.75	0.75	**2.93E-07**
		b) No. 22 Norma Road (pathway)	0.001	0.25	0.05	0.04	0.75	0.75	**2.93E-07**
		c) No. 22 Norma Road (dwelling)	0.001	0.15	0.03	0.96	1.00	0.10	**4.31E-07**
B	Landslip (rock slide/topple <$2m^3$) from the Lower GFL excavation		Appears below the soil down to 2.50m depth	a) Pathway ≤0.70m from the excavation, impact 5% b) Pathway ≤1.00m from the excavation, impact 5%		a) Person on the pathway, 1hr/day avge. b) Person on the pathway, 1hr/day avge.	a) Likely to not evacuate b) Likely to not evacuate	a) Person in open space, possibly impacted by fall b) Person in open space, possibly impacted by fall	
			Unlikely	**Prob. of Impact**	**Impacted**				
		a) No. 26 Norma Road (pathway)	0.0001	0.10	0.05	0.04	0.75	0.75	**1.17E-08**
		b) No. 22 Norma Road (pathway)	0.0001	0.20	0.05	0.04	0.75	0.75	**2.34E-08**
C	Landslip (earth slide <2m3) from the front landscape excavation		Appears below the soil down to 1.50m depth	a) Garden directly adjacent to the excavation, impact 5%. b) Road reserve directly adjacent to the excavation, impact 3%		a) Person on the garden, 0.5hr/day avge. b) Person on the road reserve, 0.5hr/day avge.	a) Possible to evacuate b) Possible to evacuate	a) Person in open space, possibly impacted by fall b) Person in open space, possible impacted by fall	
			Possible	**Prob. of Impact**	**Impacted**				
		a) No. 26 Norma Road (garden)	0.001	0.30	0.05	0.02	0.5	0.50	**7.81E-08**
		b) Norma Road (road reserve)	0.001	0.30	0.03	0.02	0.5	0.50	**4.69E-08**
D	Boulder slide/roll (≤$3m^3$) down the slope		Boulder rolling down slope	a) Garden directly adjacent to the boundary, impact 3%. b) Dwelling ≤20.0m from the boundary, impact 5%		a) Person on the garden, 1hr/day avge. b) Person in the building, 23hr/day avge.	a) Likely to not evacuate b) Likely to not evacuate	a) Person in open space, likely impacted by boulder b) Person in buiding , possible impacted by structure failure	
			Possible	**Prob. of Impact**	**Impacted**				
		a) No. 308 Whale Beach Road (rear garden)	0.001	0.05	0.03	0.04	0.75	1.00	**4.69E-08**
		b) No. 308 Whale Beach Roada (dwelling)	0.001	0.05	0.05	0.96	0.75	0.50	**8.98E-07**

* neighbouring houses considered for impact of slide to bedroom unless specified, due to high occupancy and lower potential for evacuation.
* considered for person most at Probaility of Impact refers to slide impacting structure/area expressed as a % (i.e. 1.00 = 100% probability of slide impacting area if slide occurs).
* for excavation induced landsli Impacted refers to expected % of area/structure damaged if slide impacts (i.e. small, slow earth slide will damage small portion of house structure such as 1 bedroom (5%), where as large boulder roll may damage/destroy >50%)
* evacuation scale from Almost Certain to not evacuate (1.0), Likely (0.75), Possible (0.5), Unlikely (0.25), Rare to not evacuate (0.01). Based on likelihood of person knowing of landslide and completely evacuating area prior to landslide impact.
* vulnerability assessed using Appendix F - AGS Practice Note Guidelines for Landslide Risk Management 2007

TABLE : B

Landslide risk assessment for Risk to Property

HAZARD	Description	Impacting	Likelihood		Consequences		Risk to Property
A	Landslip (earth slide <3m3) from the Lower GFL excavation	a) No. 26 Norma Road (pathway)	Unlikely	The event might occur under very adverse circumstances over the design life.	Minor	Little Damageor no impact to neighbouring properties, no significant stabilising required .	Low
		b) No. 22 Norma Road (pathway)	Unlikely	The event might occur under very adverse circumstances over the design life.	Minor	Little Damageor no impact to neighbouring properties, no significant stabilising required .	Low
		c) No. 22 Norma Road (dwelling)	Unlikely	The event might occur under very adverse circumstances over the design life.	Insignificant	Little Damageor no impact to neighbouring properties, no significant stabilising required .	Very Low
B	Landslip (rock slide/topple <2m³) from the Lower GFL excavation	a) No. 26 Norma Road (pathway)	Possible	The event could occur under adverse conditions over the design life.	Minor	Little Damageor no impact to neighbouring properties, no significant stabilising required .	Moderate
		b) No. 22 Norma Road (pathway)	Possible	The event could occur under adverse conditions over the design life.	Minor	Little Damageor no impact to neighbouring properties, no significant stabilising required .	Moderate
C	Landslip (earth slide <2m3) from the front landscape excavation	a) No. 26 Norma Road (garden)	Possible	The event could occur under adverse conditions over the design life.	Insignificant	Little Damageor no impact to neighbouring properties, no significant stabilising required .	Very Low
		b) No. 22 Norma Road (pathway)	Possible	The event could occur under adverse conditions over the design life.	Insignificant	Little Damageor no impact to neighbouring properties, no significant stabilising required .	Very Low
D	Boulder slide/roll (≤3m³) down the slope	a) No. 308 Whale Beach Road (rear garden)	Possible	The event could occur under adverse conditions over the design life.	Insignificant	Little Damageor no impact to neighbouring properties, no significant stabilising required .	Very Low
		b) No. 308 Whale Beach Roada (dwelling)	Possible	The event could occur under adverse conditions over the design life.	Minor	Little Damageor no impact to neighbouring properties, no significant stabilising required .	Moderate

