GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER
FORM NO. 1 – To be submitted with Development Application

Development Application for____
Name of Applicant
Address of site __346-352 Whale Beach Road, Palm Beach________________________

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

I, _____Woodie Theunissen__________ on behalf of JK Geotechnics Pty Ltd
(Insert Name) (Trading or Company Name)

on this the ____9 March 2021____ 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.
*we/*I have:

Please mark appropriate box

☒ 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

☐ ~~I~~ *Are*/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. *We/*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 *are/*am of the opinion that the Development Application only involves Minor Development/Alterations that do not require a Detailed Geotechnical Risk Assessment and hence my/*our* report is in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009 requirements for Minor Development/Alterations.

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

Geotechnical Report Details:

Report Title: Geotechnical Assessment

Report Date: 9 March 2021 Report Ref No: 31791SYrpt
:
Author: Woodie Theunissen

Author's Company/Organisation: JK Geotechnics Pty Ltd

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

Drawings prepared by Harry Seidler & Associates (Stage: DA, Drawings: 001, 003, 005 to 013, 020, 030, 040, N, M,
050,051, 052, 060 to 062, 064 to 066, 070, 100, 110 to 112, 115 and 116, Revision: A, B, B, J, D, E, B, E, D, D, E, P,
M, D, C, E, G, F, E, D, B, C, E, B, A, A, A, B and B)

~~I am~~ *We are* 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~~ *confirming* 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, *as discussed in the Report*.

Signature ……………………………………………..

Name ……Woodie Theunissen…………………………………………..

Chartered Professional Status……CPEng……………………..

Membership No. ……889807……………………………………

Company: JK Geotechnics Pty Ltd.

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 __346-352 Whale Beach Road, Palm Beach ________________________

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 Assessment
Report Date: 9 March 2021 Report Ref No: 31791SYrpt
Author: Woodie Theunissen
Author's Company/Organisation: JK Geotechnics Pty Ltd

Please mark appropriate box

☒ Comprehensive site mapping conducted ____23 November 2018_______
(date)

☒ Mapping details presented on contoured site plan with geomorphic mapping to a minimum scale of 1:250 (as appropriate)

☒ Subsurface investigation required

- ☒ No Justification …Bedrock exposed across site and adjoining properties
- ☐ Yes Date conducted ………………………………………………

☒ 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~~ *recommendations presented in the Report are adopted.*

☒ 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~~ *We are* aware that Pittwater Council will rely on the Geotechnical Report, to which this checklist applies, as the basis for ~~ensuring~~ *confirming* 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 *as discussed in the Report*.

Signature … ………………………………………..……..
Name …Woodie Theunissen………………………………………..……..
Chartered Professional Status……CPEng………………………
Membership No. ……889807………………………….
Company JK Geotechnics Pty Ltd.

REPORT TO

THE APPLICANT

ON

GEOTECHNICAL ASSESSMENT
(In Accordance with Pittwater Council Risk Management Policy)

FOR

PROPOSED NEW RESIDENCE

AT

346-352 WHALE BEACH ROAD, PALM BEACH, NSW

Date: 9 March 2021
Ref: 31791SYrpt

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Report prepared by:

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For and on behalf of
JK GEOTECHNICS
PO BOX 976
NORTH RYDE BC NSW 1670

DOCUMENT REVISION RECORD

Report Reference	Report Status	Report Date
31791SYrpt	Revision 5	9 March 2021

This report (which includes all attachments and annexures) has been prepared by JK Geotechnics (JKG) for its Client, and is intended for the use only by that Client.

This Report has been prepared pursuant to a contract between JKG and its Client and is therefore subject to:

a) JKG's proposal in respect of the work covered by the Report;
b) The limitations defined in the Client's brief to JKG;
c) The terms of contract between JKG and the Client, including terms limiting the liability of JKG.

If the Client, or any person, provides a copy of this Report to any third party, such third party must not rely on this Report, except with the express written consent of JKG which, if given, will be deemed to be upon the same terms, conditions, restrictions and limitations as apply by virtue of (a), (b), and (c) above.

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Table of Contents

ATTACHMENTS

1 INTRODUCTION

This report presents the results of our geotechnical investigation and stability assessment for the proposed new residence at 346 to 352 Whale Beach Road, Palm Beach, NSW. The work was commissioned by Mr Cristopher Van Haren on behalf of The Applicant. A site location plan is presented as Figure 1.

Reference to the drawings prepared by Harry Seidler & Associates (Stage: DA, Drawings: 001, 003, 005 to 013, 020, 030, 040, 050,051, 052, 060 to 062, 064 to 066, 070, 100, 110 to 112, 115 and 116, Revision: A, B, B, J, D, E, B, E, D, D, E, P, N, M, M, D, C, E, G, F, E, D, B, C, E, B, A, A, A, B and B) indicate that the proposed new residence will comprise:

- Three living levels and pool over a basement garage,
- The garage will provide off street parking for four cars, result in cuts to maximum depths of about 14m and provide lift access to the house above,
- In the void between the top of the garage and the lower level of the house, store and plant rooms, a wine cellar and rainwater storage and re-use tank will be located,
- The new house will run along the contours of the hill with excavation anticipated to be limited to maximum depths of about 6m.

This report has been prepared in accordance with the requirements of the Geotechnical Risk Management Policy for Pittwater (2009) as discussed in Section 6 below. It is understood that the report will be submitted to Council as part of the DA documentation. Our report is preceded by the completed Council Forms 1 and 1a.

2 ASSESSMENT METHODOLOGY

2.1 Walkover Survey

This stability assessment is based on a detailed inspection of the topographic, surface drainage and geological conditions of the site and its immediate environs. These features were compared to those of other similar lots in neighbouring locations to provide a comparative basis for assessing the risk of instability affecting the existing development. The attached Appendix A defines the terminology adopted for the risk assessment together with a flowchart illustrating the Risk Management Process based on the guidelines given in AGS 2007c (Reference 1).

A summary of our observations is presented in Section 3. Our assessment of the risk of slope instability for the site in its existing condition is discussed in Section 5.

The attached Figure 3 presents a geotechnical sketch plan showing the principal geotechnical features present at the site. Figure 3 is based on the survey plan prepared by Adam Clerke Surveyors Pty Ltd (Ref 15204 Sheets 1 to 3 and Ref 1218). Additional features on Figure 3 have been measured by hand held inclinometer and tape measure techniques and hence are approximate only. Should any of the features be critical, we recommend they be located more accurately using instrument survey techniques. Figures 4 to 6 present typical cross-sections through the site based on the survey data augmented by our mapping observations.

2.2 Subsurface Investigation

Prior to drilling commencing, a ‘Dial Before You Dig” services search was completed and a specialist subcontractor electromagnetically scanned the borehole and test locations for buried services. The field work was carried out over the period of the 30 to 31 August 2018 and comprised:

- One cored borehole (BH1) drilled to a depth of 14.14m and
- Seven Dynamic Cone Penetration (DCP) tests completed to depths ranging from 0.2m to 1.8m.

Due to access constraints posed by the terrain all testing was completed using portable equipment. The purpose of the borehole was to determine the nature of the materials present, particularly the underlying bedrock, while the DCP tests were used to probe the depth to bedrock. While the DCP refusal depth is typically considered to indicate the depth to bedrock, it is possible that premature refusal may have occurred on hard layers within the soils.

BH1 was initially drilled using hand auger to a depth of 1.85m, at which depth hand auger refusal occurred. From this depth portable rotary drilling techniques were adopted and the underlying bedrock cored to a depth of 14.14m (RL42.06m).

The degree of compaction of the fill and the strength/relative density of the soils was interpreted from the DCP test results. Where the bedrock was core drilled the recovered core was returned to our NATA registered laboratory, Soil Test Services (STS) for photographing and point load strength index (I_{s50}) testing. Using established correlations the unconfined compressive strength (UCS) of the sandstone bedrock was then estimated from the I_{s50} results. These results are presented in Table A.

Groundwater observations were made in the borehole during and following completion of the auger drilling. We note that water was introduced into the borehole to facilitate the coring process and therefore the water level measured after the completion of core drilling was artificially high and has not been recorded on the logs. No longer was term groundwater monitoring completed.

The borehole and DCP test locations, as shown on the attached Figure 2, were set out by taped measurements from existing surface features shown on the above reference survey drawings at or as close as practicable to the locations nominated by Taylor Thomson Whitting (NSW) Pty Ltd. The reduced levels shown on the top of the borehole and DCP tests have been interpolated from the spot levels shown on the survey drawing and should be considered only approximate.

Our Engineering Geologist, Bo Jonak, was present full-time during the fieldwork to set out the borehole/DCP test locations, direct the electro-magnetic scanning (by service locator), log the encountered subsurface profile and record the DCP results. The borehole log (with core photograph) and DCP test result sheets are attached, together with Report Explanatory Notes which provide details on the investigation procedures adopted and define the logging terms and symbols used.

3 SUMMARY OF OBSERVATIONS

The site is located over the upper eastern slopes of the peninsula that extends from Avalon to Palm Beach. The site drops down steeply to the east to Whale Beach Road with a total change in relief of about 19m over a horizontal distance of about 30m. The site encompasses four lots with a house present on only one of these lots, No. 350 Whale Beach Road.

Two clifflines are present across the site and generally run across the middle and rear of the site. In places these clifflines are not distinct and either merge to form one cliffline or form a jumbled series of lower height cliffs or rock shelves. At its greatest the upper cliffline is up to about 6m high and was generally assessed to be formed of medium to high strength sandstone, although in places it was of assessed low strength. Honeycomb erosion of the clifflines was visible as was undercutting in places. Detached blocks were also observed at or near the crest of sections of clifflines. Jointing in the rock typically was orientated east-north-east to west-south-west and south-south-east to north-north-west with the strike of these joints varying between 200^o - 250^o and 310^o. Where joints ran into the face of the clifflines they were typically vertical while those running parallel dipped out of the face at between 70^o and 80^o.

Between the clifflines and the eastern site boundary slopes were typically in the order of about 15^o to 30^o but varied up to about 45^o at some localised areas. Boulders or floaters were noted in these lower slopes and were typically embedded and were, in places of significant size. In general the site is heavily vegetated with both mature trees and thick undergrowth and was difficult to observe in places. No obvious sign of basal curvature was noted in the trunks of the mature trees.

No. 350 Whale Beach Road is occupied by a three-storey masonry house that steps up the slope and appears in good condition when viewed externally with no signs of distress in the form of cracking observed. On either side of the house landscaping has been completed to form level entertainment areas. Sandstone block walls, comprising a mix of dressed and rough-hewn and mortared and dry packed have been constructed. These walls varied in height up to about 2m but were more typically in the order of about 1m and generally appeared in good condition. To the rear of the house, located immediately adjacent to and part way up the cliffline that runs along the rear of the site is a laundry, sauna and deck, all of which are suspended on a timber structure. At this point the cliffline has been undercut to a depth of about 1.9m and an overhang is located immediately above the deck.

Access to No. 350 Whale Beach Road is via a path that snakes up the cliffline that runs along Whale Beach Road. A number of generally low height sandstone block retaining walls are present and appear in good condition. However, on the high side of the stairs sandstone flagging has been placed over a steep batter that has been formed through soils at the crest of the sandstone bedrock. This flagging is in a state of collapse. To form the path in front of the house, dressed and rough-hewn sandstone block retaining walls have been constructed to a height of about 2.9m. Although it appears that these walls are performing satisfactorily it is difficult to observe the rough-hewn portion of the wall.

To the north is a property with the same landform as the site that is occupied by a single-storey stone house. The house is located to the rear of the property between two clifflines. At the front of the house is a sandstone block retaining wall that supports the deck/terrace and has a maximum height of about 4.4m, and appears in fair condition but does display signs of distress in the form of cracking that varies in width up to about 2mm to 4mm and possibly some bulging, although it is difficult to assess whether the wall is bulging or this is how the wall has been constructed.

To the east is the Whale Beach Road reserve. This road reserve encompasses not only the road but also a strip of land that varies up to about 7.5m wide and is positioned between the road pavement and the eastern site boundary. In this strip of land is a sandstone cliffline (or series of stepped clifflines) that varies in height up to about 5m. The sandstone bedrock was typically assessed to be of low strength with similar jointing noted to that observed on site. At the crest of the cliffline the topography slopes up to the eastern site boundary at average slopes of between about 15^o and 30^o, with the site boundary set back from the cliffline between about 2.5m to 5m.

To the south is a drainage easement that is approximately 3m wide. This easement is unlined, deeply scoured and unvegetated with sandstone bedrock, boulders and soils exposed in the base and banks of the channel. Beyond this is a three-storey masonry house with suspended deck and pool that appeared in good condition when viewed from the site. Both the easement and property beyond have similar landforms to that of the site.

To the west, located at the crest of the cliffline and in the flatter slopes near the crest of the peninsula, are three houses and Annie Wyatt Reserve. All houses are set well back from the cliff line.

