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PALMDEV PTY LTD

Geotechnical Landslide Risk Assessment

1112 - 1116 Barrenjoey Road, Palm Beach NSW

E25203.G14_Rev2
19 September 2024

Document Control

Report Title: Geotechnical Landslide Risk Assessment,
1112 - 1116 Barrenjoey Road, Palm Beach NSW

Report No: E25203.G14_Rev2

Copies	Recipient
1 Soft Copy (PDF – Secured, issued by email)	William Allen Palmdev Pty Ltd Level 3, 17 Castlereagh St SYDNEY NSW 2000
2 Original (Saved to Digital Archives) (\\Pah\ei-au$\07 - Projects\E25203_Palmdev_Palm Beach_GI\05_Deliverables\Work in Progress\G14 - LRA\E25203.G14_Rev1 - Geotechnical LRA Report.docx)	EI Australia Suite 6.01, 55 Miller Street, PYRMONT NSW 2009

Author

Warwick Davies
Principal Geotechnical Engineer

Revision	Details	Date	Amended By
0	Initial Issue.	8 August 2024	
1	Update to address NBC review comments, and minor text edits.	6 September 2024	W Davies
2	Update to address client comments and minor text edits.	19 September 2024	W Davies

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Appendices

FIGURES

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

Development Application for Palmdev Pty Ltd
Name of Applicant

Address of site 1112-1116 Barrenjoey Road, Palm Beach NSW

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

I, Warwick Davies *on behalf of* EI Australia
(Insert Name) (Trading or Company Name)

on this the 19 September 2024 certify that I am a geotechnical engineer or engineering geologist or coastal engineer as defined by the Geotechnical Risk Management Policy for Pittwater - 2009 and I am authorised by the above organisation/company to issue this document and to certify that the organisation/company has a current professional indemnity policy of at least $2million.
I:

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

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

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

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

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

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

Geotechnical Report Details:

Report Title: Geotechnical Landslide Risk Assessment

Report Date: Ref. E25203.G14_Rev2, dated 19 September 2024
:
Author: Warwick Davies

Author's Company/Organisation: EI Australia

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

The documents as referenced in Section 1.2 and 1.3 of the above mentioned report

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

Signature …… 19 September 2024

Name Warwick Davies ……..

Chartered Professional Status CPEng, NER ……

Membership No. 385078 ……

Company EI Australia ……

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER
FORM NO. 1(a) - Checklist of Requirements For Geotechnical Risk Management Report for Development Application

Development Application for Palmdev Pty Ltd
Name of Applicant
Address of site 1112-1116 Barrenjoey Road, Palm Beach NSW

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

Geotechnical Report Details:

Report Title: Geotechnical Landslide Risk Assessment
Report Date: Ref. E25203.G14_Rev2, dated 19 September 2024
Author: Warwick Davies
Author's Company/Organisation: EI Australia

Please mark appropriate box

☑ Comprehensive site mapping conducted 29 July 2024 (date)
☑ Mapping details presented on contoured site plan with geomorphic mapping to a minimum scale of 1:200 (as appropriate)
☑ Subsurface investigation required
- ☐ No Justification ……
- ☑ Yes Date conducted …11 June 2021, 27 October 2021, 4-6 October 2023, 10-11 October 2023

☑ Geotechnical model developed and reported as an inferred subsurface type-section
☑ Geotechnical hazards identified
- ☑ Above the site
- ☑ On the site
- ☑ Below the site
- ☑ Beside the site

☑ Geotechnical hazards described and reported
☑ Risk assessment conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
- ☑ Consequence analysis
- ☑ Frequency analysis

☑ Risk calculation
☑ Risk assessment for property conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
☑ Risk assessment for loss of life conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
☑ Assessed risks have been compared to "Acceptable Risk Management" criteria as defined in the Geotechnical Risk Management Policy for Pittwater - 2009
☑ Opinion has been provided that the design can achieve the "Acceptable Risk Management" criteria provided that the specified conditions are achieved.
☑ Design Life Adopted:
- ☑ 100 years
- ☐ Other …… specify

☑ Geotechnical Conditions to be applied to all four phases as described in the Geotechnical Risk Management Policy for Pittwater - 2009 have been specified
☑ Additional action to remove risk where reasonable and practical have been identified and included in the report.
☐ Risk assessment within Bushfire Asset Protection Zone.

