

GEOTECHNICAL REPORT

for

PROPOSED ALTERATIONS AND ADDITIONS

at

CURRAWONG BEACH CABINS, CURRAWONG NSW

Prepared For

Northern Beaches Council

Project No.: 2017-084.3

November, 2018

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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 ____ Currawong Beach Cabins, Currawong, NSW _____	

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

Geotechnical Report Details:

Report Title: Proposed Alterations and Additions, Currawong Beach Cabins, Currawong, NSW	Project No.: 2017-084.3
Report Date: 16 th November 2018	Author: T. Crozier
Author's Company/Organisation: Crozier Geotechnical Consultants	

Please mark appropriate box

- Comprehensive site mapping conducted ____ 18th October 2018 ____
(date)
- Mapping details presented on contoured site plan with geomorphic mapping to a minimum scale of 1:200 (as appropriate)
- Subsurface investigation required
 - No Justification Minimal new footings or excavation proposed.....
 - 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.
- Design Life Adopted:
 - 100 years
 - Other50 years.....
specify
- Geotechnical Conditions to be applied to all four phases as described in the Geotechnical Risk Management Policy for Pittwater - 2009 have been specified
- Additional action to remove risk where reasonable and practical have been identified and included in the report.
- Risk assessment within Bushfire Asset Protection Zone.

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

Signature

Name ... **Troy Crozier**

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

Membership No. ... **10197**

Company... **Crozier Geotechnical Consultants**



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**GEOTECHNICAL REPORT FOR PROPOSED ALTERATIONS & ADDITIONS
CURRAWONG BEACH CABINS, CURRAWONG, NSW.**

1. INTRODUCTION:

This report details the results of a geotechnical assessment carried out for proposed alterations and additions to six of the existing cabins at Currawong Beach, NSW. The assessment was undertaken by Crozier Geotechnical Consultants (CGC) at the request of Northern Beaches Council.

Currawong Beach is situated on the western side of Pittwater waterway and contains several amenities buildings and numerous small timber cabins. Three cabins at the southern end of the beach named Kookaburra, Goanna and Blue Tongue were previously assessed for Development Applications for proposed for alterations and additions (Report No. 2017-084, Dated: 25th May 2017).

This report relates to the proposed alterations for the remaining six cabins located at the northern end of the site: Platypus, Magpie, Lorikeet, Wallaby, Possum and Echidna.

It is understood that the works involve modernisation of all six cabins and also the following works:

- Platypus Cabin
 - construct a new suspended deck at southern end of cabin
 - construct a new bathroom to the rear western side of the cabin
 - place a new water tank to rear western side of cabin
 - internal alterations and modifications

- Magpie, Lorikeet, Wallaby, Possum and Echidna cabins
 - construct a new outdoor terrace area with firepit to rear of cabins
 - construct a new bathroom extension to the western side of the cabin with paved access
 - construct a new bathroom to the north-west corner of the cabin
 - extend existing raised decks slightly to east
 - internal alterations and modifications

The proposed works for require no bulk excavation and only some minor new footings and pavements.

Reference to Pittwater Council LEP 2014 Geotechnical Risk Management Map (GTH_008 and 009), the site has been classified as being within the H1 (highest category) landslip hazard zone therefore the site requires a Geotechnical Landslip Risk Assessment to be conducted as part of any Development Application.

This report therefore includes a detailed description of the field work, assessment of proposed works, site specific risk assessment and recommendations for construction.

The investigation comprised:

- a) A detailed geotechnical inspection and mapping of the site and adjacent properties by a Principal Engineering Geologist.
- b) Review of Ortho Photomaps and Aerial Photography of the site.

The following plans and diagrams were supplied for the work;

- Design Plans by Northern Beaches Council, Drawing No.: DA02, EX01, EX02, SK01, SK02, Issue No.: B, Dated: August 2018

2. SITE FEATURES:

2.1. Description:

The site is a large area of land located on the western side of the Pittwater waterway. It comprises a sandy beach which extends between two steep sided ridge lines that terminate at the shore. The southern ridge forms a large circular structure that progressively turns from east dipping at the shore to north dipping as it curves inland to the west. The area between the ridges is near level to gently sloping and undulating with grass cover and numerous sparse trees. Along the south to west sides, the ground surface becomes steep (>18°) and rises up towards large (>10m high) sandstone bedrock cliff outcrops at the crest of the southern ridge.