4 SUBSURFACE CONDITIONS

Reference to the 1:100,000 Geological Map of the Sydney Region indicates that the site is underlain by rocks of the Hawkesbury Sandstone and the Narrabeen Group. Hawkesbury Sandstone comprises quartz sandstone interbedded with siltstone and shale while the Narrabeen Group comprises lithic and quartz sandstone, siltstones, claystones and conglomerate. The geological boundary between the overlying Hawkesbury Sandstone and underlying Narrabeen Group appears to run through the site.

The investigation revealed a relatively shallow soil cover overlying sandstone bedrock. The more pertinent details of the materials encountered are discussed below. For a more detailed description of the materials encountered at a particular location or the inferred depth to bedrock, reference should be made to the attached borehole logs and DCP test results.

Pavement

At BH1 a 0.1m thick sandstone paver was encountered and overlay a silty sand bedding layer that extended to a depth of 0.2m.

Fill

Below the pavement a silty gravelly or clayey sand fill was encountered to a depth of 0.7m. This fill contained traces of igneous/sandstone gravel and was assessed to be poorly compacted.

Natural Soils

Underlying the fill a mix of sand, clayey sand and sandy clay was encountered that were of stiff to very stiff strength or medium dense relative density. Where the soils were clayey they were assessed to be of medium to high plasticity.

Sandstone Bedrock

Sandstone bedrock outcrops across the site and was inferred from the DCP tests at depths ranging from 0.2m to 1.8m. Considering the prevalence of sandstone bedrock outcropping across the site it is likely that the DCP refusal depth is the depth to bedrock, however it is possible that premature refusal may have occurred on floaters or harder bands within the soils.

Based on our observation of the exposed bedrock it appears that the boundary between the Hawkesbury Sandstone and the Narrabeen Group is at the base of the clifflines present over the middle to the rear of the site with Hawkesbury Sandstone exposed in the clifflines and the Narrabeen Group represented by the scree slopes at the base of these clifflines and the lower clifflines dropping down to Whale Beach Road and the shoreline below.

The sandstone bedrock encountered in BH1 at a depth of 1.8m is part of the Narrabeen Group and was initially of poor quality to a depth of 5.3m, at which depth the quality of the bedrock improved markedly. In the poorer quality bedrock rock strengths varied from very low to low and a number of significant core loss zones logged. Core loss typically represents areas of poor-quality bedrock or clay that has been washed away during the coring process. Below a depth of 5.3m the bedrock increased to medium to high strength and contained only a few thin core loss zones. A siltstone band and claystone lenses were encountered below a depth of about 8m.

Defects within the bedrock typically comprised bedding partings and joints. Joints generally ranged in inclination from 45^o to 90^o.

Groundwater

Groundwater was not encountered during or on completion of auger drilling. Based on where the site is situated in the topography it is anticipated that a groundwater table as such will not be encountered. While a groundwater table is not expected to be encountered seepage should be expected and is likely to occur at the interface between the soil and bedrock and through defects within the rock mass. Any seepage that occurs into the excavation would probably emanate naturally a little further downslope and so the excavation is not considered to interfere significantly with the natural groundwater regime.

Laboratory test Results

The results of the point load strength index tests indicate that the unconfined compressive strength (UCS) of the sandstone bedrock ranges from less than 1MPa to 56MPa. Where higher UCS values were encountered within the poorer quality bedrock this reflects not the general strength of the bedrock at this location but rather the presence of high strength ironstone bands within the sandstone bedrock.

5 GEOTECHNICAL ASSESSMENT

5.1 Potential Landslide Hazards

We consider that the potential landslide hazards associated with the site to be the following:

A Stability of detached boulders:
  (i) Of the boulder
  (ii) Below the boulder

B Stability of scree slopes:
  (i) On the slope
  (ii) Below the slope

C Stability of low height retaining walls:
  (i) Above the wall
  (ii) Below the wall

D Stability of overhangs
  (i) On the overhang
  (ii) Below the overhang

E Stability of higher sandstone block retaining walls
  (i) Above the walls
  (ii) Below the walls

F Stability of cliff lines
  (ii) Below cliffline

G Stability of boulders on slopes
  (i) Of the boulder
  (ii) Below the boulder

Some of these potential hazards are indicated in schematic form on the attached Figures 3, 4, 5 and 6.

5.2 Risk Analysis

The attached Table A summarises our qualitative assessment of each potential landslide hazard and of the consequences to property should the landslide hazard occur. Use has been made of data in MacGregor *et al* (2007) to assist with our assessment of the likelihood of a potential hazard occurring. Based on the above, the qualitative risks to property have been determined. The terminology adopted for this qualitative assessment is in accordance with Table A1 given in Appendix A. Table A indicates that the assessed risk to property is very low, which would be considered acceptable in accordance with the criteria given in Reference 1 and the Pittwater Council Risk Management Policy.

We have also used the indicative probabilities associated with the assessed likelihood of instability to calculate the risk to life. The temporal and vulnerability factors that have been adopted are given in the attached Table B together with the resulting risk calculation. Our assessed risk to life for the person most at risk is about 10^{-6}. This would be considered to be acceptable in relation to the criteria given in Reference 1 and the Pittwater Council Risk Management Policy.

5.3 Risk Assessment

The Pittwater Risk Management Policy requires suitable measures 'to remove risk'. It is recognised that, due to the many complex factors that can affect a site, the subjective nature of a risk analysis, and the imprecise nature of the science of geotechnical engineering, the risk of instability for a site and/or development cannot be completely removed. It is, however, essential that risk be reduced to at least that which could be reasonably anticipated by the community in everyday life and that landowners are made aware of reasonable and practical measures available to reduce risk as far as possible. Hence, where the policy requires that 'reasonable and practical measures have been identified to remove risk', it means that there has been an active process of reducing risk, but it does not require the geotechnical engineer to warrant that risk has been completely removed, only reduced, as removing risk is not currently scientifically achievable.

Similarly, the Pittwater Risk Management Policy requires that the design project life be taken as 100 years unless otherwise justified by the applicant. This requirement provides the context within which the geotechnical risk assessment should be made. The required 100 years baseline broadly reflects the expectations of the community for the anticipated life of a residential structure and hence the timeframe to be considered when undertaking the geotechnical risk assessment and making recommendations as to the appropriateness of a development, and its design and remedial measures that should be taken to control risk. It is recognised that in a 100 year period external factors that cannot reasonably be foreseen may affect the geotechnical risks associated with a site. Hence, the Policy does not seek the geotechnical engineer to warrant the development for a 100 year period, rather to provide a professional opinion that foreseeable geotechnical risks to which the development may be subjected in that timeframe have been reasonably considered.

Our assessment of the probability of failure of existing structural elements such as retaining walls (where applicable) is based upon a visual appraisal of their type and condition at the time of our inspection. Where existing structural elements such as retaining walls will not be replaced as part of the proposed development, where appropriate we identify the time period at which reassessment of their longevity seems warranted.

In preparing our recommendations given below we have adopted the above interpretations of the Risk Management Policy requirements. We have also assumed that no activities on surrounding land which may affect the risk on the subject site would be carried out. We have further assumed that all Council's buried services are, and will be regularly maintained to remain, in good condition.

We consider that our risk analysis has shown that the site and existing and proposed development can achieve the 'Acceptable Risk Management' criteria in the Pittwater Risk Management Policy provided that the recommendations given in Section 6 below are adopted. These recommendations form an integral part of the Landslide Risk Management Process.

6 COMMENTS AND RECOMMENDATIONS

We consider that the proposed development may proceed provided the following specific design, construction and maintenance recommendations are adopted to maintain and reduce the present risk of instability of the site and to control future risks. These recommendations address geotechnical issues only and other conditions may be required to address other aspects.

6.1 Conditions Recommended to Establish the Design Parameters

6.1.1 All proposed footings must be founded on sandstone bedrock. The footings should be designed for an allowable bearing pressure (ABP) of 1,000kPa where they are founded on sandstone bedrock of at least very low strength, subject to inspection by a geotechnical engineer prior to pouring. Where footings are founded within the zone of influence of either existing or proposed excavations or existing clifflines (defined by a line drawn up from the base of the excavation/cliffline at 1 Vertical(V):1 Horizontal (H)) further advice must be sought from this office on the materials on which footings are to be founded. If any footings are founded on overhangs the overhang must be underpinned to transfer the load to the competent bedrock below. The depth at which footings are to be founded and the ABP's that may be adopted will depend on the presence of adverse defects and the quality of the bedrock.

6.1.2 Subject to inspection by a geotechnical engineer, temporary batters for the proposed excavation should be no steeper than 1 Vertical (V) in 1 Horizontal (H) within the soil profile and extremely weathered rock. Permanent batters may be formed at no steeper than 1V:2H but must be vegetated or otherwise protected from erosion. For maintenance purposes flatter batters in the order of 1V:3H or 4H may be more appropriate.

6.1.3 For the support of soils and sandstone bedrock of extremely low strength, cantilevered retaining walls to maximum heights of about 3m may be designed for a triangular earth pressure distribution and a coefficient of active lateral earth pressure of 0.35, which assumes a horizontal backfill surface. A bulk unit weight of 20kN/m^3 should be used. Appropriate hydrostatic pressures and surcharge loads should be added to the above pressures.

6.1.4 For retained heights of greater than 3m.an anchored soldier pile wall with shotcrete and mesh infill panels may be adopted. For the design of anchored retaining walls where movement sensitive structures are not located within the zone of influence of the excavation (defined by a distance 2H from the crest of the retention system where H is the retained height) a rectangular earth pressure distribution may be adopted with a pressure distribution of 4H kPa, where H is the height of retained soils and poor quality bedrock. Where movement sensitive structures are present within the zone of influence of the excavation (which is not expected to be the case) a lateral earth pressure of 8H kPa should be adopted. Appropriate hydrostatic pressures and surcharge loads (which include inclined backfill) must be added to the above pressures.

6.1.5 All anchors should be bonded in the underlying sandstone bedrock, should have minimum bond and free lengths of 3m with the bond length formed below a line drawn upwards from bulk excavation level at 45°. Where bonded in sandstone bedrock of at least low strength an allowable bond stress of 150kPa may be adopted. All anchors should be proof loaded in a staged manner to 1.3 times the design load in the presence of an experienced geotechnical engineer engaged by the principal and not the contractor. All anchors should be installed by experienced and appropriately insured anchoring contractors and should be installed on a design and construct basis such that should anchors fail proof loading there is no dispute over whether the cause of the failure is the anchor installation or the recommended allowable bond stresses.

6.1.6 An alternative means of support may be to progressively install a soil nail wall as the excavation is deepened. Where this approach is adopted further advice should be sought from this office on the design of such a retention system. The benefit of this approach is that it is likely that rock bolts and mesh will be required where excavation is completed through the more competent bedrock and as such there is no difference in the installation techniques adopted for a soil nail wall or support of adverse defects in the bedrock.

6.1.7 Where anchors are to run below adjoining properties, then the permission of the owners must be obtained before installation.

6.1.8 Sandstone bedrock of low strength or better may be cut vertically and left unsupported, provided it is free from adverse defects. The sandstone bedrock is quite heavily jointed and based on the jointing observed in the sandstone clifflines it is anticipated that adversely orientated jointing will be encountered, particularly at the rear of the cuts where it is expected to dip out of the face. Consequently, it is likely that some form of support will be required in both the short and long term. It is possible that pattern bolting may be required over the full height of the excavation which may consist of 1.5m to 3m long (possibly longer) bolts installed at 1.5m centres in both the vertical and horizontal direction. A shotcrete and mesh facing will also be required that will be tied into the bolts and will consist of a minimum of 100mm shotcrete with SL82 centrally placed. The exact support requirements, if any, will be determined as the excavation deepens following inspection by a geotechnical engineer of every 1.5m of vertical unsupported cut. Even in the event that adverse defects are not present, it is generally good practice to protect the cut faces with shotcrete and mesh to reduce long term maintenance requirements. Vertical strip drains should be installed at 1.5m centres behind the shotcrete and mesh panels. Long term support could be provided by the built structure or by use of “permanent” bolts.

6.1.9 Although not anticipated to be the case, should anchors run below adjoining properties, permission must be obtained from the owners prior to their installation.

6.1.10 Where existing slopes or batters exceed the recommended temporary or permanent batter slopes described above or where existing retaining walls are not considered suitable (such as the sandstone lagging present on the high side of the staircase providing access to the site), then slopes must be appropriately battered or engineered retaining walls constructed to support the soils.

6.1.11 Although it is not anticipated that excavation will extend below the groundwater table, seepage is anticipated at the soil bedrock interface and through defects within the bedrock, particularly during and following rainfall events. Consequently, dish drains should be constructed at the toe of all cuts to collect all groundwater flows or groundwater collected in back of wall drainage to allow controlled discharge to Council's stormwater system.

6.1.12 It is anticipated that where slabs on grade are required they will predominantly be formed over sandstone bedrock. On-grade floor slabs which are poured directly over sandstone bedrock should be provided with a separation layer and underfloor drainage. The underfloor drainage should comprise a strong, durable, single sized washed aggregate, such as 'blue metal' gravel. The underfloor drainage should collect groundwater seepage and direct it by gravity flow to the stormwater system. If a network of subsoil drains are used in preference to a drainage blanket a layer of roadbase will be required to form a bond breaker between the slab and the rock.