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

Signature …… 19 September 2024
Name Warwick Davies
Chartered Professional Status CPEng, NER
Membership No. 385078
Company EI Australia

1. Introduction

1.1 Scope of the Assessment

At the request of William Allen, on behalf of Palmdev Pty Ltd (the Client), EI Australia (EI) has carried out a Geotechnical Landslide Risk Assessment (LRA) for the proposed development at 1112 - 1116 Barrenjoey Road, Palm Beach NSW (the Site).

The purpose of the LRA is to form an opinion on the geotechnical risks associated with the proposed works.

Our opinions on the risks of slope instability are required in connection with an application to Northern Beaches Council for development approval associated with the proposed development.

Walk-over inspections of the site were undertaken on 24 and 29 July 2024 by Kaiyu Xu (Geotechnical Engineer) and Warwick Davies (Principal Geotechnical Engineer) from EI, for the purpose of slope mapping, assessment of slope conditions within and around the site, and assessment of potential geotechnical hazards.

The LRA has been undertaken in accordance with client instructions, confirmed on 25 August 2024, based on EI's proposal and scope of work referenced P19388.7, dated 9 February 2024.

A site survey, architectural drawings for the development, structural concept details associated with a proposed excavation support system and other information were supplied to us for the purposes of our investigations and site assessment. The information provided is referenced in appropriate sections of the report. The comments and recommendations in the report are based on the details provided.

1.2 Basis of the Assessment

The opinions provided in the following report are based on a visual inspection of the property and also the immediately adjoining land. As noted above, geotechnical inspections and slope mapping of the site were undertaken by our Geotechnical Engineer and Principal Geotechnical Engineer on 24 and 29 July 2024.

Detailed geotechnical investigations have been carried out within the site for the proposed development. A list of available documentation prepared by EI for the development is provided below. In addition EI have undertaken geotechnical investigations on other properties in the Northern Beaches with similar geotechnical and geological settings. The opinions expressed in this report are based on our relevant local experience.

EI has previously completed the following reports for this site:

- Geotechnical Investigation (GI), referenced E25203.G03_Rev2, dated 7 December 2021;
- Additional Geotechnical Investigation (AGI) report, referenced E25203.G04_Rev1, dated 8 August 2024;
- Groundwater Monitoring Report No. 1, referenced E25203.G11.01, dated 28 February 2024;
- Groundwater Take Assessment (GTA), referenced E25203.G12_Rev2, dated 8 August 2024; and
- Construction Methodology Report, referenced E25203.G15, dated 8 August 2024.

Our opinions and conclusions on the stability of the site are presented in the framework of the Australian Geomechanics Society's publication Practice Note Guidelines for Landslide Risk Management 2007, described and referenced in the report.

The property is within an area recognized as having potential risks in regard to slope instability. Important factors relating to the local slope conditions and the impact of development, which commonly influence the risks of slope instability, are discussed in the report.

An owner's decision to acquire, develop or build on land within an area such as this involves the acceptance of a level of risk. It is important to recognize that soil and rock movements are an ongoing geological process, which may be affected by development and land management within the site or on adjoining land. Soil or rock movements may cause visible damage to structures even where the risk of slope failure is considered low. This report is intended to assess the risk of slope instability, apparent at the time of inspection.

Our opinion is provided on the risk of instability specifically referenced in the title to this report. Foundations suitable for development on this site may be discussed in relation to stability considerations and the anticipated subsurface conditions.

However, this report is not intended as, is not suitable for, and must not be used in lieu of a detailed foundation investigation for final design or costing of foundations, retaining walls or other structures associated with a future development of the property.

1.3 Proposed Development

The proposed development is detailed on drawings prepared by Koichi Takada Architects , provided to EI for the purposes of the LRA.

The proposed works are for a 4-level commercial and residential development with a single split-level basement. Further discussion is provided in 6.1 below.