Cabins and amenities buildings are located partially up the base of the southern ridge. The cabins are located at the northern end of the development rising up along a gently south to east dipping terrace that rises along the mid-slope level of the ridge. The cabins appear to be old (>50 years) timber structures supported off brick and sandstone block footings.

2.2. Geology:

Reference to the Sydney 1: 100,000 Geological Series sheet (9130) indicates that the site is underlain by Newport Formation (Rnn) of the Upper Narrabeen Group. Newport Formation (Upper Narrabeen Group) is of middle Triassic Age and typically comprises interbedded laminite, shale and quartz to lithic quartz sandstones and pink clay pellet sandstones. Hawkesbury Sandstone (Rh) which overlies the Narrabeen Group is located to the west of the site whilst Quaternary age sediments (Qha and Qhb) are located within the valley floor and beach. These sediments consist of modern marine and estuarine beach deposits which consist of coarse quartz sand with varying amounts of shell fragments.

It is considered that the cabins are entirely underlain by the Narrabeen Group rocks, which are dominated by shales and thin siltstone/sandstone beds and often form rounded convex ridge tops with moderate angle (<20°) side slopes. These side slopes can be either concave or convex depending on geology, internally they comprise interbedded shale and siltstone beds with close spaced bedding partings that have either close spaced vertical joints or in extreme cases large space convex joints. The Narrabeen Group rocks often weather to create deep residual soil profiles with thin silty colluvial cover containing small to large sandstone boulders eroded from the overlying Hawkesbury Sandstone.

3. FIELD WORK:

3.1. Methods:

The field investigation comprised a walk over inspection and mapping of the site and adjacent properties on the 18th October 2018 by a Principal Engineering Geologist. It included a photographic record of the site conditions as well as geological/geomorphological mapping of the site and adjacent land with examination of soil slopes, vegetation, cliff outcrops and existing structures.

3.2. Field Observations:

The cabins are all formed as timber and weatherboard sheet structures supported off rendered brick columns to interpreted brick pad footings founded at shallow depth. The structures vary up to approximately 1.20m above ground surface levels and are all formed along the western edge of a gently south-east dipping terrace that rises up from the site entry towards the north-west. Platypus Cabin is located at the southern end of the listed cabins with Echidna located at the northern end, see photographs below. All cabins show deterioration due to age however there were no indications of significant foundation movement.



Platypus



Magpie



Lorrieket



Wallaby



Possum



Echidna

To the front of the cabins the grass covered terrace extends variable distances between approximately 7m and 10m to the east/north-east of the cabins with a change in gradient to a moderate (average 15 deg) east to north-east dipping soil slope which drops down to the near level valley floor. The slope is covered in grass and low bushes along with medium to large trees and scattered partially buried sandstone boulders.



Terrace edge and slope to east of cabins

To the rear of the cabins is the base of another moderate (15 ó 19 deg) natural slope that rises up to the west approximately 50 to 70m to the base of a large cliff line. The soil slope is covered in low bushes and moderate density of medium to large trees with numerous small to large boulders partially buried across its surface.



Slope rising up from rear of cabins towards the west

At the crest of this soil slope is an approximately 10 to 15m high sub-vertical sandstone bedrock cliff line that is formed along north-west and south-west striking, planar, continuous joint defects. Above this section of cliff are further outcrops/cliffs that were inaccessible but appear to rise another 15 to 20m in elevation and are sub-vertical to steeply sloping outcrops of sandstone bedrock.



Lower sub-vertical joint defined cliff line and upper more variable cliff/outcrop partially viewed

In general the lower cliff line showed no signs of recent or apparent impending instability, however several overhangs have developed through weathering that will eventually become unstable whilst some boulders were noted at the crest of the upper cliff line.



Two identified overhangs through weathering and defects that appear of potential limited stability.

4. COMMENTS:

4.1. Geotechnical Assessment:

The inspection and assessment identified no obvious credible impending landslip hazards around the cabins. The cabins and moderate soil slopes adjacent show no signs of excess creep movement, erosion or recent instability and there were no boulders across the upper soil slopes that were considered unstable at present, though all will be slowly (expect < 10mm/year) creeping down hill.