* hazards considered in current condition, without remedial/stabilisation measures and during construction works.
* qualitative expression of likelihood incorporates both frequency analysis estimate and spatial impact probability estimate as per AGS guidelines.
* qualitative measures of consequences to property assessed per Appendix C in AGS Guidelines for Landslide Risk Management.
* Indicative cost of damage expressed as cost of site development with respect to consequence values: Catastrophic : 200%, Major: 60%, Medium: 20%, Minor: 5%, Insignificant: 0.5%.
* Cost of site development estimated at $5,000,000

TABLE: 2

Recommended Maintenance and Inspection Program

Structure	Maintenance/ Inspection Item	Frequency
Stormwater drains.	Owner to inspect to ensure that the open drains, and pipes are free of debris & sediment build-up. Clear surface grates and litter. Owner to check and flush retaining wall drainage pipes/systems	Every year or following each major rainfall event. Every 7 years or where dampness/moisture
Retaining Walls. or remedial measures	Owner to inspect walls for deveation from as constructed condition and repair/replace. Replace non engineered rock/timber walls prior to collapse	Every two years or following major rainfall event. As soon as practicable
Large Trees on or adjacent to site	Arborist to check condition of trees and remove as required. Where tree within steep slopes (>18°) or adjacent to structures requires geotechincal inspection prior to removal	Every five years
Slope Stability	Geotechnical Engineering Consultant to check on site stability and maintenance	Five years after construction is completed.

N.B. Provided the above shedule is maintained the design life of the property should conform with Councils Risk Management Policy.

Appendix 4

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%	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.

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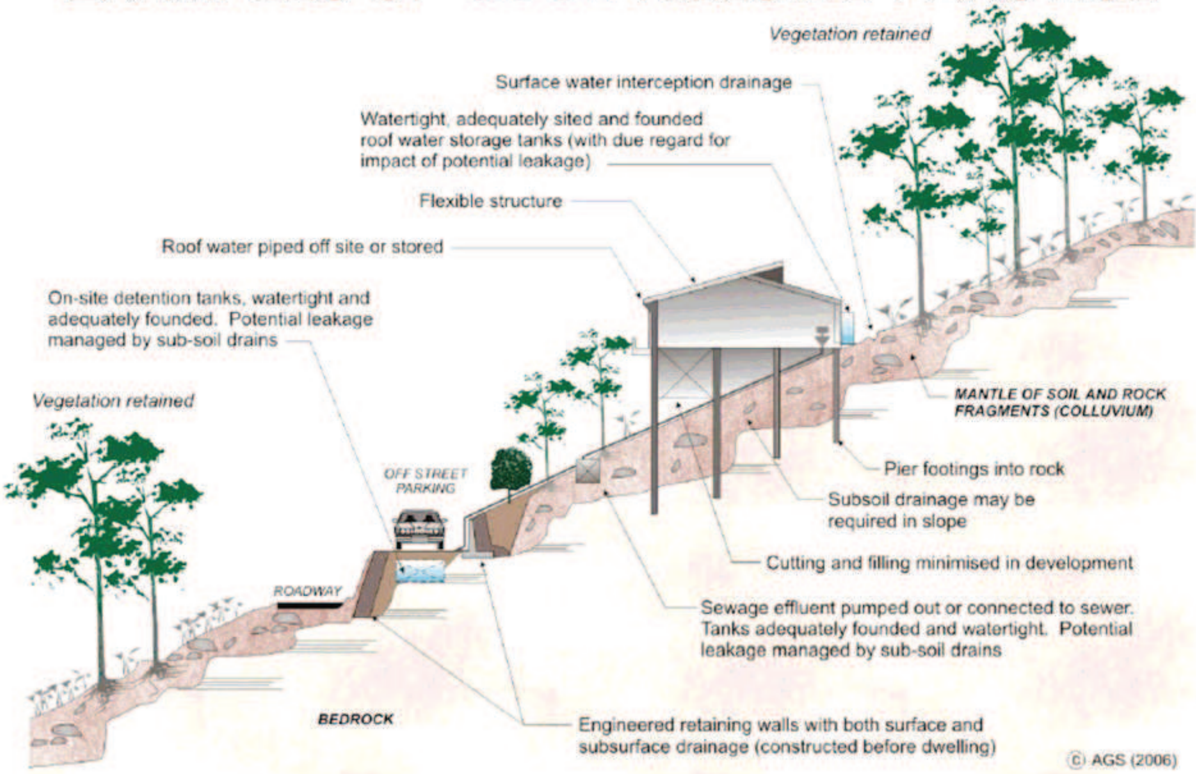
Appendix 5

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



EXAMPLES OF POOR HILLSIDE PRACTICE