

REPORT TO MR AND MRS T BROWNE

ON

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

FOR PROPOSED ALTERATION AND ADDITIONS

AT 140A CRESCENT ROAD, NEWPORT, NSW

Date: 23 April 2020 Ref: 22486Z4rpt

JKGeotechnics www.jkgeotechnics.com.au

T: +61 2 9888 5000 JK Geotechnics Pty Ltd ABN 17 003 550 801



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

Development Application for MR + MES BROWNE

Name of Applicant

Address of site <u>JUD A CRESCENT FD</u> <u>NEWPOET</u> Declaration made by geotechnical engineer or engineering geologist or coastal engineer (where applicable) as part of a geotechnical report

geotechnical report
I, AGI ZENUN on behalf ofJK GEOTECHNICS (Insert Name) (Trading or Company Name)
on this the <u>23 AREL ZOR</u> 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.
Please mark appropriate box have prepared the detailed Geotechnical Report referenced below in accordance with the Australia Geomechanics Society's Landslide Risk Management Guidelines (AGS 2007) and the Geotechnical Risk Management Policy for Pittwater - 2009
Are 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/Alteration that does not require a Geotechnical Report or Risk Assessment and hence my/our Report is in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009 requirements.
have examined the site and the proposed development/alteration is separate from and is not affected by a Geotechnical Hazard and does not require a Geotechnical Report or Risk Assessment and hence my Report is in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009 requirements.
have provided the coastal process and coastal forces analysis for inclusion in the Geotechnical Report
Report Title: Gesternuch Agenment - 1404 Crevent Ed Newport
Report Date: 2.5 ADTO 2020 Report Ref No:
Author A Zouran 22486 Z4 1pt
Authors Company/Organization: IK GEOTECHNICS
Documentation which relate to or are relied upon in report preparation:
· MCDP DIOWWY Nos ZOOZ LOODA ABIA LIOZA A103A
· Borton + Field Svivey (ly ET950, 80068, 5/02/2020).
We are aware that the above Geotechnical Report, prepared for the abovementioned site is to be submitted in support of a Development

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 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 Agi Lenin
Chartered Professional Status CP Enc. FIE ANDT
Membership No. 2132971
CompanyJK GEOTECHNICS

P21 DCP Appendix 5 Page 21

Adopted: 15 December 2014 In Force From: 20 December 2014

Document Set ID: 5273966 Version: 1, Version Date: 26/11/2015

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER

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

	Application
	Development Application for MR+ Mes BLOWNE
	Address of site 140 A CZESCONT RD. NEWPOLT
The follow checklist	wing checklist covers the minimum requirements to be addressed in a Geotechnical Risk Management Geotechnical Report. This is to accompany the Geotechnical Report and its certification (Form No. 1).
Geotech	nical Report Details:
	Report Title: Geotechme Assessment - NOA CRESCEN Ed, New port
	Report Date: 23 Ap: 2 1020 Report Ref No:
	Author: A. Zenon 22486 Z41pt
	Author's Company/Organisation: JK GEOTECHNICS
Please m	nark appropriate box
Ð	Comprehensive site mapping conducted IGH pict Zozo
A	(date) Mapping details presented on contoured site plan with geomorphic mapping to a minimum scale of 1:200 (as appropriate)
J	Subsurface investigation required
	Yes Date conducted 2009 (New Date Conducted 2009 (New Date Conducted 2009)
d	Geotechnical model developed and reported as an inferred subsurface type-section
Ī	Geotechnical hazards identified
	Above the site
	On the site
	Below the site
0	Chotechnical bazards described and reported
	Risk assessment conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
	Consequence analysis
P	Bisk 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
Y	Assessed risks have been compared to "Acceptable Risk Management" criteria as defined in the Geotechnical Risk Management Policy for Pithwater - 2009
	Opinion has been provided that the design can achieve the "Acceptable Risk Management" criteria provided that the specified
	recommendations presented in the Report are adopted.
1	Design Life Adopted:
	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
Ð	Additional action to remove risk where reasonable and practical have been identified and included in the report.
Ū	Risk assessment within Bushfire Asset Protection Zone.
We are a the geote	aware that Pittwater Council will rely on the Geotechnical Report, to which this checklist applies, as the basis for confirming that echnical risk management aspects of the proposal have been adequately addressed to achieve an "Acceptable Risk Management" the life of the structure, taken as at least (1)(0) years unless otherwise stated, and justified in the Report and that reasonable and
practical	measures have been identified to remove (preseeable risk as discussed in the Report.
	Signature
	Name Agi Cenin
	Chartered Professional Status. CPENG FIEAVOT
	Membership No 2132971
	Company JK GEOTECHNICS
	company

P21 DCP Appendix 5 Page 22

Adopted: 15 December 2014 In Force From: 20 December 2014



Dh

Report prepared by:

Agi Zenon Principal Consultant | Geotechnical Engineer

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

DOCUMENT REVISION RECORD

Report Reference	Report Status	Report Date
22486Z4rpt	Final Report	23 April 2020

© Document copyright of JK Geotechnics

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.