There were no indicators of impending instability within the inspected portion of the cliff line however the two significant overhangs identified along with boulders or unseen overhangs from the upper section of cliff do present an ongoing hazard to the site. The failure of any of these sections will result in a rock fall/topple style failure with fragments of rock of variable size impacting the soil slope below and potentially travelling down slope towards the cabins.

Boulders that have likely come from the cliff line are located across the slopes to the west and east of the cabins, however the number of blocks generally reduces in volume and size to the east with long term creep movement likely to have contributed to some of these distal blocks as opposed to sudden failure mechanisms. Recent sudden instability has been documented (Bishop et.al 2014) for the cliff lines to the south of the site.

The majority of the cliff line to the west is inaccessible and would require specialized rope access or aerial photographic methods for a detailed assessment. It is recommended that further inspection with specific focus on the two identified overhangs detailed in this report be considered to allow better assessment of the potential risk levels and implementation of support measures as required.

The proposed works will involve modernizing of the existing cabins and construction of alterations and additions. The additions may require some very minor excavation for new footings and pavements however these works should not create any landslip instability.

4.2. Slope Stability & Risk Assessment:

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

- A. Debris slide/boulder roll due to collapse of overhang in cliff line to west
- B. Boulder roll due to re-mobilization of existing boulders within slope to west of cabins

The hazards have been assessed in accordance with the methods of the Australian Geomechanics Society (Landslide Risk Management, AGS Subcommittee, May 2002 and March 2007), see Tables: A and B, Appendix: 2. The Australian Geomechanics Society Qualitative Risk Analysis Matrix is enclosed in Appendix: 3 along with relevant AGS notes and figures. The frequency of failure was interpreted from existing site conditions and previous experience in these geological units.

Due to the position of overhangs at several locations across the cliff line above the cabins, along with the potential for unseen overhangs or boulders in the inaccessible portion, and the generally planar slope below resulting in highly variable run-out possibilities of any one collapse, the assessment has been based on instability occurring anywhere along the cliff line to the west of the cabins and impacting any one cabin. A more detailed phase of mapping across the cliff line using specialized access equipment along with computer analysis would be required to assess the risk levels to each individual cabin from each individual potential failure.

The **Risk to Life** from the hazards was estimated to be 0.446×10^{-6} for a single person, whilst the **Risk to Property** was considered to be ‘**Low to Very Low**’.

The site and surrounding slopes have been assessed as per the Council Geotechnical Risk Management Policy 2009. This assessment identified potential landslip hazards within the cliff to the west with the potential for unidentified hazards due to the very limited access to this part of the site. However, all identified and sensibly theoretical hazards were assessed to meet the ‘Acceptable’ risk management criteria for the design life of the development, taken as 50 years.

4.3. Design & Construction Recommendations:

Design and the construction recommendations are tabulated below:

4.3.1. New Footings:	
Site Classification as per AS2870 ó 2011 for new footing design	Class øø for footings in sandy clay residual soils. (potential for sand foundation ó Class A)
Type of Footing	Strip/pad or Pier
Sub-grade material and Maximum Allowable Bearing Capacity	Stiff sandy clay/Medium dense sand: 100kPa Very stiff sandy clay: 200kPa
Site sub-soil classification as per <i>Structural design actions AS1170.4 – 2007, Part 4: Earthquake actions in Australia</i>	C _e ó shallow soil site

Remarks:

All footings should be founded off soils of similar strength/density to prevent differential settlement.
All new footings must be inspected by an experienced geotechnical professional before concrete or steel are placed to verify their bearing capacity and the in-situ nature of the founding strata. This is mandatory to allow them to be certified at the end of the project

4.3.2. Drainage and Hydrogeology		
Groundwater Table or Seepage identified in Investigation		No
Excavation likely to intersect	Water Table	No
	Seepage	Minor (0.50 L/min)
Site Location and Topography		Mid-level of moderate natural slope
Impact of development on local hydrogeology		Negligible
Onsite Stormwater Disposal		Directly to Pittwater or via dispersion systems located preferably at base of slope within valley floor or upon moderate embankment to east of cabins.
Remarks:		
Trenches, as well as all new building gutters, down pipes and stormwater intercept trenches should be connected to a stormwater system designed by a Hydraulic Engineer.		