The architectural drawings, site survey details and structural concept details provided to EI are listed below:-

- Architectural drawings prepared by Koichi Takada Architects – Project at 1112-1118 Barrenjoey Road, Palm Beach, Drawing Nos. A0001, A0010 to A0013, A0019, A0022, A0050, A0051, A0099 to A0105, A0200 to A0203, A0300 to A0305, and A0320, latest revision I, dated 31 July 2024;
- Structural drawings prepared by M&G Consulting Engineers Pty Ltd – Job No. 5598, Drawing Nos. S010, S011, S015 and S020, Issue 1, dated 7 August 2024; and
- Site survey plan prepared by Beveridge Williams – Project No. 2101343, Drawing Ref. 2101343, Version B, dated 6 September 2021. The datum in the survey plan is in Australian Height Datum (AHD), hence all Reduced Levels (RL) mentioned in this report are henceforth in AHD.

2. Geology

2.1 General Geology

The geology of this site is shown on the Sydney 1:100,000 scale Geological Series Sheet 9130 (DMR 1983) published by the NSW Geological Survey.

The slopes of the locality are formed on the Triassic-age Narrabeen Group, Newport Formation (Rnn) and Garie Formation, overlain by the Hawkesbury Sandstone, the latter forming a capping to the local ridge topography.

The rock of the Narrabeen Group comprises interbedded laminite, shale, and quartz, to lithic-quartz sandstone, and minor red claystone.

The site is indicated on the Locality Plan, **Plate 1** below. Local geology is shown on **Plate 2.**

Plate 1: Aerial photograph of the site (source: Nearmap, accessed 24/10/2023)

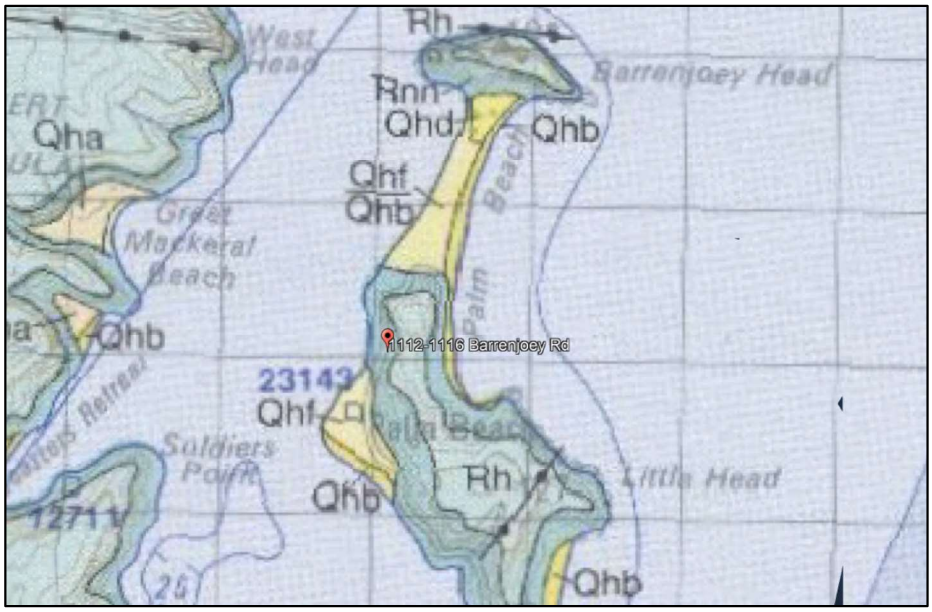


Plate 2: Extract from 100,000 scale Geology Sheet Sydney 9130, showing location of site.

2.2 Site Geology and Stability in Vicinity of 1112 – 1116 Barrenjoey Rd

The site at 1112 – 1116 Barrenjoey Rd is located on the footslope of a steep hillside rising to the east on the Narrabeen Group bedrock, eventually to a ridge capped by the Hawkesbury Sandstone.

The front (western) half of the property is flat, where the Pittwater foreshore zone has been developed on marine sand alluvium.

A Geotechnical Slope Section has been prepared, presented as Figure 1 herewith, showing the subsurface conditions determined from EI's geotechnical investigations (refer Section 1.2 above and Section 4 below).

There are no bedrock outcrops within the site, however the geology is exposed on the hillside south from the site (viewed from Barrenjoey Rd), and in the road cutting along Barrenjoey Rd north from the site near the intersection of Palm Beach Rd.

Bedrock exposures in the Narrabeen Group are seen in the cutting along Palm Beach Rd rising up to the intersection of Pacific Rd near the local crest of the hill/ridge, almost directly upslope from the site.

The site lies within the mapped Hazard Zone H1(slope), in accordance with GHD Geotechnics – Geotechnical Hazard Mapping of Pittwater LGA, 2007 (reference 7).