Any third party who seeks to rely on this Report without the express written consent of JKG does so entirely at their own risk and to the fullest extent permitted by law, JKG accepts no liability whatsoever, in respect of any loss or damage suffered by any such third party.

At the Company's discretion, JKG may send a paper copy of this report for confirmation. In the event of any discrepancy between paper and electronic versions, the paper version is to take precedence. The USER shall ascertain the accuracy and the suitability of this information for the purpose intended; reasonable effort is made at the time of assembling this information to ensure its integrity. The recipient is not authorised to modify the content of the information supplied without the prior written consent of JKG.



Table of Contents

1	INTR	ODUCTION	1
2	BACKGROUND INFORMATION 1		
3	ASSE	SSMENT METHODOLOGY	2
4	SUM	MARY OF OBSERVATIONS	2
5	SUBS	SURFACE CONDITIONS	3
6	PRO	POSED DEVELOPMENT	3
7	GEO [.]	TECHNICAL ASSESSMENT	3
	7.1	Potential Landslide Hazards	4
	7.2	Risk Assessment	4
8	COM	MENTS AND RECOMMENDATIONS	5
	8.1	Conditions Recommended to Establish the Design Parameters	5
	8.2	Conditions Recommended to the Detailed Design to be Undertaken for	
		the Construction Certificate	5
	8.3	Conditions Recommended During the Construction Period	5
	8.4	Conditions Recommended for Ongoing Management of the Site/Structure(s)	6
9	OVE	RVIEW	6

ATTACHMENTS

Figure 1: Site Location Plan Figure 2: Geotechnical Site Plan Figure 3: Geotechnical Mapping Symbols Appendix A:Landslide Risk Management Terminology

JKGeotechnics



1 INTRODUCTION

This report presents the results of our geotechnical assessment of the site at 140A Crescent Road, Newport, NSW. The location of the site is shown in Figure 1. The assessment was commissioned by Mr Grant Mills of Mark Hurcum Design Practice, on behalf of Mr and Mrs T Browne, on the basis of our email proposal dated 29 January 2020. The site was inspected by our Principal Consultant, Agi Zenon, on 16 April 2020, in order to assess the existing stability of the site and the effect on stability of the proposed development.

Details of the proposed development are presented in Section 6 below. In summary, however, it is proposed to extend the first-floor balcony.

This report has been prepared in accordance with the requirements of the Geotechnical Risk Management Policy for Pittwater (2009) as discussed in Section 7 below. We understand that the report will be submitted to Council as part of the DA documentation. Our report is thus preceded by the completed Council Forms 1 and 1a.

2 BACKGROUND INFORMATION

We have been involved with the site since 2008 and have carried out geotechnical investigations, geotechnical assessments and geotechnical inspections for previous stages of improvements, as detailed below.

We addressed the alterations and additions to the house and pool in our geotechnical assessment report (Ref: 22486Zrpt, dated 27 October 2008) and our geotechnical investigation report (Ref:22486Zlet, dated 11 May 2009). The former report was preceded by completed Council Forms 1 and 1a, for the Development Application. We reviewed the associated structural drawings and completed Council Form 2 Part B, for the Construction Certificate. We carried out inspections during the construction stage and on completion we signed off Form 3, for the Occupation Certificate.

We addressed the boathouse in our geotechnical investigation report (Ref: 22486ZN3let, dated 3 November 2010) and our geotechnical assessment report (Ref: 22486ZN3rpt, dated 10 November 2010). The latter report was preceded by completed Council Forms 1 and 1a, for the Development Application. We reviewed the structural drawings and completed Council Form 2 Part B, for the Construction Certificate. We carried out inspections during the construction stage and on completion, we signed off Council Form 3, for the Occupation Certificate.

We are thus familiar with the site history and with the site surface and subsurface conditions.



3 ASSESSMENT METHODOLOGY

This stability assessment is based upon 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 proposed 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 4 below. Our specific recommendations regarding the proposed development are discussed in Section 8 following our geotechnical assessment.

The attached Figure 2 presents a geotechnical sketch plan showing the principal geotechnical features present at the site. Figure 2 is based on the survey plan prepared by Burton & Field (Ref: E5950 80668, dated 5/02/2020). Additional features on Figure 2 have been measured by handheld inclinometer and tape measure techniques and hence are only approximate. Should any of the features be critical to the proposed development, we recommend they be located more accurately using instrument survey techniques.

4 SUMMARY OF OBSERVATIONS

We recommend that the summary of observations which follows be read in conjunction with the attached Figure 2. For ease of description, we have assumed that at this location, Crescent Road has a north-south orientation.