4.4. Conditions Relating to Design and Construction Monitoring:

If requested by Council to complete Form: 2b and Form 3 as part of construction, building and post-construction certificate requirements of the Councils Geotechnical Risk Management Policy 2009, it will be necessary for Crozier Geotechnical Consultants to:

1. Review and approve the structural drawings for compliance with the recommendations of this report
2. Inspect new footings and earthworks to confirm foundation conditions meet structural engineers design requirements.
3. Inspect the site upon completion of the construction to confirm no changes to slope stability as a result of the works and that the stormwater system has been suitably connected/upgraded.

Crozier Geotechnical Consultants will not sign Form: 3 of the policy for an occupation certificate if it has not reviewed structural designs and been called to site to undertake any required inspections.

4.5. Design Life of Structure:

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

- Stormwater, sewer and subsoil drainage systems,
- retaining walls and soil slope erosion and instability,
- maintenance of trees/vegetation on this and adjacent properties,

Man-made features should be designed and maintained for a design life consistent with surrounding structures (as per AS2870 ó 2011 (50 years)). In order to attain a 'Acceptable Risk Management Criteria' for a design life of 100 years as required by the Councils Risk Management Policy, it will be necessary for the property owner to adopt and implement a maintenance and inspection program. It is considered that the existing cabins will have a design life of 50 years from upgrade following the proposed works.

If a maintenance and inspection schedule are not implemented the 'Acceptable' risk management criteria for the design life of the development may not be attained. A recommended program is given in Table: 1 below and should also include the following guidelines.

- The conditions on the site don't change from those present at the time this report was prepared, except for the changes due to this development.
- There is no change to the property due to an extraordinary event external to this site, and the property is maintained in good order and in accordance with the guidelines set out in;
 - a) CSIRO sheet BTF 18
 - b) Australian Geomechanics 'Landslide Risk Management' Volume 42, March 2007.
 - c) AS 2870 ó 2011, Australian Standard for Residential Slabs and Footings

Where changes to site conditions are identified during the maintenance and inspection program, reference should be made to relevant professionals (e.g. structural engineer, geotechnical engineer or Council). It is assumed that Pittwater Council will control development within the site, carry out regular inspections and maintenance of the stormwater/sewerage systems and large trees adjacent to the site so as to ensure that stability conditions do not deteriorate with potential increase in risk level to the site.

Table 1: Recommended Maintenance and Inspection Program

Structure	Maintenance/ Inspection Item	Frequency
Stormwater drains.	Owner to inspect to ensure that the drains and pipes are free of debris & sediment build-up. Clear surface grates and litter.	Every year or following each major rainfall event
Large Trees on or adjacent to site	Arborist to check condition of trees and remove dead vegetation as required. Provide comment to geotechnical engineer where areas of dead vegetation occur.	Every five years
Cliff and Slope Stability	Geotechnical Engineer to inspect the slope and cliff line to west of cabins	Every ten years

5. CONCLUSION:

The inspection and assessment identified no obvious impending significant slope movement, excess surface stormwater flow, seepage or erosion within the areas of the existing cabins. The cliff line to the west does contain several identified overhangs and detached sections which will eventually fail from the cliff line, however none show impending collapse. The majority of the cliff is inaccessible to standard access therefore it is recommended that further assessment using either ropes or aerial methods be considered, especially for the two overhangs detailed in this report.

The site and surrounding slopes were assessed as per the Council Geotechnical Risk Management Policy 2009 and AGS Guidelines. The potential landslip hazards were considered to achieve the -Acceptable Risk Managementøcriteria of Councils Policy. This risk level does not rule out that instability will not occur and the large cliff line to the west of the site will continue to provide potential hazards due to natural ongoing erosion.

The proposed works considered to be relatively minor and do not involve any significant excavation or slope modification and therefore are considered suitable for the site. It is considered that the site will meet the -Acceptable Risk Managementøcriteria for the design life of the development provided the property is maintained as per the recommendations of this report.



Prepared by:

Troy Crozier

Principal Engineering Geologist

6.0. REFERENCES:

1. Australian Geomechanics Society 2007, "Landslide Risk Assessment and Management", Australian Geomechanics Journal Vol 42, No 1, March 2007.
2. Geotechnical Risk Management Policy for Pittwater, 2009.
3. Australian Geomechanics Society 2014, "Rock Fall Case Study: Hawkesbury Sandstone", Australian Geomechanics Journal Vol 49, No 1, March 20014, Daniel Bishop, Stephen Fityus, David Piccolo, Garry Mostyn.