6.1.13 Where slabs are formed over natural soils and will be trafficked, we recommend that they first be proof rolled using a small smooth drum roller in the presence of an experienced geotechnical engineer. The purpose of proof rolling is to identify any soft or unstable areas so that they may be remediated. In this regard further advice would be provided by the geotechnical engineer at this stage. It should be noted that it is quite difficult to complete earthworks on a small scale and consequently consideration could be given to designing the slabs as suspended slabs rather than slabs on grade.

6.1.14 All trafficable slabs on grade should be provided with a minimum 100mm crushed rock to RTA QA specification 3051 (1994) unbound base material (or equivalent good quality durable fine crushed rock) which is compacted to at least 100% of SMDD. All slabs on grade should be designed with shear effective transmission by way of either dowelled or keyed joints. The need for drainage below the slabs should be considered. Perimeter subsoil drains are likely to be a minimum requirement.

6.1.15 The surface water discharging from the new roof and paved areas must be diverted to outlets for controlled discharge to the existing stormwater system and discharge at the water course at the south-western corner of the site.

6.1.16 The results of the soil aggression testing returned a pH of 5.3, chloride and sulphate contents of 22mg/kg respectively and a resistivity of 24,000ohm.cm. In accordance with AS2159-2009, Tables 6.4.2(c) and 6.5.2(c) the site poses a moderate corrosion risk to concrete structures in contact with the ground and is non-aggressive for steel structures in contact with the ground.

6.1.17 The guidelines for Hillside Construction given in Appendix B should also be adopted.

6.2 Conditions Recommended to the Detailed Design to be Undertaken for the Construction Certificate

6.2.1 All structural design drawings must be reviewed by the geotechnical engineer who should endorse that the recommendations contained in this report have been adopted in principle.

6.2.2 All hydraulic design drawings must be reviewed by the geotechnical engineer who should endorse that the recommendations contained in this report have been adopted in principle.

6.2.3 All landscape design drawings must be reviewed by the geotechnical engineer who should endorse that the recommendations contained in this report have been adopted in principle.

6.2.4 Where excavation is proposed an excavation/retention methodology must be prepared prior to bulk excavation commencing. The methodology must include but not be limited to proposed excavation techniques, the proposed excavation equipment, excavation sequencing, geotechnical inspection intervals or hold points, vibration monitoring procedures, monitor locations, monitor types, contingency plans in case of exceedances.

6.2.5 The excavation/retention methodology must be reviewed and approved by the geotechnical engineer.

6.3 Conditions Recommended During the Construction Period

6.3.1 The geotechnical engineer must inspect all footing excavations prior to placing reinforcement.

6.3.2 Where excavation is proposed the approved excavation/retention methodology must be followed. This includes periodic inspection of every 1.5m of vertical unsupported cut formed through sandstone bedrock of low strength or greater.

6.3.3 Proposed material to be used for backfilling behind retaining walls must be approved by the geotechnical engineer prior to placement.

6.3.4 The geotechnical engineer must inspect all overhangs and detached boulders once appropriate clearing and access is provided to determine whether remedial works are required. Where detached blocks are present and remedial measures are necessary they will either require removal or anchoring. Similarly, should remedial measures be required with respect to the overhangs they either need to be removed or underpinned. Where existing retaining walls are kept as part of the development they must be inspected by the structural engineer to confirm that they have an adequate factor of safety (FOS) for the design life of the site, which is 100 years in accordance with the policy. Should the structural engineer be unable to confirm that the walls have an acceptable FOS for the required design life ongoing inspections by the structural engineer may be required at regular intervals or, alternatively the walls may be reconstructed or strengthened such that they have a suitable FOS for the site design life.

6.3.5 If they are to be retained, the existing stormwater system, sewer and water mains must be checked for leaks by using static head and pressure tests under the direction of the hydraulic engineer or architect, and repaired if found to be leaking.

6.3.6 The geotechnical engineer must inspect all subsurface drains prior to backfilling.

6.3.7 If they are to be retained, the existing stormwater system, sewer and water mains must be checked for leaks by using static head and pressure tests under the direction of the hydraulic engineer or architect, and repaired if found to be leaking.

6.3.8 An 'as-built' drawing of all buried services at the site must be prepared (including all pipe diameters, pipe depths, pipe types, inlet pits, inspection pits, etc).

6.3.9 All rock anchors must be proof-tested in a staged manner to 1.3 times the working load. In addition, the anchors must be subjected to lift-off testing no sooner than 24 hours after locking off at the working load. The proof-testing and lift-off tests must be witnessed by the geotechnical engineer. The anchor contractor must provide the geotechnical engineer with all field records including anchor installation and testing records.

6.3.10 The geotechnical engineer must confirm that the proposed works have been completed in accordance with the geotechnical reports.

We note that all above Conditions must be complied with. Where this has not been done, it may not be possible for Form 3, which is required for the Occupation Certificate to be signed.

6.4 Conditions Recommended for Ongoing Management of the Site/Structure(s)

The following recommendations have been included so that the current and future owners of the subject property are aware of their responsibilities:

6.4.1 All existing and proposed surface (including roof) and subsurface drains must be subject to ongoing and regular maintenance by the property owners. In addition, such maintenance must also be carried out by a plumber at no more than ten yearly intervals including provision of a written report confirming scope of work completed (with reference to the 'as-built' drawing) and identifying any required remedial measures.

6.4.2 Where existing retaining walls are kept and the structural engineer is unable to confirm that they have an acceptable FOS for the design life of the site, they should be inspected at the period designated by the structural engineer. Following these periodic the structural engineer must provide a written report confirming the scope of work completed, any required remedial measures and required future inspections.

6.4.3 No cut or fill in excess of 0.5m (eg. for landscaping, buried pipes, retaining walls, etc), is to be carried out on site without prior consent from Pittwater Council.

6.4.4 Where the structural engineer has indicated a design life of less than 100 years then the structure and/or structural elements must be inspected by a structural engineer at the end of their design life; including a written report confirming scope of work completed and identifying the required remedial measures to extend the design life over the remaining 100 year period.

7 OVERVIEW

Provided the above comments and recommendations are closely followed, we consider that the above development will pose an acceptable rick to both life and property.

It is possible that the subsurface soil, rock or groundwater conditions encountered during construction may be found to be different (or may be interpreted to be different) from those inferred from our surface observations in preparing this report. Also, we have not had the opportunity to observe surface run-off patterns during heavy rainfall and cannot comment directly on this aspect. If conditions appear to be at variance or cause concern for any reason, then we recommend that you immediately contact this office.

This report has been prepared for the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. If there is any change in the proposed development described in this report then all recommendations should be reviewed. Copyright in this report is the property of JK Geotechnics. We have used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended. Subject to payment of all fees due for the investigation, the client alone shall have a licence to use this report. The report shall not be reproduced except in full.

Reference 1: Australian Geomechanics Society (2007c) *'Practice Note Guidelines for Landslide Risk Management'*, Australian Geomechanics, Vol 42, No 1, March 2007, pp63-114.

Reference 2: MacGregor, P, Walker, B, Fell, R, and Leventhal, A (2007) *'Assessment of Landslide Likelihood in the Pittwater Local Government Area'*, Australian Geomechanics, Vol 42, No 1, March 2007, pp183-196.

TABLE A
SUMMARY OF RISK ASSESSMENT TO PROPERTY

Potential Landslide Hazard	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Assessed Likelihood	Possible	Unlikely	Possible	Possible	Possible	Rare	Unlikely
Assessed Consequences	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant
Risk	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
Comments		Small scale slumps anticipated with existing house apparently founded on bedrock	Should the debris strike the house when walls fail it is likely to cause nominal damage			Failures are likely to be limited to small volumes of material rather than large defect controlled failures	

* Assumed value of site $9M

TABLE B
SUMMARY OF RISK ASSESSMENT TO LIFE

Potential Landslide Hazard	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Assessed Likelihood	Possible	Unlikely	Possible	Possible	Possible	Rare	Unlikely
Indicative Annual Probability	1 x 10^{-3}	1 x 10^{-4}	1 x 10^{-3}	1 x 10^{-3}	1 x 10^{-3}	1 x 10^{-5}	1 x 10^{-4}
Duration of Use of Area Affected (Temporal Probability)	(i) 1 minute/month 2.4 x 10^{-5} (ii) 5 minutes/week 4.96 x 10^{-4}	(i) & (ii) 10 minute/week 9.92 x 10^{-4}	(i) 5 minute/day 3.47 x 10^{-3} (ii) 1 minutes/day 6.94 x 10^{-4}	(i) 1 minute/month 2.4 x 10^{-5} (ii) 5 minutes/week 4.96 x 10^{-4}	(i) 5 minute/day 3.47 x 10^{-3} (ii) 1 minutes/day 6.94 x 10^{-4}	5 minute/day 3.47 x 10^{-3}	(i) 1 minute/month 2.4 x 10^{-5} (ii) 5 minutes/week 4.96 x 10^{-4}
Probability of Not Evacuating Area Affected	(i) 1 (ii) 0.5	(i) 1 (ii) 0.5	(i) 0.8 (ii) 0.5	(i) 1 (ii) 1	(i) 0.8 (ii) 0.5	0.8	(i) 0.9 (ii) 0.5
Vulnerability to Life if Failure Occurs Whilst Person Present	(i) 0.5 Likely to ride fall down (ii) 1	(i) & (ii) 0.01 Likely to slide failure down and unlikely to be buried	(i) & (ii) 0.01 Likely to ride failure down and unlikely to be buried	(i) 0.5 Likely to ride fall down (ii) 1 Likely to be buried	(i) 0.1 Likely to ride failure down (ii) 0.9 Possibly buried	0. 1 Likely to be relatively small pieces falling from face	(i) 0.1 Likely to ride failure down (ii) 0.5
Risk for Person Most at Risk	(i) 1.2 x 10^{-8} (ii) 2.48 x 10^{-7}	(i) 9.92 x 10^{-9} (ii) 4.96 x 10^{-8}	(i) 2.78 x 10^{-8} (ii) 3.47 x 10^{-9}	(i) 1.2 x 10^{-8} (ii) 4.96 x 10^{-7}	(i) 2.78 x 10^{-7} (ii) 3.12 x 10^{-7}	(i) 2.78 x 10^{-9}	(i) 2.16 x 10^{-10} (ii) 1.24 x 10^{-8}
Total Risk for Person Most at Risk	1.46 x 10						

115 Wicks Road
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SOIL TEST SERVICES

TABLE A
POINT LOAD STRENGTH INDEX TEST REPORT

Client:	JK Geotechnics	**Ref No:**	31791SY
Project:	Proposed Residence	**Report:**	A
Location:	346-354 Whale Beach Road, Whale Beach, NSW	**Report Date:**	7/09/2018
		Page 1 of 1	

BOREHOLE NUMBER	DEPTH m	$I_{S\,(50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
1	2.10 - 2.13	0.7	14
	3.00 - 3.03	0.02	<1
	3.92 - 3.96	1.6	32
	4.27 - 4.31	1.3	26
	4.72 - 4.75	0.2	4
	5.34 - 5.37	2.2	44
	5.59 - 5.62	1.9	38
	6.38 - 6.41	0.2	4
	6.80 - 6.83	0.7	14
	7.40 - 7.44	0.7	14
	7.80 - 7.84	0.7	14
	8.17 - 8.20	0.4	8
	8.78 - 8.82	1.1	22
	9.12 - 9.16	0.8	16
	9.78 - 9.82	0.8	16
	10.23 - 10.26	0.5	10
	10.77 - 10.81	1.1	22
	11.34 - 11.37	1.6	32
	11.60 - 11.64	2.6	52
	12.14 - 12.17	2.8	56
	12.67 - 12.71	1.3	26
	13.25 - 13.29	0.8	16
	13.86 - 13.90	1.5	30
	14.06 - 14.09	1.3	26

NOTES:

1. In the above table testing was completed in the Axial direction.
2. The above strength tests were completed at the 'as received' moisture content.
3. Test Method: RMS T223.
4. For reporting purposes, the $I_{S(50)}$ has been rounded to the nearest 0.1MPa, or to one significant figure if less than 0.1MPa
5. The Estimated Unconfined Compressive Strength was calculated from the point load Strength Index by the following approximate relationship and rounded off to the nearest whole number : U.C.S. = 20 IS (50)

Envirolab Services Pty Ltd
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12 Ashley St Chatswood NSW 2067
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customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 199990

Client Details

Client	JK Geotechnics
Attention	B Jonak
Address	PO Box 976, North Ryde BC, NSW, 1670

Sample Details

Your Reference	**31791SY, Whale Beach**
Number of Samples	1 Soil
Date samples received	04/09/2018
Date completed instructions received	04/09/2018

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date results requested by	11/09/2018
Date of Issue	10/09/2018

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

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

Results Approved By
Nick Sarlamis, Inorganics Supervisor

Authorised By

Jacinta Hurst, Laboratory Manager

ACCREDITED FOR TECHNICAL COMPETENCE

Misc Inorg - Soil		
Our Reference		199990-1
Your Reference	UNITS	BH1
Depth		1.25-1.35
Date Sampled		30/08/2018
Type of sample		Soil
Date prepared	-	05/09/2018
Date analysed	-	05/09/2018
pH 1:5 soil:water	pH Units	5.3
Chloride, Cl 1:5 soil:water	mg/kg	22
Sulphate, SO4 1:5 soil:water	mg/kg	23
Resistivity in soil*	ohm m	240

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA 22nd ED 2510 and Rayment & Lyons. Resistivity is calculated from Conductivity.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Alternatively determined by colourimetry/turbidity using Discrete Analyer.