- The site comprises a battle-axe waterfront property. Access to the site is by means of approximately 87m long concrete driveway off Crescent Road. The driveway initially had a grade of 4° increasing to 12° down towards the west.
- The main body of the site is roughly rectangular, being between about 27m and 33m deep (east to west) by an average of 32m wide (north to south).
- At the time of our inspection, the central portion of the site was occupied by a new two storey concrete house with the ground floor level being partly inground. The house appeared in good external condition based on a cursory inspection. The concrete driveway extended across the front of the house (to the east) to an attached concrete garage at first floor level and was bounded by a concrete block wall faced with sandstone tiles between about 0.5m and 1.8m high, which retained the ground straddling the eastern site boundary. The wall was in fair condition but with some cracking and dislodged facing tiles at the southern end.
- A relatively level lawn area led off the rear (to the west) verandah at ground floor level to a part inground pool. An overgrown stone pitched area then sloped down at 27° to a sandstone seawall. The seawall was about 2m above seabed level and appeared in good condition. The pool was supported above the slope at its western end by concrete piers. To the north of the pool, the level area was retained above the slope by sandstone, brick and concrete block walls between 0.3m and 1.5m high. Below the lawn to the south of the pool was a part inground boat house. Steps led from the level



area down to a metal slipway in front of the boat house and a timber jetty with pontoon at the southern end.

- Steps along the northern and southern sides of the house provided external pedestrian access between the upper driveway and garage area and the lower level area.
- A two-storey house was located about 3m beyond the eastern site boundary. A two-storey brick house with adjacent brick garage were located about 1.5m beyond the northern site boundary. Ground levels across the northern and southern site boundaries were essentially similar. A sandstone wall retained a plantar about 0.5m above the northern side of the driveway at its western end. A concrete block wall along this portion of the site boundary dropped about 2m down to the level of the neighbouring property.

5 SUBSURFACE CONDITIONS

The 1:100,000 geological map of Sydney indicates that the site is underlain by rocks of the Newport Formation, Narrabeen Group (interbedded laminae, shale and sandstone). The geotechnical investigation previously carried out has revealed a subsurface profile comprising silty sand and silty clay fill with bedrock inferred at variable depth, but generally sloping down the hillside towards the west. For detailed subsurface conditions at specific locations, reference should be made to our previous report (Ref: 22468Zlet, dated 11 May 2009).

6 PROPOSED DEVELOPMENT

We understand from the provided architectural drawings (2002 A000 A, A001 A, A101 A, A102 A and A103 A) prepared by Mark Hurcum Design Practice, that the proposed development will include the following:

- Extend the west facing first floor balcony to the north towards the existing stairs. The extension will be supported by the existing balcony along its southern and eastern sides, and a new column will support the north-western corner.
- Re-align the west facing first floor sliding doors.

The footprint of the proposed development is indicated on Figure 2.

7 GEOTECHNICAL ASSESSMENT

In the vicinity of the proposed balcony extension, the site is level, appears moderately well drained and, based on the 2009 geotechnical investigation, is underlain by silty sand and/or silty clay fill to about 0.8m with weathered bedrock inferred at 1m depth.



7.1 Potential Landslide Hazards

Our signing off of Council Forms 3 on 15 November 2010 and 31 July 2012, for the previous works undertaken, implies that the potential geotechnical hazards identified at the site were associated with 'low', or lower, risks to life and property. Our site inspection on 16 April 2020 confirmed the above 'low' or lower risks, and did not identify any additional potential geotechnical hazards or changes to site features since July 2012.

Our latest inspection also confirmed that the alterations and additions currently proposed are not associated with potential geotechnical hazards as they involve a local footing over a level area with no bulk excavations proposed. As a result, the 'low' or lower risk to life and property will be maintained.

The above terminology is in accordance with TableA1 given in Appendix A.

7.2 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 8 below are adopted. These recommendations form an integral part of the Landslide Risk Management Process.

8 COMMENTS AND RECOMMENDATIONS

We consider that the proposed development may proceed provided the following specific design, construction and maintenance recommendations are adopted to maintain 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.

8.1 Conditions Recommended to Establish the Design Parameters

8.1.1 The proposed footing must be founded in weathered shale bedrock. The footings should be designed for an allowable bearing pressure of 600kPa, subject to inspection by a geotechnical engineer prior to pouring. A relatively deep pad footing or bucket pile is considered suitable, given the estimated founding depth of at least 1m.

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

8.2.1 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.

8.3 Conditions Recommended During the Construction Period

- 8.3.1 The geotechnical engineer must inspect all footing excavations prior to placing reinforcement or pouring the concrete.
- 8.3.2 The geotechnical engineer must confirm that the proposed alterations and additions have been completed in accordance with the geotechnical reports.