Appendix 1

NOTES RELATING TO THIS REPORT

Introduction

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

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

Description and classification Methods

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

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

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

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

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

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

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

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

Sampling

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

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

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

Drilling Methods

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

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

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

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

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

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

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

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

Standard Penetration Tests

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

The test is carried out in a borehole by driving a 50mm diameter split sample tube under the impact of a 63kg hammer with a free fall of 760mm. It is normal for the tube to be driven in three successive 150mm increments and the 'N' value is taken

as the number of blows for the last 300mm. In dense sands, very hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

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

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

Cone Penetrometer Testing and Interpretation

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

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

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

The information provided on the plotted results comprises: -

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

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

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

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

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

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

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

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

Dynamic Penetrometers

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

Two relatively similar tests are used.

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

Laboratory Testing

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

Borehole Logs

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

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

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

D	Disturbed Sample	E	Environmental sample
B	Bulk Sample	PP	Pocket Penetrometer Test
U50	50mm Undisturbed Tube Sample	SPT	Standard Penetration Test
U63	63mm “ “ “ “ “		

Ground Water

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

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

Engineering Reports

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

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

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

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

Site Anomalies

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

Reproduction of Information for Contractual Purposes

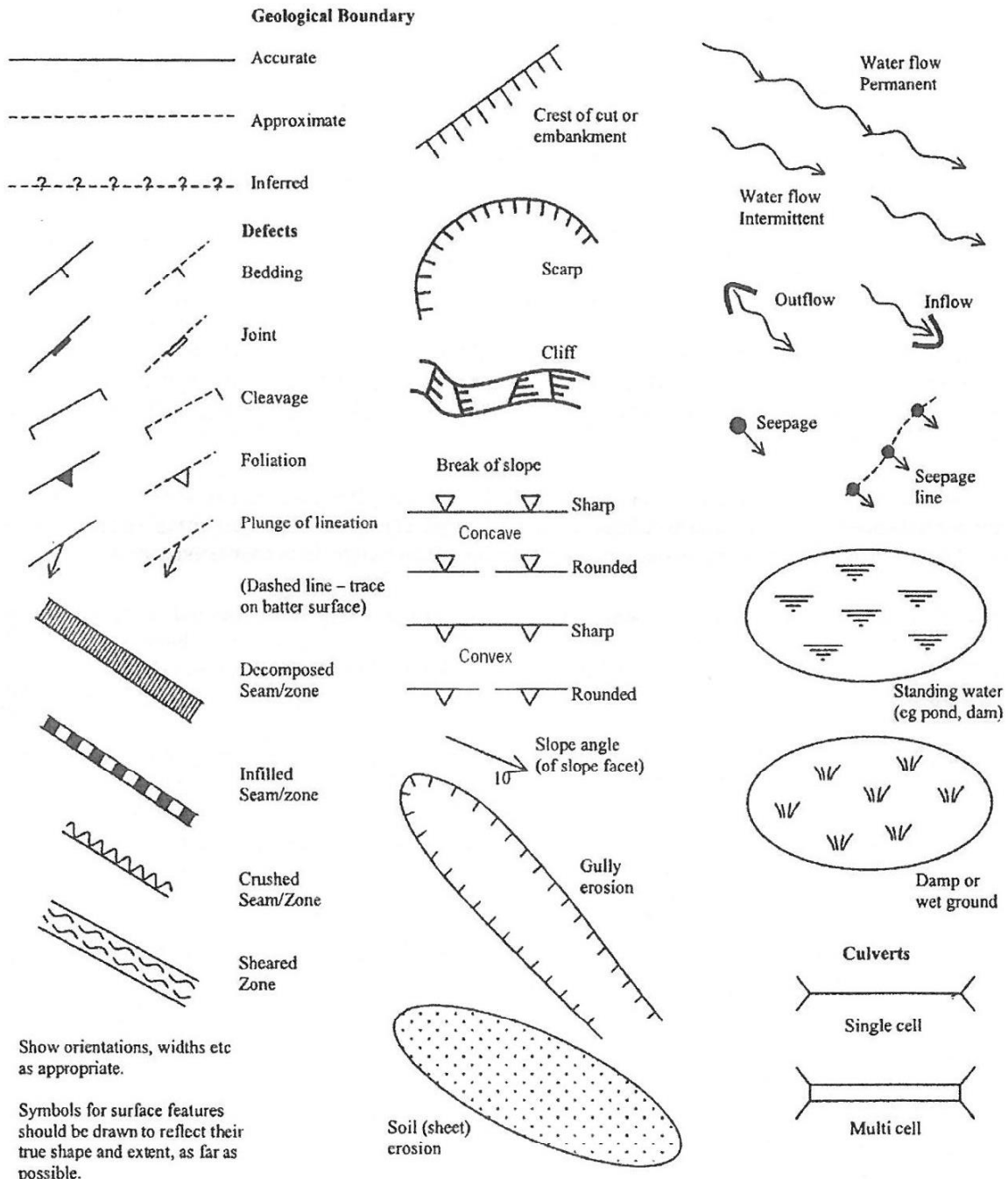
Attention is drawn to the document “Guidelines for the Provision of Geotechnical Information in Tender Documents”, published by the Institution of Engineers Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including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