QUALITY CONTROL: Misc Inorg - Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	199990-1
Date prepared	-			05/09/2018	1	05/09/2018	05/09/2018		05/09/2018	05/09/2018
Date analysed	-			05/09/2018	1	05/09/2018	05/09/2018		05/09/2018	05/09/2018
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	1	5.3	5.3	0	102	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	1	22	28	24	87	98
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	1	23	25	8	90	90
Resistivity in soil*	ohm m	1	Inorg-002	<1	1	240	220	9	[NT]	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

BOREHOLE LOG

Borehole No.
1
1 / 3

Client: THE APPLICANT
Project: PROPOSED RESIDENCE
Location: 346-352 WHALE BEACH ROAD, PALM BEACH, NSW

Job No.: 31791SY
Method: HAND AUGER
R.L. Surface: ~56.2 m
Date: 30/8/18
Datum: AHD
Plant Type:
Logged/Checked By: J.B.J/W.T.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION					REFER TO DCP TEST RESULTS (1)					SANDSTONE PAVING: 100mm.t.				
						56			-	FILL: Silty sand, fine to medium grained, dark brown orange.	M			APPEARS POORLY COMPACTED
										FILL: Silty gravelly sand, fine to medium grained, light grey brown, trace of sandstone, fine to coarse grained gravel and root fibres.				
										FILL: Clayey sand, fine to medium grained, light grey brown, trace of sandstone, medium to coarse grained, gravel.				
									CI-CH	Sandy CLAY: medium to high plasticity, light orange brown, with ash, trace of ironstone gravel.	w>PL	St		RESIDUAL
						55	1		SP	SAND: fine to medium grained, brown.	M	MD		
									CI	Sandy CLAY: medium plasticity, orange brown.	w>PL	St		
									SC	Clayey SAND: fine to medium grained, orange.	M	MD		
									-	Extremely Weathered sandstone: SAND, fine to medium grained, orange grey.	XW	D		
						54	2			REFER TO CORED BOREHOLE LOG				
						53	3							
						52	4							
						51	5							
						50	6							

JK 9.02.4 LIB.GLB Log JK AUGERHOLE - MASTER 31791SY PALM BEACH.GPJ <<DrawingFile>> 09/03/2021 16:04 10.01.00.01 Datgel Lab and In Situ Tool - DGD | Lib: JK 9.02.4 2019-05-31 Prj: JK 9.01.0 2018-03-20

JKGeotechnics

CORED BOREHOLE LOG

Borehole No.
1
2 / 3

Client: THE APPLICANT
Project: PROPOSED RESIDENCE
Location: 346-352 WHALE BEACH ROAD, PALM BEACH, NSW

Job No.: 31791SY
Core Size: NMLC
R.L. Surface: ~56.2 m
Date: 30/8/18
Inclination: VERTICAL
Datum: AHD
Plant Type: MELVELLE
Bearing: N/A
Logged/Checked By: J.B.J/W.T.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ VL 0.1 L 0.3 M 1 H 3 VH 10 EH	DEFECT DETAILS SPACING (mm) 600 200 60 20	DEFECT DETAILS DESCRIPTION Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness Specific General	Formation
		55			START CORING AT 1.85m						
		54	2		SANDSTONE: fine to coarse grained, dark orange, with bands of extremely weathered material, clayey sand, bedding at 2-5°.	HW	VL - L	0.70		(1.94m) J, 50°, P, R, Cn	Newport Formation
					NO CORE 0.64m						
			3		SANDSTONE: fine to medium grained, orange grey, bedded at 2-5°	HW	VL - L	0.020			Newport Formation
		53			NO CORE 0.46m						
		52	4		SANDSTONE: fine to medium grained, orange grey, with extremely weathered bands, bedding at 2-5°.	HW	L	1.6 1.3	200 60 20	(3.80m) J, 80°, Ir, R, Cn (3.95m) J, 80°, C, Fe Vn (4.14m) J, 80°, Ir, R, Fe Vn	Newport Formation
					NO CORE 0.19m						
		51	5		SANDSTONE: fine to medium grained, light grey, with some orange red banding, bedding at 2-5°.	HW	L	0.20			Newport Formation
						MW	M	2.2 1.9		(5.28m) XWS, 20 mm.t (5.82m) J, 80°, Un, R, Clay, 1 mm.t	
			6		NO CORE 0.19m						
		50	7		SANDSTONE: fine to medium grained, light grey with slight orange staining, bedding at 2-5°.	MW	M	0.20 0.70		(7.13m) J, 45°, P, R, Clay, 1 mm.t	Newport Formation
		49			NO CORE 0.10m						
					SANDSTONE: fine to medium grained, light grey, with slight orange staining.	MW	M	0.70 0.70	200 60 20	(7.32m) Be, 5°, Ir, R, Cn (7.65m) J, 30°, Ir, R, Fe, 1 mm.t (7.97m) J, 50°, P, R, Fe, 3 mm.t	

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS

CORED BOREHOLE LOG

Borehole No.
1
3 / 3

Client: THE APPLICANT
Project: PROPOSED RESIDENCE
Location: 346-352 WHALE BEACH ROAD, PALM BEACH, NSW

Job No.: 31791SY
Core Size: NMLC
R.L. Surface: ~56.2 m
Date: 30/8/18
Inclination: VERTICAL
Datum: AHD
Plant Type: MELVELLE
Bearing: N/A
Logged/Checked By: J.B.J/W.T.

CORE DESCRIPTION (Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components)	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$	DEFECT DETAILS – DESCRIPTION (Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness) Specific	General	Formation
SANDSTONE: fine to medium grained, light grey, trace of claystone lenses, dark grey, bedding at 2-5°.	FR	M	0.40 1.1 0.80	(8.28m) J, 45°, Ir, Vr, Cn		Newport Formation
NO CORE 0.04m						
SANDSTONE: fine to medium grained, light grey, trace ofclaystone lenses, dark grey, bedded at 2-5°.	FR	M	0.80 0.50	(9.87m) J, 90°, Ir, Qz, 1 mm.t (10.00m) Be, 5°, P, R, Clay, 1 mm.t (10.34m) J, 30°, Ir, Vr, Cn		Newport Formation
SILTSTONE: dark grey, bedding at 0°.		H	1.1	(10.56m) Be, 0°, St, S, Cn (10.63m) J, 25°, St, S, Cn		
NO CORE 0.09m						
SANDSTONE: fine to medium grained, light grey with bands of siltstone, bedding at 2-5°.	FR	H	1.6 2.6 2.8 1.3	(11.37m) Be, 2°, Un, S, Cn (11.58m) Be, 0°, P, S, Cn (11.76m) Be, 2°, Un, S, Cn (12.33m) Be, 2°, Un, S, Cn (12.43m) Be, 2°, Un, S, Cn (12.62m) Be, 2°, Un, S, Cn		Newport Formation
SANDSTONE: fine to medium grained, light grey, bedding at 2-5°.			0.80 1.5 1.3	(13.52m) Be, 2°, Un, S, Cn		
END OF BOREHOLE AT 14.14 m						

JK 9.02.4 LIB.GLB Log JK CORED BOREHOLE - MASTER 31791SY PALM BEACH.GPJ <<DrawingFile>> 09/03/2021 16:04 10.01.00.01 Datgel Lab and In Situ Tool - DGD | Lib: JK 9.02.4 2019-05-31 Prj: JK 9.01.0 2018-03-20

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


JK Geotechnics
JOB N* 31791SY BH1 START CORING AT 1.77m
2
CORE LOSS 0.64m
3
CORE LOSS 0.46m
4
CORE LOSS 0.19m
5
6
CORE LOSS 0.19
7
C/L 0.1m
8
9
C/L 0.04
10
11
C/L 0.09m
12
13
14
END OF HOLE 14.14m

JK Geotechnics

GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

DYNAMIC CONE PENETRATION TEST RESULTS

Client: THE APPLICANT
Project: PROPOSED RESIDENCE
Location: 346-352 WHALE BEACH ROAD, PALM BEACH, NSW

Job No. 31791SY
Date: 30-8-18
Tested By: J.B.J.

Hammer Weight & Drop: 9kg/510mm
Rod Diameter: 16mm
Point Diameter: 20mm

Test Location	1	2	3	4	5	6	7
Surface RL	≈56.2m	≈66.5m	≈65.0m	≈57.4m	≈55.0m	≈70.0m	≈71.5m
Depth (mm)	Number of Blows per 100mm Penetration						
0 - 100	PAVER	3	6	1	1	1	1
100 - 200	7	3	8	3	4	3	4/100mm
200 - 300	3	4	10	4	6	6/50mm	REFUSAL
300 - 400	3	5	REFUSAL	4	10	REFUSAL	
400 - 500	6	10		5	REFUSAL		
500 - 600	3	REFUSAL		8			
600 - 700	3			8			
700 - 800	3			8			
800 - 900	3			6/10mm			
900 - 1000	5			REFUSAL			
1000 - 1100	4						
1100 - 1200	4						
1200 - 1300	5						
1300 - 1400	5						
1400 - 1500	5						
1500 - 1600	8						
1600 - 1700	14						
1700 - 1800	20/100mm						
1800 - 1900	REFUSAL						
1900 - 2000							
2000 - 2100							
2100 - 2200							
2200 - 2300							
2300 - 2400							
2400 - 2500							
2500 - 2600							
2600 - 2700							
2700 - 2800							
2800 - 2900							
2900 - 3000							

Remarks:
1. The procedure used for this test is described in AS1289.6.3.2-1997 (R2013)
2. Usually 8 blows per 20mm is taken as refusal
3. Datum of levels is AHD

Ref: JK Geotechnics DCP 0-3m Rev3 Feb18

SOURCE: http://www.whereis.com/

AERIAL IMAGE SOURCE: MAPS.AU.NEARMAP.COM.

This plan should be read in conjunction with the JK Geotechnics report.

Title:

SITE LOCATION PLAN

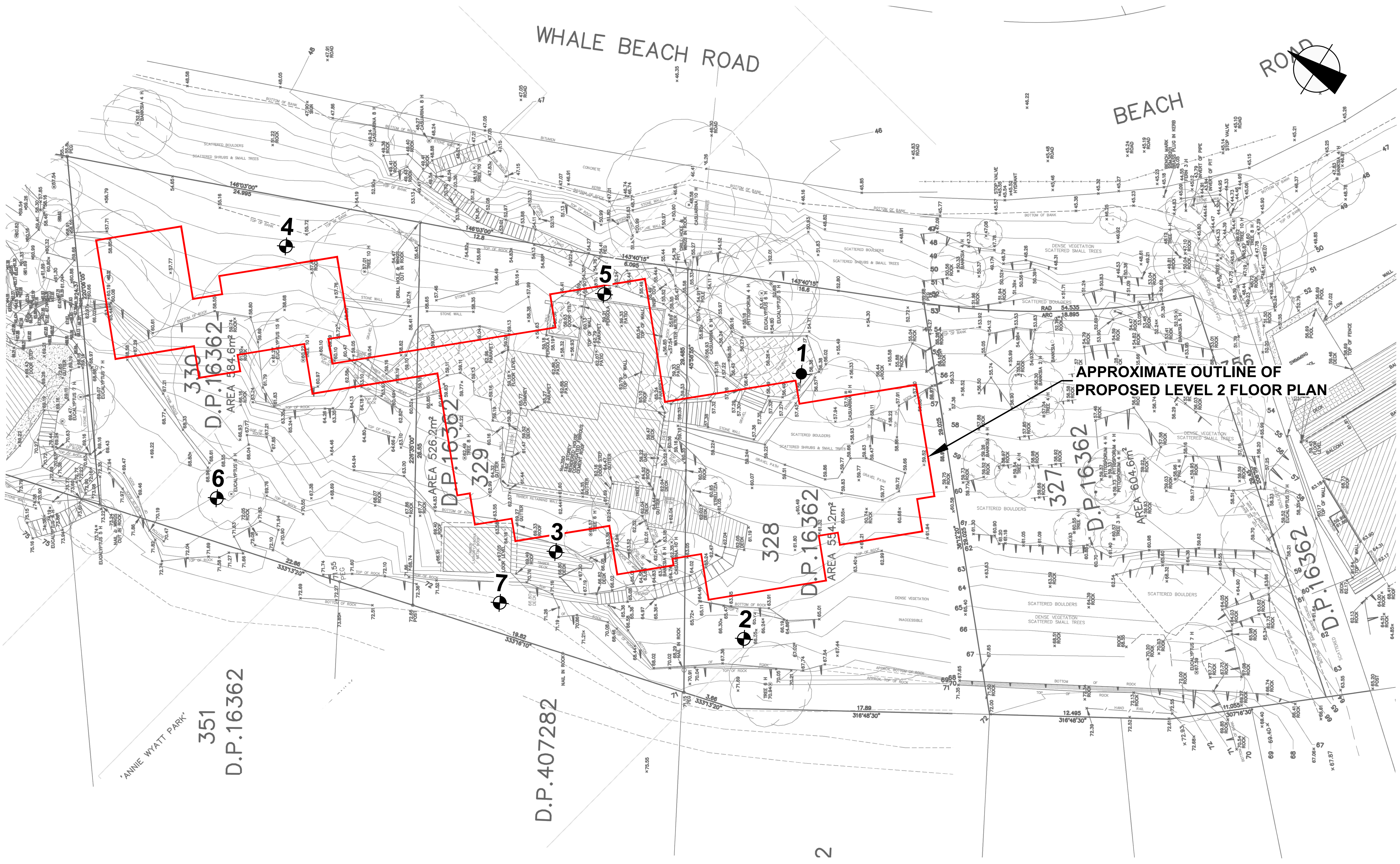
Location: 346-352 WHALE BEACH ROAD,
PALM BEACH, NSW