As subject site is located within an area having known landslide risk. Accordingly, this LRA is required as part of the Development Assessment process, in accordance with the NBC Pittwater Geotechnical Risk Management Policy (reference 4).

2.3 Geotechnical Slope Section

A Geotechnical Slope Section is provided in **Figure 1** attached to this report, to illustrate the interpreted geotechnical model for the site based on the local geological conditions, and potential influence of the geology on the existing development and proposed additions/alterations.

Figure A1 and **Figure A2** (**Appendix A** herewith) show interpreted slope hazards and excavation details relevant to the LRA presented herein.

3. Site Conditions

3.1 Topography

The site is located on the east side of Barrenjoey Rd.

The land is initially flat, and has been excavated into the toe of the steep hillslope that rises up to the east across the site, initially at ~37°, reducing to ~30°, continuing over adjoining developed properties and flattening to ~18° – 20°, then ~12° at Palm Beach Rd.

The ridge crest locally occurs just east of Palm Beach Rd, at ~RL42m.

Site levels vary from RL2.3m (AHD) at the Barrenjoey Rd frontage, to approximately RL15.5m at the south-eastern site corner.

The current site conditions at the front half of the site are shown in **Plates 3 – 6** below.

The excavation into the toe of the slope is supported by the 2.5m high block wall, **Plates 4 & 5.**

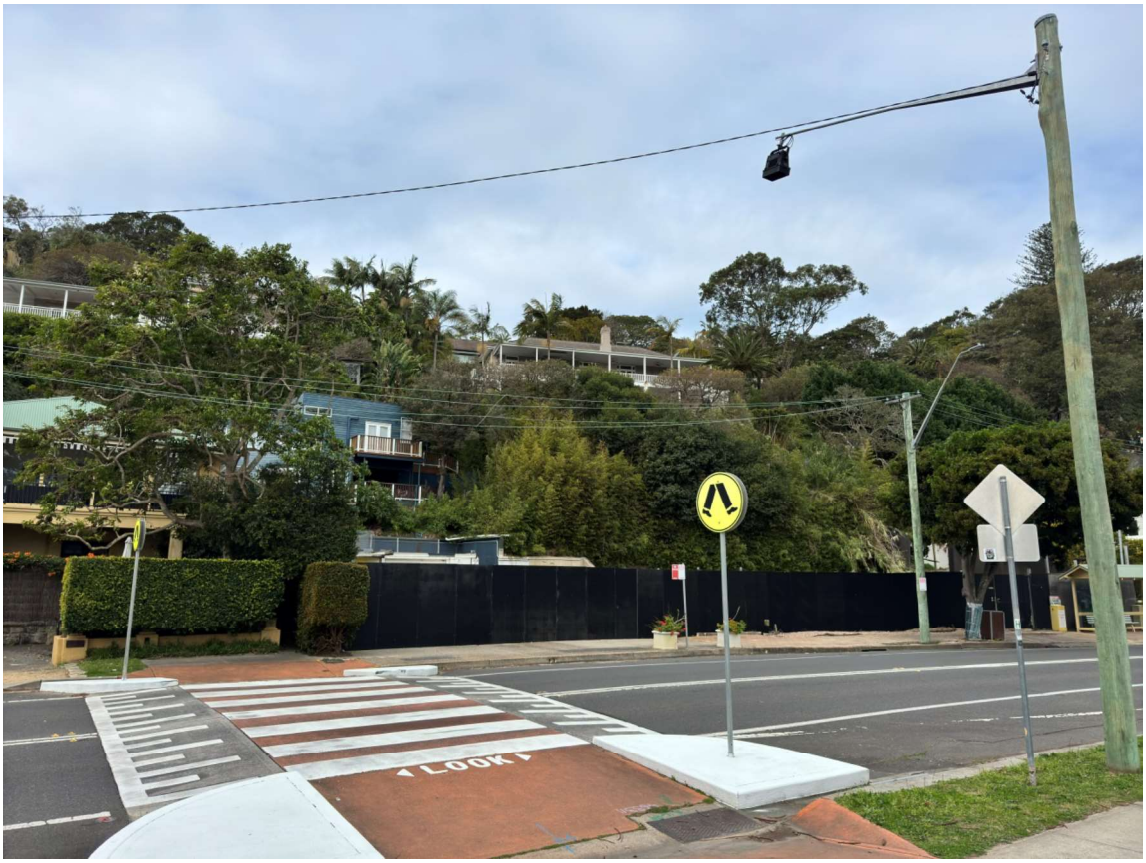


Plate 3: View of the site looking SE from Barrenjoey Rd

Plate 4: Interior view at front half of the site, looking to NE.