Site Inspection

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

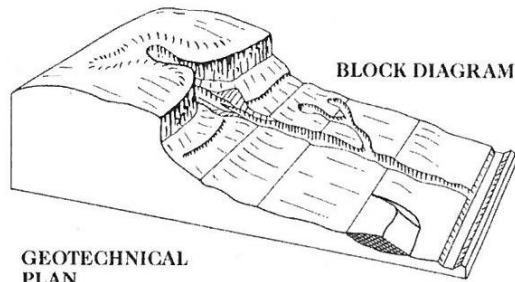
PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX E - GEOLOGICAL AND GEOMORPHOLOGICAL MAPPING SYMBOLS AND TERMINOLOGY

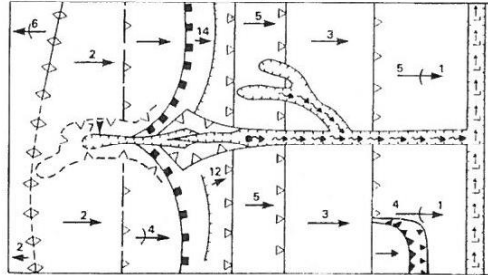


Examples of Mapping Symbols (after Guide to Slope Risk Analysis Version 3.1 November 2001, Roads and Traffic Authority of New South Wales).

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007



GEOTECHNICAL PLAN



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

Example of Mapping Symbols

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

Appendix 2

TABLE : A

Landslide risk assessment for Risk to life

HAZARD	Description	Impacting	Likelihood of Slide	Spatial Impact of Slide		Occupancy	Evacuation	Vulnerability	Risk to Life
A	Debris slide/boulder roll due to collapse of overhang in cliff line to west, assessed for boulder/s >1m ³		Several overhangs show significant weathering and are separated along defects.	a) cabins located approximately 70m down slope of cliff base, with moderate soil slope between. Numerous small to large boulders partially buried in slope above cabins already indicating previous failures have generally not travelled down slope significant distances, however some small to large boulders are also located down slope to east of cabins		a) Person in cabin 40hrs/week avge over year.	a) Likely to not evacuate	a) Person in building, collapse	
			Possible	Prob. of Impact	Impacted				
		a) Cabin	0.001	0.10	0.25	0.2381	0.75	1.0	4.46E-06
B	B. Boulder roll due to re-mobilization of existing boulders within slope to west of cabins		No boulders showing signs of impending sudden/large scale movement	a) cabins located at base of slope, boulder movement down sandy slope and impact cabin unlikely, may impact small portion of cabin		a) Person in cabin 40hrs/week avge over year.	a) Possible to not evacuate	a) Person in building, unlikely collapse however possible significant impact	
			Unlikely	Prob. of Impact	Impacted				
		a) Cabin	0.0001	0.05	0.10	0.2381	0.5	0.50	2.98E-08

* hazards considered in current condition and/or without remedial/stabilisation measures

* likelihood of occurrence for design life of 50 years

* Spatial Impact - Probability of Impact refers to slide impacting structure/area expressed as a % (1.00 = 100% probability of slide impacting area if it occurs), Impacted refers to % of area/structure impacted

* considered for person most at risk

* evacuation scale from Almost Certain to not evacuate (1.0), Likely (0.75), Possible (0.5), Unlikely (0.25), Rare to not evacuate (0.01). Based on likelihood of person knowing of landslide and completely evacuating area prior to landslide impact.