Report No: 31791SY

Figure No: 1

JKGeotechnics

PLOT DATE: 9/03/2021 4:02:49 PM DWG FILE: Y:\31000'S\31791SY WHALE BEACH\CAD\31791SY.DWG



PLOT DATE: 9/03/2021 4:03:03 PM   DWG FILE: Y:\31000'S\31791SY WHALE BEACH\CAD\31791SY.DWG

LEGEND

● HAND AUGER AND DCP TEST

⊕ DCP TEST

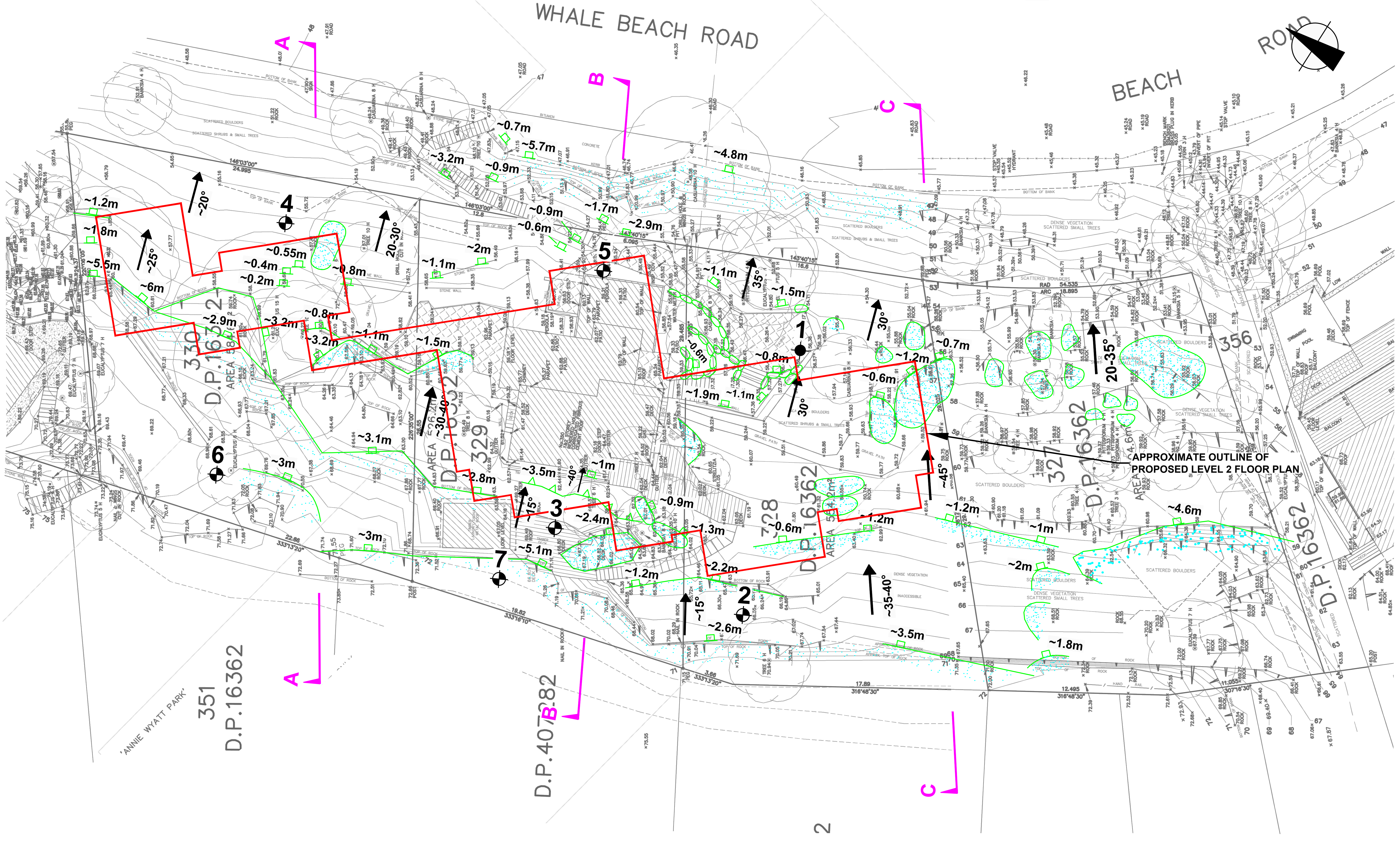
0 2.5 5 7.5 10 12.5

SCALE 1:250 @A3 METRES

This plan should be read in conjunction with the JK Geotechnics report.

Title:	TEST LOCATION PLAN
Location:	346-352 WHALE BEACH ROAD, PALM BEACH, NSW
Report No:	31791SY
Figure No:	2

JKGeotechnics



LEGEND

● HAND AUGER AND DCP TEST

⊕ DCP TEST

0 2.5 5 7.5 10 12.5
SCALE 1:250 @A3 METRES

This plan should be read in conjunction with the JK Geotechnics report.

Title:
GEOTECHNICAL SITE PLAN

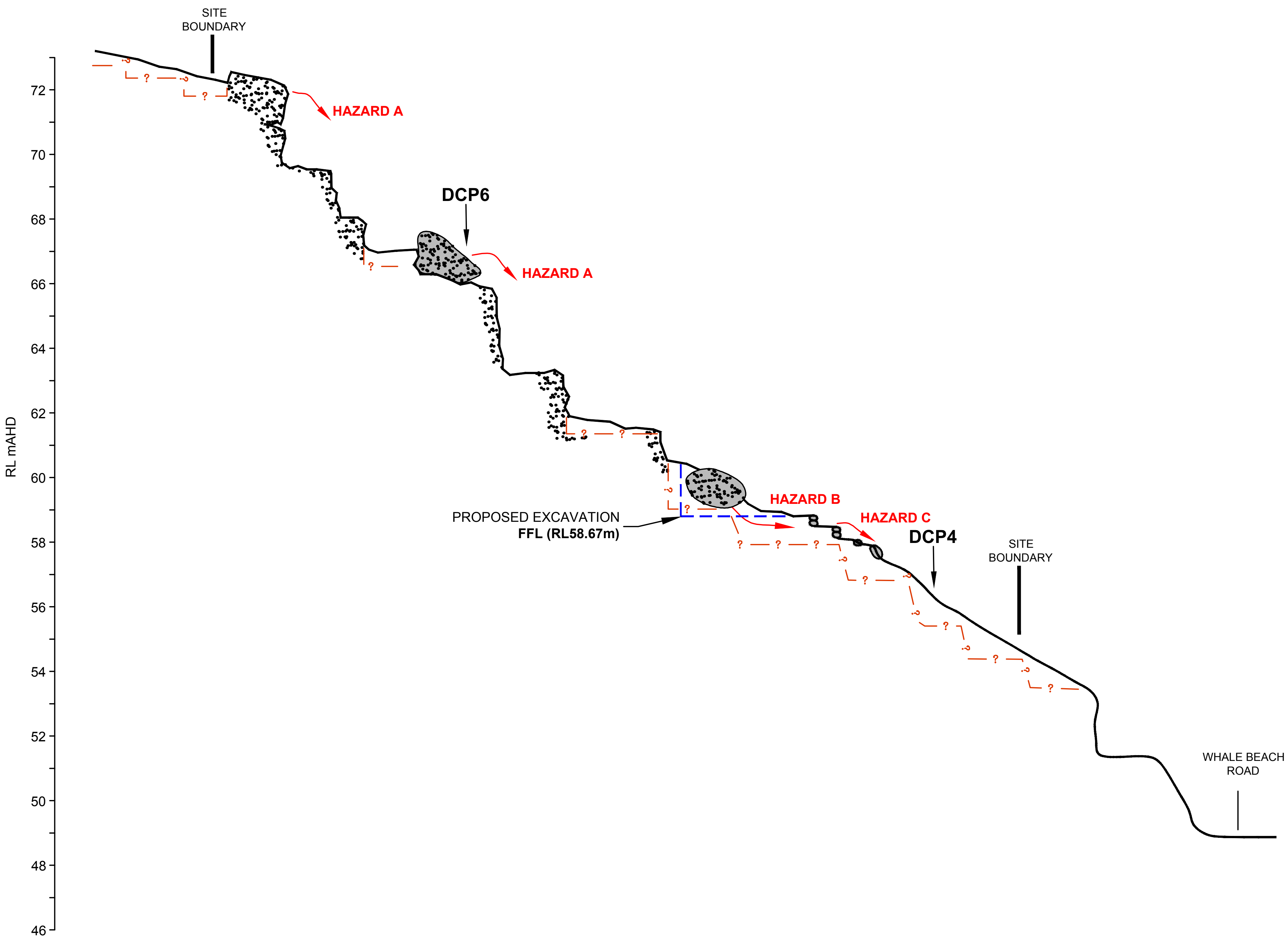
Location: 346-352 WHALE BEACH ROAD,
PALM BEACH, NSW

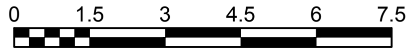
Report No: 31791SY

Figure No: 3

JKGeotechnics

PLOT DATE: 9/03/2021 4:03:19 PM   DWG FILE: Y:\31000's\31791SY WHALE BEACH\CAD\31791SY.DWG





SCALE 1:150 @A3 METRES

This plan should be read in conjunction with the JK Geotechnics report.

Title:

SECTION A-A

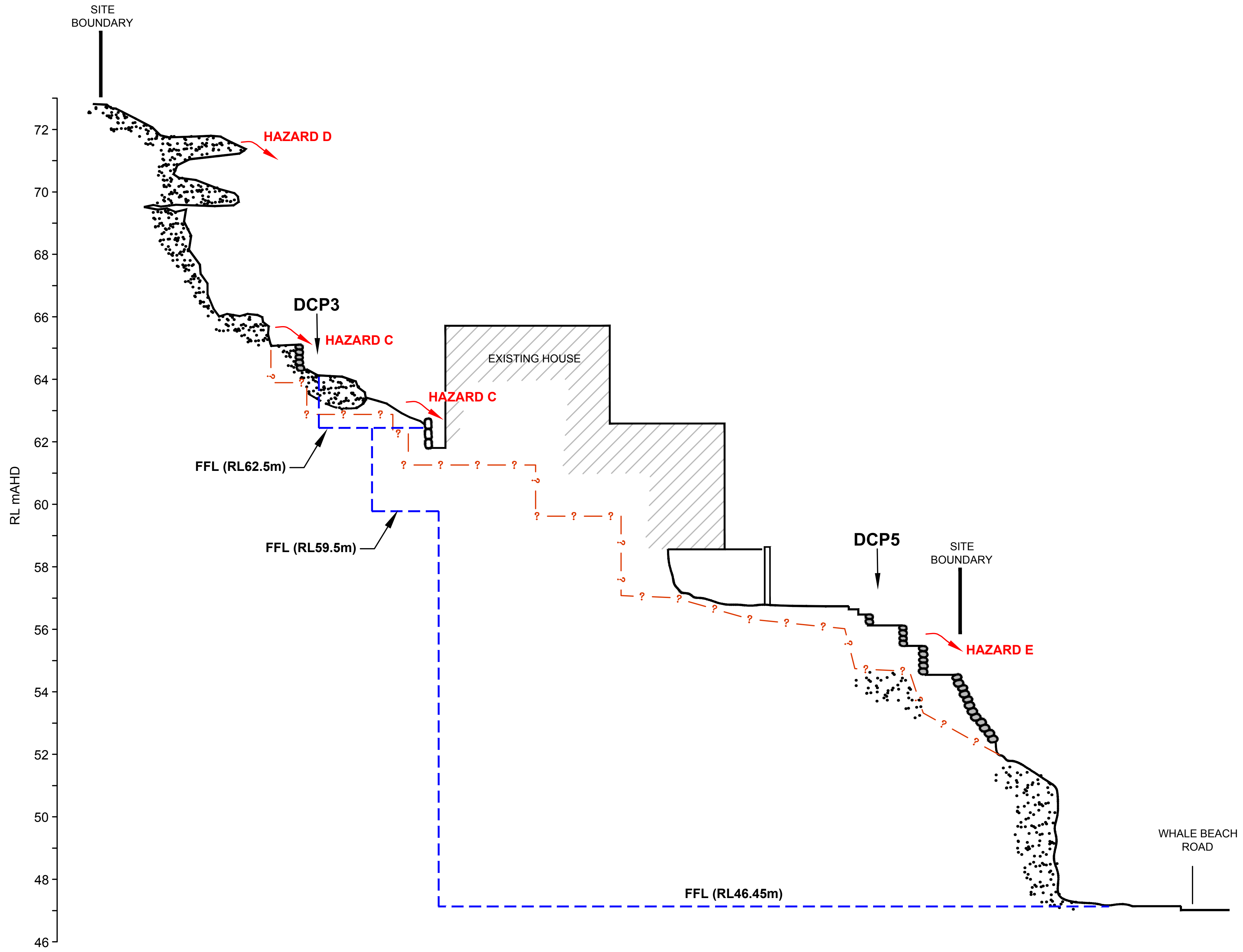
Location: 346-352 WHALE BEACH ROAD,
PALM BEACH, NSW

Report No: 31791SY

Figure No: 4

JKGeotechnics

PLOT DATE: 9/03/2021 4:03:30 PM DWG FILE: Y:\31000'S\31791SY WHALE BEACH\CAD\31791SY.DWG



0 1.5 3 4.5 6 7.5

SCALE 1:150 @A3 METRES

This plan should be read in conjunction with the JK Geotechnics report.