Plate 5: Interior view at front half of the site, looking to east.

Plate 6: View east at northern side, partly demolished remains with remaining dwelling uphill.

Survey details of the site are provided in **Figure 2** herewith.

3.2 Vegetation

The site is cleared of original natural vegetation. Thick bamboo covers the steep slope above the block retaining wall, and continues onto the adjoining land above.

3.3 Drainage

Surface drainage within the property is directed to Barrenjoey Rd.

There are no obvious natural drainage lines flowing across or above the property.

Disposal of stormwater and roofwater from the immediately adjoining properties, No.21A and No.23 Palm Beach Rd uphill is not evident from our slope inspection.

3.4 Existing Development

The previous development on 1112 – 1116 Barrenjoey Rd has been partly demolished. The pre-existing development was surveyed in June 2021 (refer **Figure 2** herewith).

A dwelling remains within the property against the northern side boundary, seen in Plate 6 above. The dwelling has been excavated about 1.5m into the slope at the rear against the uphill boundary.

4. Subsurface Conditions

Geotechnical investigations have been carried out by EI (refer **Section 1.2** above). **Figure 3** provides a plan of the site showing the borehole locations.

Detailed subsurface information is available in the borehole records provided in our Additional Geotechnical Investigation (AGI) as referenced above.

A summary of the soil and rock stratigraphy and the groundwater conditions encountered at the time of the investigations is presented in the AGI. Reference should be made to the AGI report.

Sufficient for the purposes of this LRA, the stratigraphy from Table 3.1 in the AGI can be summarized as below:-

Unit	Material[2]	Observed Thickness (m)	Comments
1	**Fill/ Topsoil**	0.3 to 1.33	Low plasticity sandy clay fill/topsoil, Silty sand fill;
2a	**Marine Soil**	1.0 to 2.93	Fine to medium grained, loose sand/silty sand, becoming dense with depth. SPT N values range from 2 to 32;
2b	**Residual Soil**	1.35 to 6.87	Low to high plasticity sandy clay/ clayey sand, stiff/dense to hard with trace ironstone gravels. SPT values ranged from 25 to harmer bounce;
3	**Very Low Strength Sandstone/ Laminite**	1.3 to 8.5	Distinctly weathered, very low strength sandstone and laminite comprising of sandstone, claystone and siltstone, with frequent extremely weathered seams. Extremely weathered sandstone with bands of medium strength ironstone observed in BH103 and BH104M. In BH204M, observed low strength sandstone with ironstaining, and very low strength claystone.
4	**Low to Medium Strength Laminite**	-[3]	Distinctly weathered, low to medium strength laminite comprising of siltstone and sandstone. Not observed in BH101M and BH102.

Borehole details and locations are provided in the AGI and should be referred to for relevance in the geotechnical interpretation presented herein for purposes of the LRA.

5. Landslide Risk Assessment

5.1 General

The landslide risk appraisal for 1112 – 1116 Barrenjoey Rd, presented in this report, is based on procedures outlined in the Australian Geomechanics Society's (AGS) *Practice Note Guidelines for Landslide Risk Management*.

5.2 Risk Assessment

Discussion is presented in **Appendix A** of this report, regarding the assessed geotechnical hazards, our assessment for frequency analysis, consequences to property, and risk to property and life, for the existing and anticipated future slope conditions, and the proposed development.

For each identified hazard/event, the elements of the existing conditions and the proposed development that would be considered to be at risk are residential and associated structure(s), services, and landscaping improvements on property adjoining the development. **Tables A1(a), A1(b)** and **Tables A2(a)** and **A2(b)** provide a risk analysis for the proposed development.

In summary, the outcome and conclusions of the risk assessment undertaken are as follows:

	Risk to Property **Tables A1(a) & A1(b)**	**Risk to Life** **(for person most at risk)** **Tables A2(a) & A2(b)**	**Comment**
Proposed Development	Very Low to Low [1]	*< 10^{-5} per annum* [2]	Tolerable to Acceptable

Note 1: Estimated risk levels, with good engineering controls.
Note 2: Estimated risk levels, includes some with poor engineering controls..