* vulnerability assessed using Appendix F - AGS Practice Note Guidelines for Landslide Risk Management 2007

TABLE : B

Landslide risk assessment for Risk to Property

HAZARD	Description	Impacting	Likelihood		Consequences		Risk to Property
A	Debris slide/boulder roll due to collapse of overhang in cliff line to west, assessed for boulder/s >1m ³	a) Cabin	Unlikely	The event might occur under very adverse circumstances over the design life.	Medium	Moderate damage to some of structure or significant part of site, requires large stabilising works or MINOR damage to neighbouring property.	Low
B	B. Boulder roll due to re-mobilization of existing boulders within slope to west of cabins	a) Cabin	Rare	The event is conceivable but only under exceptional circumstances over the design life.	Minor	Limited Damage to part of structure or site requires some stabilisation or INSIGNIFICANT damage to neighbouring properties.	Very Low

* hazards considered in current condition, without remedial/stabilisation measures and during construction works.

* qualitative expression of likelihood incorporates both frequency analysis estimate and spatial impact probability estimate as per AGS guidelines.

* qualitative measures of consequences to property assessed per Appendix C in AGS Guidelines for Landslide Risk Management.

* Indicative cost of damage expressed as cost of site development with respect to consequence values: Catastrophic : 200%, Major: 60%, Medium: 20%, Minor: 5%, Insignificant: 0.5%.

Appendix 3

APPENDIX A

DEFINITION OF TERMS

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

- Risk** – A measure of the probability and severity of an adverse effect to health, property or the environment. Risk is often estimated by the product of probability x consequences. However, a more general interpretation of risk involves a comparison of the probability and consequences in a non-product form.
- Hazard** – A condition with the potential for causing an undesirable consequence (*the landslide*). The description of landslide hazard should include the location, volume (or area), classification and velocity of the potential landslides and any resultant detached material, and the likelihood of their occurrence within a given period of time.
- Elements at Risk** – Meaning the population, buildings and engineering works, economic activities, public services utilities, infrastructure and environmental features in the area potentially affected by landslides.
- Probability** – The likelihood of a specific outcome, measured by the ratio of specific outcomes to the total number of possible outcomes. Probability is expressed as a number between 0 and 1, with 0 indicating an impossible outcome, and 1 indicating that an outcome is certain.
- Frequency** – A measure of likelihood expressed as the number of occurrences of an event in a given time. See also Likelihood and Probability.
- Likelihood** – used as a qualitative description of probability or frequency.
- Temporal Probability** – The probability that the element at risk is in the area affected by the landsliding, at the time of the landslide.
- Vulnerability** – The degree of loss to a given element or set of elements within the area affected by the landslide hazard. It is expressed on a scale of 0 (no loss) to 1 (total loss). For property, the loss will be the value of the damage relative to the value of the property; for persons, it will be the probability that a particular life (the element at risk) will be lost, given the person(s) is affected by the landslide.
- Consequence** – The outcomes or potential outcomes arising from the occurrence of a landslide expressed qualitatively or quantitatively, in terms of loss, disadvantage or gain, damage, injury or loss of life.
- Risk Analysis** – The use of available information to estimate the risk to individuals or populations, property, or the environment, from hazards. Risk analyses generally contain the following steps: scope definition, hazard identification, and risk estimation.
- Risk Estimation** – The process used to produce a measure of the level of health, property, or environmental risks being analysed. Risk estimation contains the following steps: frequency analysis, consequence analysis, and their integration.
- Risk Evaluation** – The stage at which values and judgements enter the decision process, explicitly or implicitly, by including consideration of the importance of the estimated risks and the associated social, environmental, and economic consequences, in order to identify a range of alternatives for managing the risks.
- Risk Assessment** – The process of risk analysis and risk evaluation.
- Risk Control or Risk Treatment** – The process of decision making for managing risk, and the implementation, or enforcement of risk mitigation measures and the re-evaluation of its effectiveness from time to time, using the results of risk assessment as one input.
- Risk Management** – The complete process of risk assessment and risk control (*or risk treatment*).