Title:

SECTION B-B

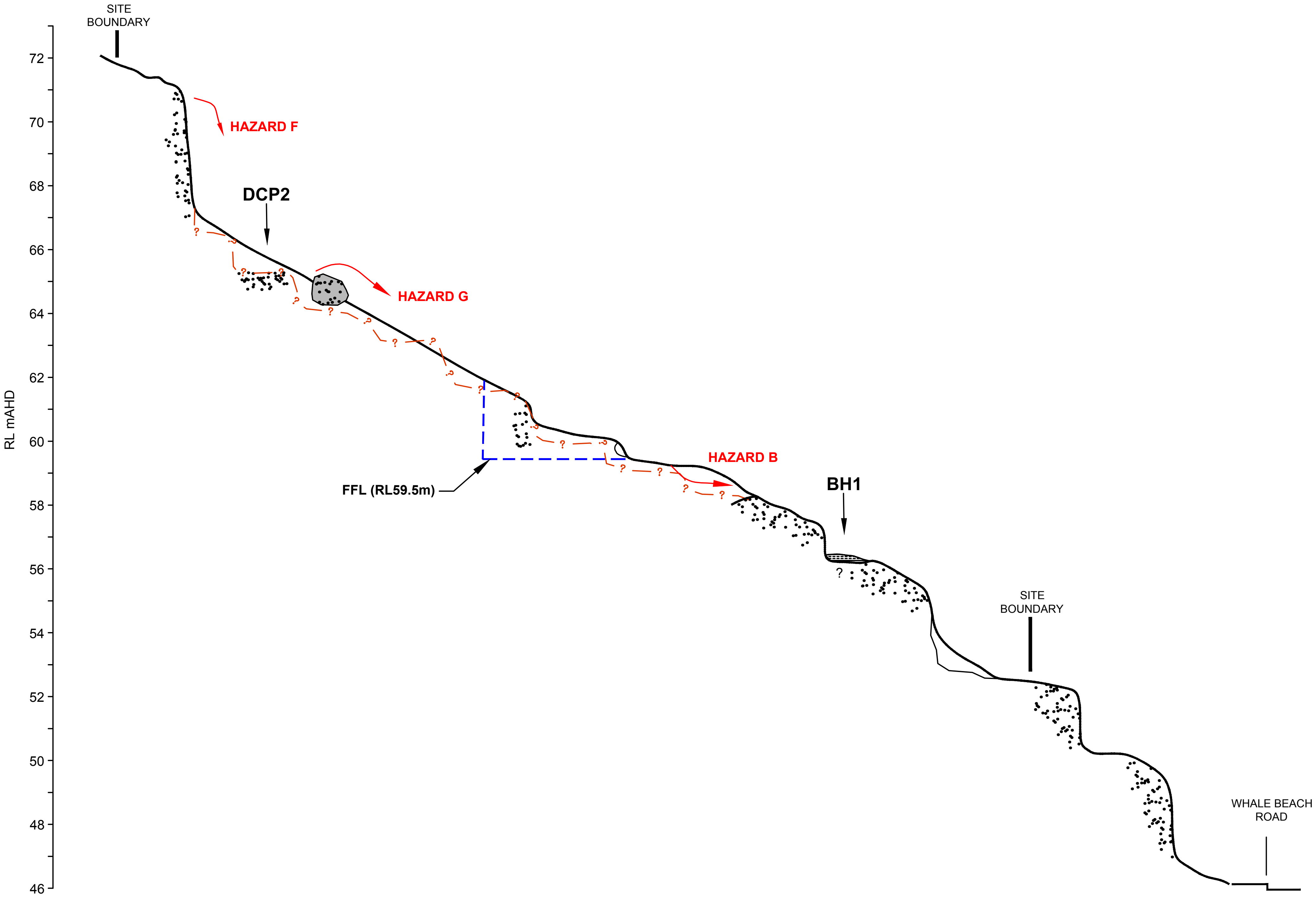
Location: 346-352 WHALE BEACH ROAD,
PALM BEACH, NSW

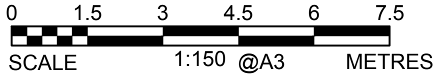
Report No: 31791SY

Figure No: 5

JKGeotechnics

PLOT DATE: 9/03/2021 4:03:39 PM DWG FILE: Y:\31000'S\31791SY WHALE BEACH\CAD\31791SY.DWG





This plan should be read in conjunction with the JK Geotechnics report.

Title:

SECTION C-C

Location: 346-352 WHALE BEACH ROAD,
PALM BEACH, NSW

Report No: 31791SY

Figure No: 6

JKGeotechnics

TOPOGRAPHY

Symbol *Ground Profile*

convex
concave
} well defined or angular break of slope

convex
concave
} poorly defined or smooth change of slope

breaks of slope
changes of slope
} convex and concave too close together to allow the use of separate symbols

sharp
rounded
} ridge crest

Cliff or escarpment or sharp break 40° or more (estimated height in metres)
3

15 Uniform Slope
10 Concave Slope
8 Convex Slope
} Slope direction and angle (Degrees)

Top
Bottom
} Cut or fill slope, arrows pointing down slope

Hummocky or irregular ground

OTHER FEATURES

Boulder

Seepage/spring

Swallow hole for runoff

Natural water course

Open drain, unlined

Open drain, lined

Fenceline

Property boundary

Dry Stone Wall

J ——— J Major joint in rock face
200 (opening in millimetres)

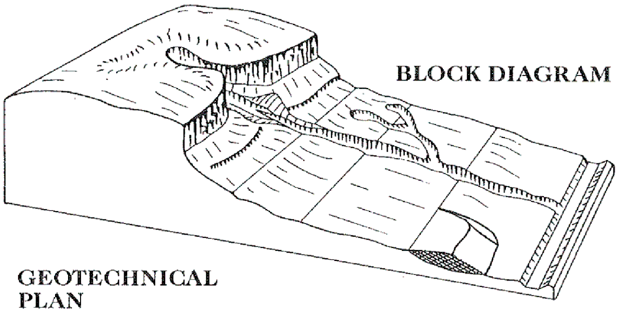
– T – T – Tension crack
10 (opening in millimetres)

Masonry or concrete wall

Ponding water

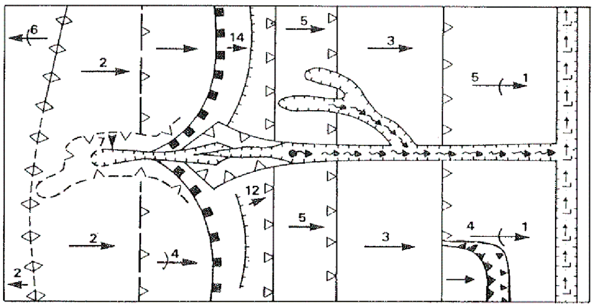
Boggy or swampy area

EXAMPLE OF USE OF TOPOGRAPHIC SYMBOLS:



BLOCK DIAGRAM

GEOTECHNICAL PLAN



(After Gardiner, V & Dackombe, R. V. (1983), Geomorphological Field Manual; George Allen & Unwin).

PLOT DATE: 9/03/2021 4:04:00 PM DWG FILE: Y:\31000'S\31791SY WHALE BEACH\CAD\31791SY.DWG

This plan should be read in conjunction with the JK Geotechnics report.

Title: **GEOTECHNICAL MAPPING SYMBOLS**

Location: 346-352 WHALE BEACH ROAD,
PALM BEACH, NSW

Report No: 31791SY

Figure No: 7

JKGeotechnics

APPENDIX A

LANDSLIDE RISK MANAGEMENT TERMINOLOGY

LANDSLIDE RISK MANAGEMENT

Definition of Terms and Landslide Risk

Risk Terminology	Description
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.
Annual Exceedance Probability (AEP)	The estimated probability that an event of specified magnitude will be exceeded in any year.
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.
Elements at Risk	The population, buildings and engineering works, economic activities, public services utilities, infrastructure and environmental features in the area potentially affected by landslides.
Frequency	A measure of likelihood expressed as the number of occurrences of an event in a given time. See also 'Likelihood' and 'Probability'.
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.
Individual Risk to Life	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.
Landslide Activity	The stage of development of a landslide; pre failure when the slope is strained throughout but is essentially intact; failure characterised by the formation of a continuous surface of rupture; post failure which includes movement from just after failure to when it essentially stops; and reactivation when the slope slides along one or several pre-existing surfaces of rupture. Reactivation may be occasional (eg. seasonal) or continuous (in which case the slide is 'active').
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, or kinetic energy per unit area.
Landslide Risk	The AGS Australian GeoGuide LR7 (AGS, 2007e) should be referred to for an explanation of Landslide Risk.
Landslide Susceptibility	The classification, and volume (or area) of landslides which exist or potentially may occur in an area or may travel or retrogress onto it. Susceptibility may also include a description of the velocity and intensity of the existing or potential landsliding.
Likelihood	Used as a qualitative description of probability or frequency.
Probability	A measure of the degree of certainty. This measure has a value between zero (impossibility) and 1.0 (certainty). It is an estimate of the likelihood of the magnitude of the uncertain quantity, or the likelihood of the occurrence of the uncertain future event. These are two main interpretations: (i) Statistical – frequency or fraction – The outcome of a repetitive experiment of some kind like flipping coins. It includes also the idea of population variability. Such a number is called an 'objective' or relative frequentist probability because it exists in the real world and is in principle measurable by doing the experiment.

Risk Terminology	Description
Probability *(continued)*	(ii) Subjective probability (degree of belief) – Quantified measure of belief, judgment, or confidence in the likelihood of an outcome, obtained by considering all available information honestly, fairly, and with a minimum of bias. Subjective probability is affected by the state of understanding of a process, judgment regarding an evaluation, or the quality and quantity of information. It may change over time as the state of knowledge changes.
Qualitative Risk Analysis	An analysis which uses word form, descriptive or numeric rating scales to describe the magnitude of potential consequences and the likelihood that those consequences will occur.
Quantitative Risk Analysis	An analysis based on numerical values of the probability, vulnerability and consequences and resulting in a numerical value of the risk.
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.
Risk Analysis	The use of available information to estimate the risk to individual, population, property, or the environment, from hazards. Risk analyses generally contain the following steps: scope definition, hazard identification and risk estimation.
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 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 judgments 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 Management	The complete process of risk assessment and risk control (or risk treatment).
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.
Susceptibility	See 'Landslide Susceptibility'.
Temporal Spatial Probability	The probability that the element at risk is in the area affected by the landsliding, at the time of the landslide.
Tolerable Risk	A risk within a range that society can live with so as to secure certain net benefits. It is a range of risk regarded as non-negligible and needing to be kept under review and reduced further if possible.
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.

NOTE: Reference should be made to Figure A1 which shows the inter-relationship of many of these terms and the relevant portion of Landslide Risk Management.

Reference should also be made to the paper referenced below for Landslide Terminology and more detailed discussion of the above terminology.

This appendix is an extract from PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT as presented in Australian Geomechanics, Vol 42, No 1, March 2007, which discusses the matter more fully.