It is noted that Moderate Risk outcomes are highlighted in **Table A1(a)** and **Table A1(b),** associated with the dwellings adjoining the development. where assumed failure probabilities of Possible and Unlikely were adopted. For Risk to Life, Tolerable Risk was determined for several cases, and one Not Tolerable Risk (**Table A2(b)**). These are cases where engineering design and some construction controls would be assumed to be in place, but at a less robust level than those where a Rare likelihood can be assumed. Nonetheless, an acceptable risk outcome is predicted for robust engineering design (Rare likelihood) and associated controls during construction.

It is noted that the risk assessment and analyses presented for this report, and consideration of the outcome in terms of acceptance criteria, are based on the normally accepted risk levels in accordance with recommendations of AGS 2007, namely for "*the person most at risk*".

The assessed risks are subject to maintenance and/or improvement of the present site conditions as discussed elsewhere in the report, and to further geotechnical review should these conditions alter significantly in the future.

Examples of recommended hillside development and construction practice are provided in the attachments to this report. Where relevant, the examples provide guidance for future development on this site, and should be incorporated in the development.

Recommendations are provided in **Sections 6.2** and **6.3** below, as appropriate, and are consistent with maintaining or improving the slope conditions, and with lowering the assessed

risk levels where possible for achieving an **acceptable risk outcome** during and on completion of the development.

6. Future Development and Recommendations

6.1 General

Details and design at the time of preparing this report are provided on the architectural drawings prepared by Koichi Takada Architects as listed in **Section 1.3** above.

The proposed works involve excavation for the basement. Excavation depths are in the order of 16m at the rear and 5m at the front. The excavation will be 3m away from the eastern (uphill) boundary.

Details of the proposed excavation and the support system and methodology intended for the works are outlined in Section 3 of the accompanying EI Construction Methodology Report referenced in **Section 1.2** above.

Geotechnical visual inspection as described herein has been undertaken to provide assessment of the existing slope conditions and development, and to determine appropriate engineering design and construction controls relevant for slope stability considerations.

Subject to the recommendations of this report being implemented through the design and construction phases of the project, it is our opinion that the proposed development can be undertaken within the framework of the assessed degree of risk in relation to slope instability, as discussed in **Section 5** above.

The recommendations provided below will assist in maintaining or improving the slope conditions and geotechnical risk.

6.2 Recommendations – Proposed Development

a) All footings for the proposed construction should be taken to a uniform bearing in or on bedrock.

b) The ground conditions and founding levels for all structural footings are to be verified by a geotechnical engineer during the construction, involving inspection of bulk excavation, and in footing excavations. Where necessary, the builder is to arrange hold points for the geotechnical inspections at appropriate stages of the work.

c) Engineering details for the proposed works are to be prepared by a suitably experienced consulting structural or civil engineer, and must be reviewed by a geotechnical engineer in regard to geotechnical aspects, prior to issue of the Construction Certificate (ie prior to commencement of site works). The following components of the development are to be included:

   i) Footings for building structures, and temporary and permanent retaining walls.
   ii) Excavation and other slope support systems, including a staged construction methodology as appropriate.
   iii) Retaining wall drainage systems, stormwater.

d) In regard to (c)(ii) above, the geotechnical review prior to release of a Construction Certificate must include a rigorous geotechnical analysis (Plaxis or equivalent) of the proposed excavation support system and the staged methodology for undertaking the excavation.

e) All aspects of the design and construction for the development should be in accordance with the guidelines provided in the attached *Some Guidelines for Hillside Construction* (refer to Appendix A of this report).

7. Summary & General Limitations

The above report provides the results of a geotechnical assessment of the land at 1112 - 1116 Barrenjoey Road, Palm Beach NSW. The assessment and report are for the purposes of a DA submission to Northern Beaches Council, in accordance with requirements of NBC's Pittwater Geotechnical Risk Management Policy.

The landslide risk assessment reported herein concludes that:

- The proposed site development can be undertaken, and
- The proposed works can achieve an **Acceptable Risk Level** in accordance with recommendations of AGS 2007, provided that all the recommendations of the report are properly implemented during and following development.