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

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

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

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

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

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

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

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval	Description	Descriptor	Level	
Indicative Value	Notional Boundary					
10 ⁻¹	5x10 ⁻²	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10 ⁻²		100 years		The event will probably occur under adverse conditions over the design life.	LIKELY	B
10 ⁻³	5x10 ⁻³	1000 years	200 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10 ⁻⁴	5x10 ⁻⁴	10,000 years	2000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10 ⁻⁵	5x10 ⁻⁵	100,000 years	20,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10 ⁻⁶	5x10 ⁻⁶	1,000,000 years	200,000 years	The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

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

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

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

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

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

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

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

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

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

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

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

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

RISK LEVEL IMPLICATIONS

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

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

Appendix 4

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

GOOD ENGINEERING PRACTICE

POOR ENGINEERING PRACTICE

ADVICE

GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical practitioner at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
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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.
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DESIGN AND CONSTRUCTION

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

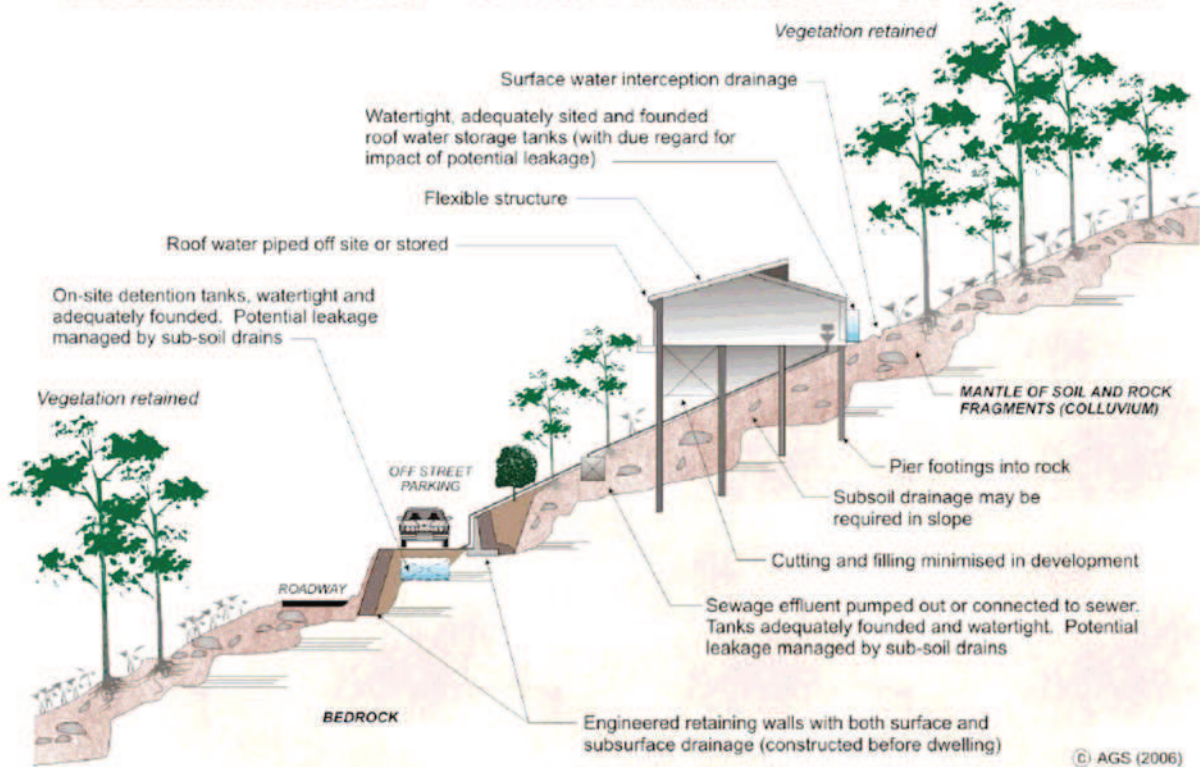
DRAWINGS AND SITE VISITS DURING CONSTRUCTION

DRAWINGS	Building Application drawings should be viewed by geotechnical consultant	
SITE VISITS	Site Visits by consultant may be appropriate during construction/	

INSPECTION AND MAINTENANCE BY OWNER

OWNER'S RESPONSIBILITY	Clean drainage systems; repair broken joints in drains and leaks in supply pipes. Where structural distress is evident see advice. If seepage observed, determine causes or seek advice on consequences.	
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EXAMPLES OF **GOOD** HILLSIDE PRACTICE



EXAMPLES OF **POOR** HILLSIDE PRACTICE