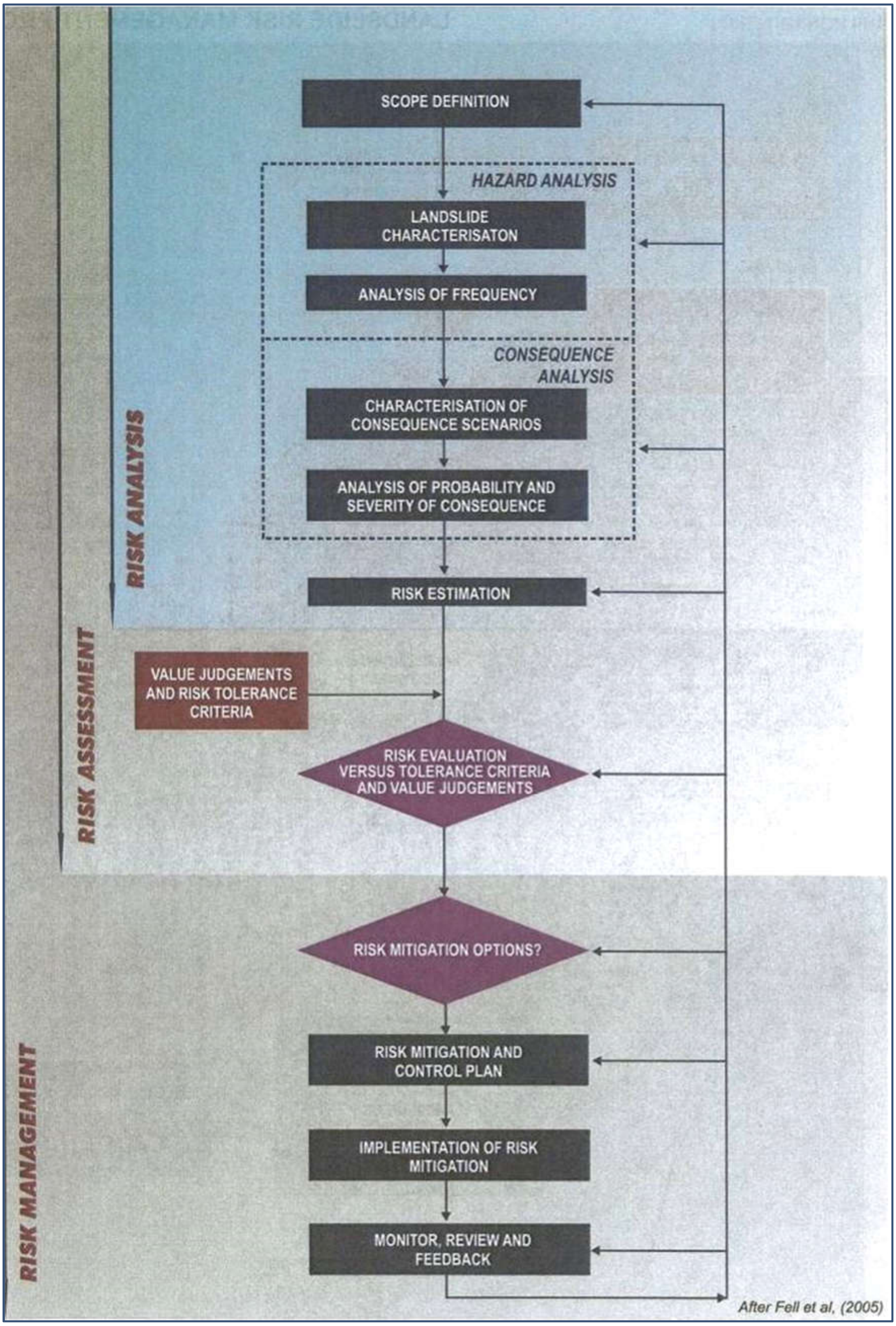


FIGURE A1: Flowchart for Landslide Risk Management.

This figure is an extract from GUIDELINE FOR LANDSLIDE SUSCEPTIBILITY, HAZARD AND RISK ZONING FOR LAND USE PLANNING, as presented in Australian Geomechanics Vol 42, No 1, March 2007, which discusses the matter more fully.

TABLE A1: LANDSLIDE RISK ASSESSMENT
QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

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

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

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

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

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

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

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

Extract from PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT as presented in Australian Geomechanics, Vol 42, No 1, March 2007, which discusses the matter more fully.

TABLE A1: LANDSLIDE RISK ASSESSMENT
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) 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.

Extract from PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT as presented in Australian Geomechanics, Vol 42, No 1, March 2007, which discusses the matter more fully.

AUSTRALIAN GEOGUIDE LR2 (LANDSLIDES)

What is a Landslide?

Any movement of a mass of rock, debris, or earth, down a slope, constitutes a “landslide”. Landslides take many forms, some of which are illustrated. More information can be obtained from Geoscience Australia, or by visiting its Australian landslide Database at www.ga.gov.au/urban/factsheets/landslide.jsp. Aspects of the impact of landslides on buildings are dealt with in the book “Guideline Document Landslide Hazards” published by the Australian Building Codes Board and referenced in the Building Code of Australia. This document can be purchased over the internet at the Australian Building Codes Board’s website www.abcb.gov.au.

Landslides vary in size. They can be small and localised or very large, sometimes extending for kilometres and involving millions of tonnes of soil or rock. It is important to realise that even a 1 cubic metre boulder of soil, or rock, weighs at least 2 tonnes. If it falls, or slides, it is large enough to kill a person, crush a car, or cause serious structural damage to a house. The material in a landslide may travel downhill well beyond the point where the failure first occurred, leaving destruction in its wake. It may also leave an unstable slope in the ground behind it, which has the potential to fall again, causing the landslide to extend (regress) uphill, or expand sideways. For all these reasons, both “potential” and “actual” landslides must be taken very seriously. The present a real threat to life and property and require proper management.

Identification of landslide risk is a complex task and must be undertaken by a geotechnical practitioner (GeoGuide LR1) with specialist experience in slope stability assessment and slope stabilisation.

What Causes a Landslide?

Landslides occur as a result of local geological and groundwater conditions, but can be exacerbated by inappropriate development (GeoGuide LR8), exceptional weather, earthquakes and other factors. Some slopes and cliffs never seem to change, but are actually on the verge of failing. Others, often moderate slopes (Table 1), move continuously, but so slowly that it is not apparent to a casual observer. In both cases, small changes in conditions can trigger a landslide with series consequences. Wetting up of the ground (which may involve a rise in groundwater table) is the single most important cause of landslides (GeoGuide LR5). This is why they often occur during, or soon after, heavy rain. Inappropriate development often results in small scale landslides which are very expensive in human terms because of the proximity of housing and people.

Does a Landslide Affect You?

Any slope, cliff, cutting, or fill embankment may be a hazard which has the potential to impact on people, property, roads and services. Some tell-tale signs that might indicate that a landslide is occurring are listed below:

- Open cracks, or steps, along contours
- Groundwater seepage, or springs
- Bulging in the lower part of the slope
- Hummocky ground
- trees leaning down slope, or with exposed roots
- debris/fallen rocks at the foot of a cliff
- tilted power poles, or fences
- cracked or distorted structures

These indications of instability may be seen on almost any slope and are not necessarily confined to the steeper ones (Table 1). Advice should be sought from a geotechnical practitioner if any of them are observed. Landslides do not respect property boundaries. As mentioned above they can “run-out” from above, “regress” from below, or expand sideways, so a landslide hazard affecting your property may actually exist on someone else’s land.

Local councils are usually aware of slope instability problems within their jurisdiction and often have specific development and maintenance requirements. **Your local council is the first place to make enquiries if you are responsible for any sort of development or own or occupy property on or near sloping land or a cliff.**

TABLE 1 – Slope Descriptions

Appearance	Slope Angle	Maximum Gradient	Slope Characteristics
Gentle	0° - 10°	1 on 6	Easy walking.
Moderate	10° - 18°	1 on 3	Walkable. Can drive and manoeuvre a car on driveway.
Steep	18° - 27°	1 on 2	Walkable with effort. Possible to drive straight up or down roughened concrete driveway, but cannot practically manoeuvre a car.
Very Steep	27° - 45°	1 on 1	Can only climb slope by clutching at vegetation, rocks, etc.
Extreme	45° - 64°	1 on 0.5	Need rope access to climb slope.
Cliff	64° - 84°	1 on 0.1	Appears vertical. Can abseil down.
Vertical or Overhang	84° - 90±°	Infinite	Appears to overhang. Abseiler likely to lose contact with the face.

Some typical landslides which could affect residential housing are illustrated below:

Rotational or circular slip failures (Figure 1) - can occur on moderate to very steep soil and weathered rock slopes (Table 1). The sliding surface of the moving mass tends to be deep seated. Tension cracks may open at the top of the slope and bulging may occur at the toe. The ground may move in discrete "steps" separated by long periods without movement. More rapid movement may occur after heavy rain.

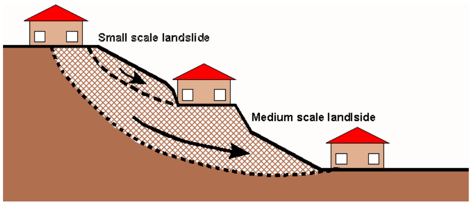


Figure 1

Translational slip failures (Figure 2) - tend to occur on moderate to very steep slopes (Table 1) where soil, or weak rock, overlies stronger strata. The sliding mass is often relatively shallow. It can move, or deform slowly (creep) over long periods of time. Extensive linear cracks and hummocks sometimes form along the contours. The sliding mass may accelerate after heavy rain.

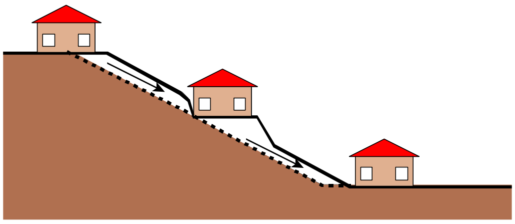


Figure 2

Wedge failures (Figure 3) - normally only occur on extreme slopes, or cliffs (Table 1), where discontinuities in the rock are inclined steeply downwards out of the face.

Rock falls (Figure 3) - tend to occur from cliffs and overhangs (Table 1).

Cliffs may remain, apparently unchanged, for hundreds of years. Collections of boulders at the foot of a cliff may indicate that rock falls are ongoing. Wedge failures and rock falls do not "creep". Familiarity with a particular local situation can instil a false sense of security since failure, when it occurs, is usually sudden and catastrophic.

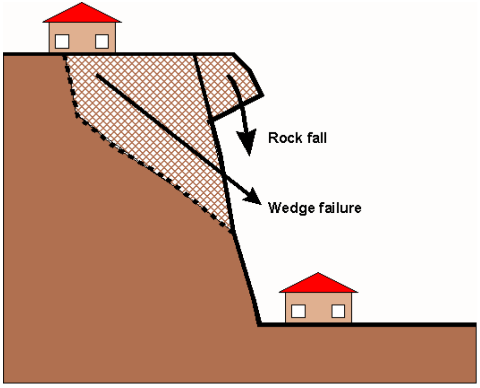


Figure 3

Debris flows and mud slides (Figure 4) - may occur in the foothills of ranges, where erosion has formed valleys which slope down to the plains below. The valley bottoms are often lined with loose eroded material (debris) which can "flow" if it becomes saturated during and after heavy rain. Debris flows are likely to occur with little warning; they travel a long way and often involve large volumes of soil. The consequences can be devastating.

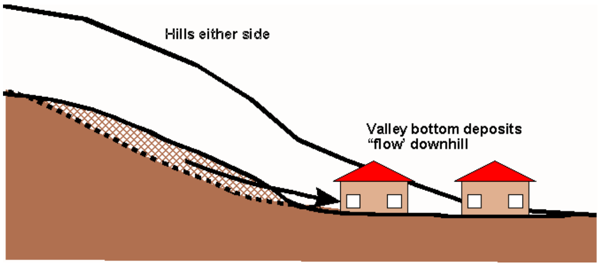


Figure 4

More information relevant to your particular situation may be found in other Australian GeoGuides:

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- GeoGuide LR4 - Rock Slopes
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AUSTRALIAN GEOGUIDE LR7 (LANDSLIDE RISK)

Concept of Risk

Risk is a familiar term, but what does it really mean? It can be defined as *"a measure of the probability and severity of an adverse effect to health, property, or the environment."* This definition may seem a bit complicated. In relation to landslides, geotechnical practitioners (see GeoGuide LR1) are required to assess risk in terms of the likelihood that a particular landslide will occur and the possible consequences. This is called landslide risk assessment. The consequences of a landslide are many and varied, but our concerns normally focus on loss of, or damage to, property and loss of life.

Landslide Risk Assessment

Some local councils in Australia are aware of the potential for landslides within their jurisdiction and have responded by designating specific "landslide hazard zones". Development in these areas is normally covered by special regulations. If you are contemplating building, or buying an existing house, particularly in a hilly area, or near cliffs, then go first for information to your local council.

Landslide risk assessment must be undertaken by a geotechnical practitioner. It may involve visual inspection, geological mapping, geotechnical investigation and monitoring to identify:

- potential landslides (there may be more than one that could impact on your site);
- the likelihood that they will occur;
- the damage that could result;
- the cost of disruption and repairs; and
- the extent to which lives could be lost.

Risk assessment is a predictive exercise, but since the ground and the processes involved are complex, prediction tends to lack precision. If you commission a landslide risk assessment for a particular site you should expect to receive a report prepared in accordance with current professional guidelines and in a form that is acceptable to your local council, or planning authority.