Engineering controls are recommended to ensure **Acceptable Risk Levels** can be achieved. These controls are to be embraced in the detailed design and construction phases of the development, and are to be reviewed for geotechnical purposes prior to commencement of construction, as discussed in the report.

Recommendations are provided in the report to guide the various design components, in regard to geotechnical requirements. Geotechnical analysis must be undertaken for verification of (a) potential impacts on adjoining property and infrastructure, and together with the project structural engineer (b) safety in design.

The report recommends that the proposed work should include certain engineering requirements for the construction. The bulk excavation proposed as part of the development, and the footing design require engineering controls.

The owner, potential owner or interested party in regard to this site should assess whether the risk levels determined in **Tables A1(a)** & **A1(b)** (risk to property) and **Tables A2(a)** & **A2(b)** (risk to life) are acceptable for the site in its present state, and following completion of the approved development, taking into account the possible economic and societal consequences associated with the risks.

The report recommends certain requirements for the proposed construction and for the longer term, during the life of the development, consistent with maintaining or improving the slope conditions, and with lowering the assessed risk levels where possible.

The risk of slope instability within this property may be affected by changes in land management or development on this or adjacent property. Review of the risk appraisal is recommended if significant changes occur to the natural site features or to the development, which are outside the scope of this report.

If any conditions are encountered that vary significantly from those described in the above report, or that might affect the probability of occurrence, and/or the consequences of the defined geotechnical hazards, it is a condition of the report that we be advised so that those conditions, and the conclusions discussed in the report, can be reviewed and alternative recommendations assessed, if appropriate.

The appendices, which are attached to this report, are important in understanding the basis of the assessment undertaken, and the conclusions reached. This report must be read in conjunction with these appendices, and with accompanying documentation as referenced herein.

8. Statement of Limitations

This report has been prepared for the exclusive use of William Allen and Palmdev Pty Ltd who is the only intended beneficiary of EI's work. The scope of the assessment carried out for the purpose of this report is limited to that agreed with William Allen and Palmdev Pty Ltd.

No other party should rely on the document without the prior written consent of EI, and EI undertakes no duty, or accepts any responsibility or liability, to any third party who purports to rely upon this document without EI's approval.

EI has used a degree of care and skill ordinarily exercised in similar assessments by reputable members of the geotechnical industry in Australia as at the date of this document. No other warranty, expressed or implied, is made or intended. Each section of this report must be read in conjunction with the whole of this report, including its appendices and attachments.

EI's professional opinions are reasonable and based on its professional judgment, experience, training and results from analytical data. EI may also have relied upon information provided by the Client and other third parties to prepare this document, some of which may not have been verified by EI.

EI's professional opinions contained in this document are subject to modification if additional information is obtained through further observations, or validation testing and analysis during construction. In some cases, further assessment and analysis may be required, which may result in a further report with different conclusions.

We draw your attention to the document "Important Information", which is included in **Appendix D** of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be. The document is not intended to reduce the level of responsibility accepted by EI, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

Should you have any queries regarding this report, please do not hesitate to contact EI.