We note that the 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.



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

There are no maintenance recommendations associated with the current alterations and additions. However, the maintenance recommendations from our previous geotechnical assessment reports remain valid.

9 OVERVIEW

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.



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





		G SYMB	OLS	
	Location: 140A CRESCENT ROA NEWPORT, NSW	JD,		
	Report No: 22486Z4	Figure:	3	
This plan should be read in conjunction with the JK Geotechnics report.	JK Geotechn	ics		



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		loss list to discussion from		Developing	Description	1
Indicative Notional		Implied Indicative Landslide Recurrence Interval		Description	Descriptor	Level
10-1	boundary	10 years 20 years 100 years 200 years		The event is expected to occur over the design life.	ALMOST CERTAIN	A
10-2	5×10 ⁻²			The event will probably occur under adverse conditions over the design life.	LIKELY	В
10-3	5×10 ⁻³	1000 years	2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	С
10-4	5×10-5	10,000 years	2000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10-5	5×10-2	100,000 years	20,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10-6	5×10 ⁻²	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				
Indicative Notional		Description	Descriptor	Level
Value	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%		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.

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

LIKELIHOOI	CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)					
	Indicative Value of	1: CATASTROPHIC	2: MAJOR	3: MEDIUM	4: MINOR	5: INSIGNIFICANT
	Approximate Annual	200%	60%	20%	5%	0.5%
	Probability					
A – ALMOST CERTAIN	10-1	VH	VH	VH	Н	M or L (5)
B - LIKELY	10-2	VH	VH	Н	М	L
C - POSSIBLE	10-3	VH	Н	М	М	VL
D - UNLIKELY	10-4	Н	М	L	L	VL
E - RARE	10-5	М	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.
н	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.
М	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 <u>www.ga.gov.au/urban/factsheets/landslide.jsp</u>. 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 <u>www.abcb.gov.au</u>.

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

JKGeotechnics

- 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. <u>Your local council is the first place to make enquiries if you are responsible for any sort of development</u> or own or occupy property on or near sloping land or a cliff.

	Slope	Maximum	
Appearance	Angle	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.

TABLE 1 – Slope Descriptions





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.

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 3



Figure 4

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.

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.



- GeoGuide LR1 Introduction
- GeoGuide LR3 Soil Slopes
- GeoGuide LR4 Rock Slopes
- GeoGuide LR5 Water & Drainage
- GeoGuide LR6 Retaining Walls

- GeoGuide LR7 Landslide Risk
- GeoGuide LR8 Hillside Construction
 - GeoGuide LR9 Effluent & Surface Water Disposal
- GeoGuide LR10 Coastal Landslides
- GeoGuide LR11 Record Keeping

The Australian GeoGuides (LR series) are a set of publications intended for property owners; local councils; planning authorities; developers; insurers; lawyers and, in fact, anyone who lives with, or has an interest in, a natural or engineered slope, a cutting, or an excavation. They are intended to help you understand why slopes and retaining structures can be a hazard and what can be done with appropriate professional advice and local council approval (if required) to remove, reduce, or minimise the risk they represent. The GeoGuides have been prepared by the Australian Geomechanics Society, a specialist technical society within Engineers Australia, the national peak body for all engineering disciplines in Australia, whose members are professional geotechnical engineers and engineering geologists with a particular interest in ground engineering. The GeoGuides have been funded under the Australian governments' National Disaster Mitigation Program.





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.

Qualitative Ris	sk	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	н	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	М	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.		

TABLE 1 - RISK TO PROPERTY



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.

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

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

- GeoGuide LR1 Introduction
- GeoGuide LR3 Soil Slopes
- GeoGuide LR4 Rock Slopes
- GeoGuide LR5 Water & Drainage
- GeoGuide LR6 Retaining Walls

- GeoGuide LR7 Landslide Risk
- GeoGuide LR8 Hillside Construction
 - GeoGuide LR9 Effluent & Surface Water Disposal
- GeoGuide LR10 Coastal Landslides
- GeoGuide LR11 Record Keeping

The Australian GeoGuides (LR series) are a set of publications intended for property owners; local councils; planning authorities; developers; insurers; lawyers and, in fact, anyone who lives with, or has an interest in, a natural or engineered slope, a cutting, or an excavation. They are intended to help you understand why slopes and retaining structures can be a hazard and what can be done with appropriate professional advice and local council approval (if required) to remove, reduce, or minimise the risk they represent. The GeoGuides have been prepared by the <u>Australian Geomechanics Society</u>, a specialist technical society within Engineers Australia, the national peak body for all engineering disciplines in Australia, whose members are professional geotechnical engineers and engineering geologists with a particular interest in ground engineering. The GeoGuides have been funded under the Australian governments' National Disaster Mitigation Program.