Risk to Property

Table 1 indicates the terms used to describe risk to property. Each risk level depends on an assessment of how likely a landslide is to occur and its consequences in dollar terms. "Likelihood" is the chance of it happening in any one year, as indicated in Table 2. "Consequences" are related to the cost of the repairs and temporary loss of use if the landslide occurs. These two factors are combined by the geotechnical practitioner to determine the Qualitative Risk.

TABLE 2 – LIKELIHOOD

Likelihood	Annual Probability
Almost Certain	1:10
Likely	1:100
Possible	1:1,000
Unlikely	1:10,000
Rare	1:100,000
Barely credible	1:1,000,000

The terms "unacceptable", "may be tolerable" etc. in Table 1 indicate how most people react to an assessed risk level. However, some people will always be more prepared, or better able, to tolerate a higher risk level than others.

Some local councils and planning authorities stipulate a maximum tolerable risk level of risk to property for developments within their jurisdictions. In these situations the risk must be assessed by a geotechnical practitioner. If stabilisation works are needed to meet the stipulated requirements these will normally have to be carried out as part of the development, or consent will be withheld.

TABLE 1 – RISK TO PROPERTY

Qualitative Risk		Significance - Geotechnical engineering requirements
Very high	VH	**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 the value of the property.
High	H	**Unacceptable** without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to acceptable level. Work would cost a substantial sum in relation to the value of the property.
Moderate	M	**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 possible.
Low	L	**Usually acceptable** to regulators. Where treatment has been needed to reduce the risk to this level, ongoing maintenance is required.
Very Low	VL	**Acceptable**. Manage by normal slope maintenance procedures.

Risk to Life

Most of us have some difficulty grappling with the concept of risk and deciding whether, or not, we are prepared to accept it. However, without doing any sort of analysis, or commissioning a report from an "expert", we all take risks every day. One of them is the risk of being killed in an accident. This is worth thinking about, because it tells us a lot about ourselves and can help to put an assessed risk into a meaningful context. By identifying activities that we either are, or are not, prepared to engage in, we can get some indication of the maximum level of risk that we are prepared to take. This knowledge can help us to decide whether we really are able to accept a particular risk, or to tolerate a particular likelihood of loss, or damage, to our property (Table 2).

In Table 3, data from NSW for the years 1998 to 2002, and other sources, is presented. A risk of 1 in 100,000 means that, in any one year, 1 person is killed for every 100,000 people undertaking that particular activity. The NSW data assumes that the whole population undertakes the activity. That is, we are all at risk of being killed in a fire, or of choking on our food, but it is reasonable to assume that only people who go deep sea fishing run a risk of being killed while doing it.

It can be seen that the risks of dying as a result of falling, using a motor vehicle, or engaging in water-related activities (including bathing) are all greater than 1:100,000 and yet few people actively avoid situations where these risks are present. Some people are averse to flying and yet it represents a lower risk than choking to death on food. The data also indicate that, even when the risk of dying as a consequence of a particular event is very small, it could still happen to any one of us today. If this were not so, there would be no risk at all and clearly that is not the case.

In NSW, the planning authorities consider that 1:1,000,000 is the maximum tolerable risk for domestic housing built near an obvious hazard, such as a chemical factory. Although not specifically considered in the NSW guidelines there is little difference between the hazard presented by a neighbouring factory and a landslide: both have the capacity to destroy life and property and both are always present.

TABLE 3 – RISK TO LIFE

Risk (deaths per participant per year)	**Activity/Event Leading to Death** (NSW data unless noted)
1:1,000	Deep sea fishing (UK)
1:1,000 to 1:10,000	Motor cycling, horse riding, ultra-light flying (Canada)
1:23,000	Motor vehicle use
1:30,000	Fall
1:70,000	Drowning
1:180,000	Fire/burn
1:660,000	Choking on food
1:1,000,000	Scheduled airlines (Canada)
1:2,300,000	Train travel
1:32,000,000	Lightning strike

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APPENDIX B

SOME GUIDELINES
FOR
HILLSIDE CONSTRUCTION

SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

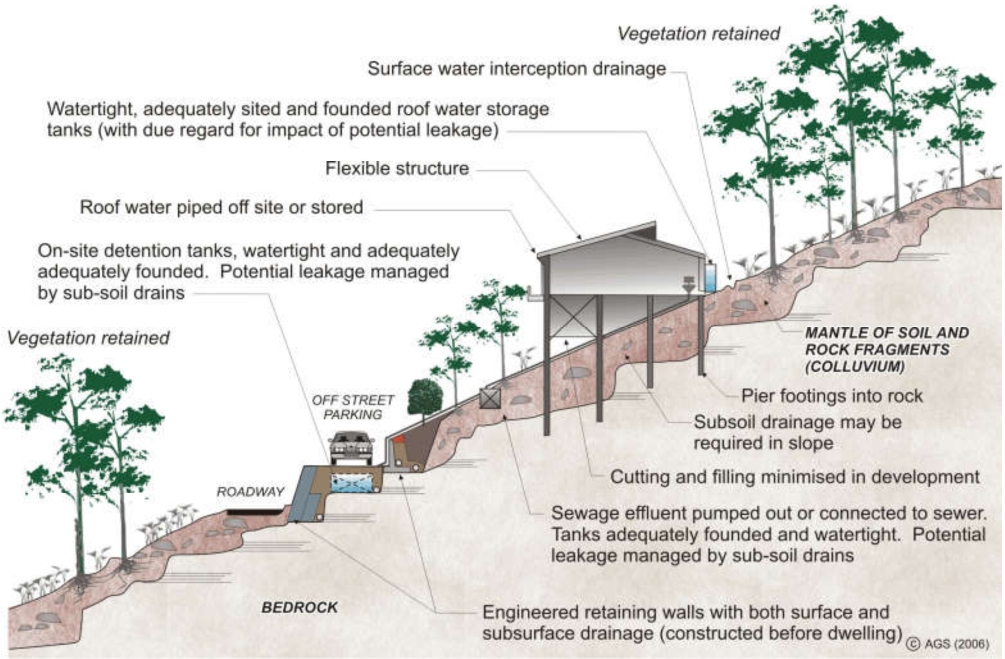
	GOOD ENGINEERING PRACTICE	POOR ENGINEERING PRACTICE
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical consultant at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
PLANNING		
SITE PLANNING	Having 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.	Indiscriminant 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 properties 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 bedrock 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 bedrock 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 generous 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 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 of roof run-off 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 of 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 a 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 seek advice. If seepage observed, determine cause or seek advice on consequences.	

This table is extracted from PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT as presented in *Australian Geomechanics*, Vol 42, No 1, March 2007 which discusses the matter more fully.

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

Sensible development practices are required when building on hillsides, particularly if the hillside has more than a low risk of instability (GeoGuide LR7). Only building techniques intended to maintain, or reduce, the overall level of landslide risk should be considered. Examples of good hillside construction practice are illustrated below.

EXAMPLES FOR GOOD HILLSIDE CONSTRUCTION PRACTICE



WHY ARE THESE PRACTICES GOOD?

Roadways and parking areas - are paved and incorporate kerbs which prevent water discharging straight into the hillside (GeoGuide LR5).

Cuttings - are supported by retaining walls (GeoGuide LR6).

Retaining walls - are engineer designed to withstand the lateral earth pressures and surcharges expected, and include drains to prevent water pressures developing in the backfill. Where the ground slopes steeply down towards the high side of a retaining wall, the disturbing force (see GeoGuide LR6) can be two or more times that due to level ground. Retaining walls must be designed taking these forces into account.

Sewage - whether treated or not is either taken away in pipes or contained in properly founded tanks so it cannot soak into the ground.

Surface water - from roofs and other hard surfaces is piped away to a suitable discharge point rather than being allowed to infiltrate into the ground. Preferably, the discharge point will be in a natural creek where ground water exits, rather than enters, the ground. Shallow, lined, drains on the surface can fulfill the same purpose (GeoGuide LR5).

Surface loads - are minimised. No fill embankments have been built. The house is a lightweight structure. Foundation loads have been taken down below the level at which a landslide is likely to occur and, preferably, to rock. This sort of construction is probably not applicable to soil slopes (GeoGuide LR3). If you are uncertain whether your site has rock near the surface, or is essentially a soil slope, you should engage a geotechnical practitioner to find out.

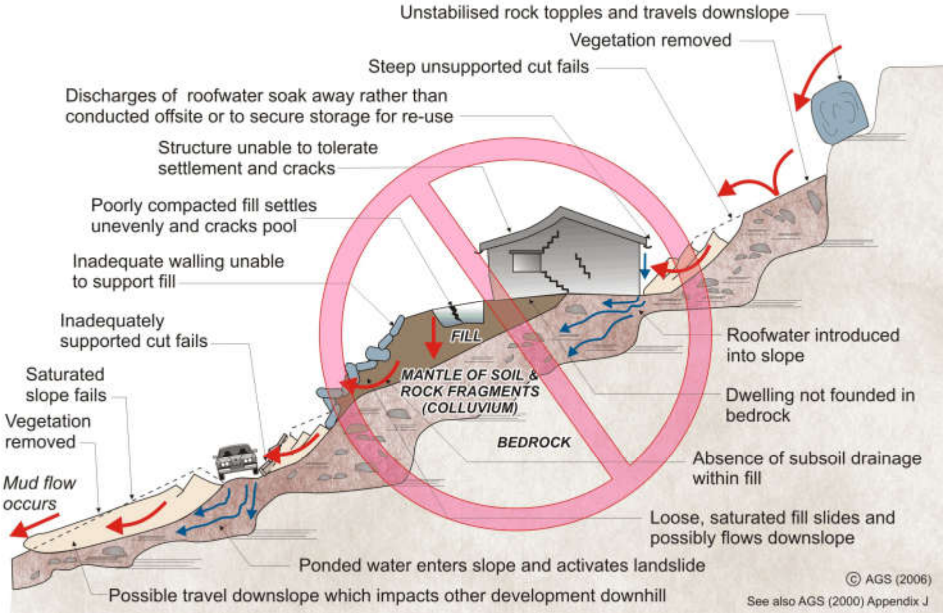
Flexible structures - have been used because they can tolerate a certain amount of movement with minimal signs of distress and maintain their functionality.

Vegetation clearance - on soil slopes has been kept to a reasonable minimum. Trees, and to a lesser extent smaller vegetation, take large quantities of water out of the ground every day. This lowers the ground water table, which in turn helps to maintain the stability of the slope. Large scale clearing can result in a rise in water table with a consequent increase in the likelihood of a landslide (GeoGuide LR5). An exception may have to be made to this rule on steep rock slopes where trees have little effect on the water table, but their roots pose a landslide hazard by dislodging boulders.

Possible effects of ignoring good construction practices are illustrated on page 2. Unfortunately, these poor construction practices are not as unusual as you might think and are often chosen because, on the face of it, they will save the developer, or owner, money. You should not lose sight of the fact that the cost and anguish associated with any one of the disasters illustrated, is likely to more than wipe out any apparent savings at the outset.

ADOPT GOOD PRACTICE ON HILLSIDE SITES

EXAMPLES FOR **POOR** HILLSIDE CONSTRUCTION PRACTICE



WHY ARE THESE PRACTICES POOR?

Roadways and parking areas - are unsurfaced and lack proper table drains (gutters) causing surface water to pond and soaks into the ground.

Cut and fill - has been used to balance earthworks quantities and level the site leaving unstable cut faces and added large surface loads to the ground. Failure to compact the fill properly has led to settlement, which will probably continue for several years after completion. The house and pool have been built on the fill and have settled with it and cracked. Leakage from the cracked pool and the applied surface loads from the fill have combined to cause landslides.

Retaining walls - have been avoided, to minimise cost, and hand placed rock walls used instead. Without applying engineering design principles, the walls have failed to provide the required support to the ground and have failed, creating a very dangerous situation.

A heavy, rigid, house - has been built on shallow, conventional, footings. Not only has the brickwork cracked because of the resulting ground movements, but it has also become involved in a man-made landslide.

Soak-away drainage - has been used for sewage and surface water run-off from roofs and pavements. This water soaks into the ground and raises the water table (GeoGuide LR5). Subsoil drains that run along the contours should be avoided for the same reason. If felt necessary, subsoil drains should run steeply downhill in a chevron, or herringbone, pattern. This may conflict with the requirements for effluent and surface water disposal (GeoGuide LR9) and if so, you will need to seek professional advice.

Rock debris - from landslides higher up on the slope seems likely to pass through the site. Such locations are often referred to by geotechnical practitioners as "debris flow paths". Rock is normally even denser than ordinary fill, so even quite modest boulders are likely to weigh many tonnes and do a lot of damage once they start to roll. Boulders have been known to travel hundreds of metres downhill leaving behind a trail of destruction.

Vegetation - has been completely cleared, leading to a possible rise in the water table and increased landslide risk (GeoGuide LR5).

DON'T CUT CORNERS ON HILLSIDE SITES - OBTAIN ADVICE FROM A GEOTECHNICAL PRACTITIONER

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