References

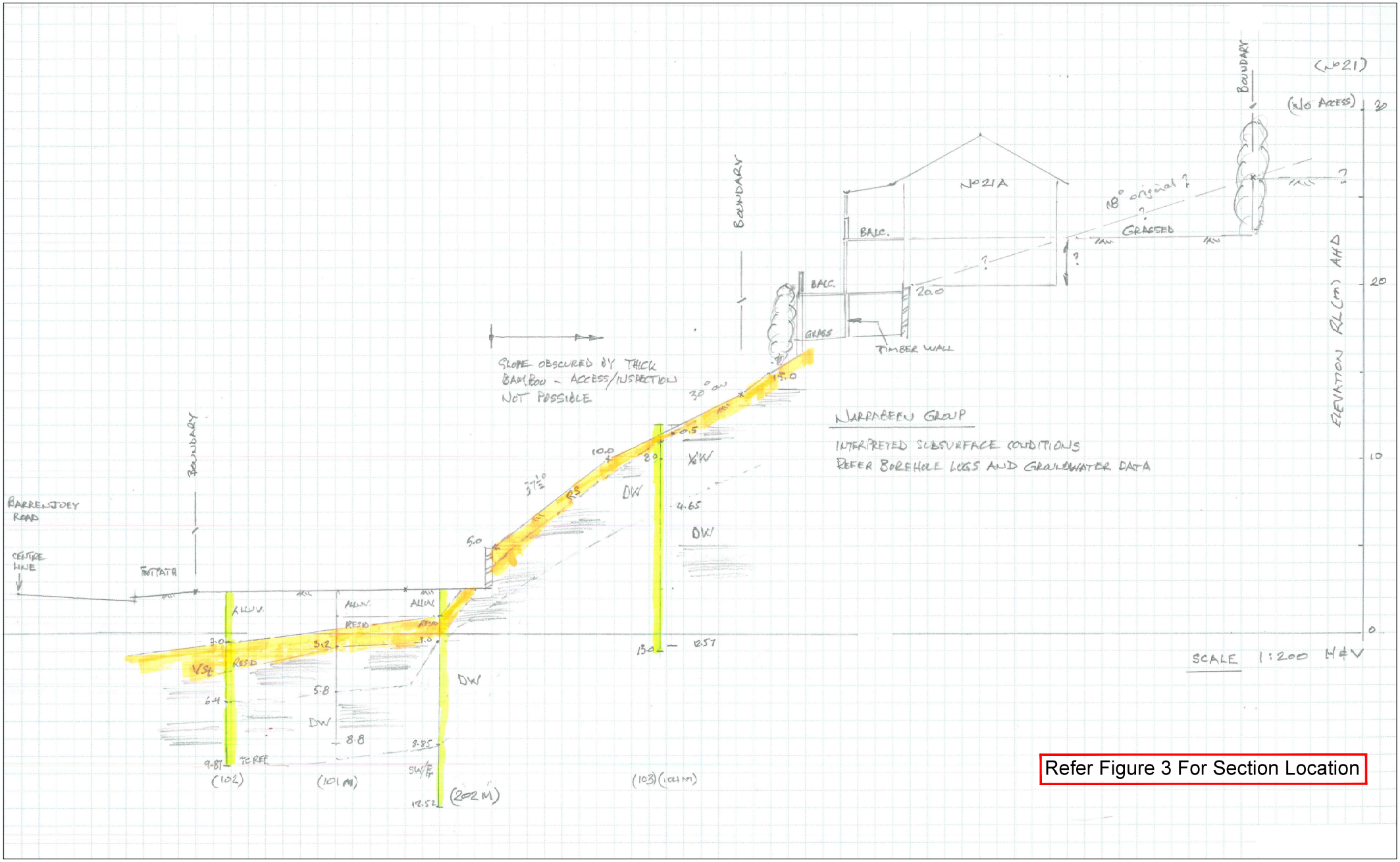
REFERENCES

1. *Practice Note Guidelines for Landslide Risk Management 2007 [and Commentary],* Australian Geomechanics, Vol.42, No.1, March 2007.
2. Geol. Sur. NSW, Dept Min Resources (1983). *Geological Series Sheet 9130 (Sydney) 1:100,000*
3. Chapman, G.A. and Murphy, C.L. (1989), *Soil Landscapes of the Sydney 1:100,000 sheet*. Soil Conservation Service of NSW, Sydney
4. *Geotechnical Risk Management Policy for Pittwater - 2009,* Pittwater Council P21 DCP Appendix 5, Policy No.178 amended 4 November 2013.
5. MacGregor, P., Walker, B.F., Fell, R., and Leventhal, A.R., (2007). *Assessment of Landslide Likelihood in the Pittwater Local Government Area*, Australian Geomechanics, Vol.42, No.1, March 2007.
6. Walker, B.F. (2002). *An Example of Semi Quantitative Landslide Risk Management for an Individual Lot in Northern Sydney,* Australian Geomechanics, Vol.37, No.2, May 2002.
7. GHD Geotechnics. *Geotechnical Hazard Mapping of the Pittwater LGA, 2007*. Pittwater Council's Geotechnical Risk Management Map P21CDP-BC-MDCP083.
8. Pells P.J.N., Mostyn G. and Walker B.F. (1998). "*Foundations on Sandstone and Shale in the Sydney Region*" Australian Geomechanics, Number 33 Part 3 Dec.1998
9. TfNSW (Roads & Maritime Services)_Guide to Slope Risk Analysis Version 4.0 2014

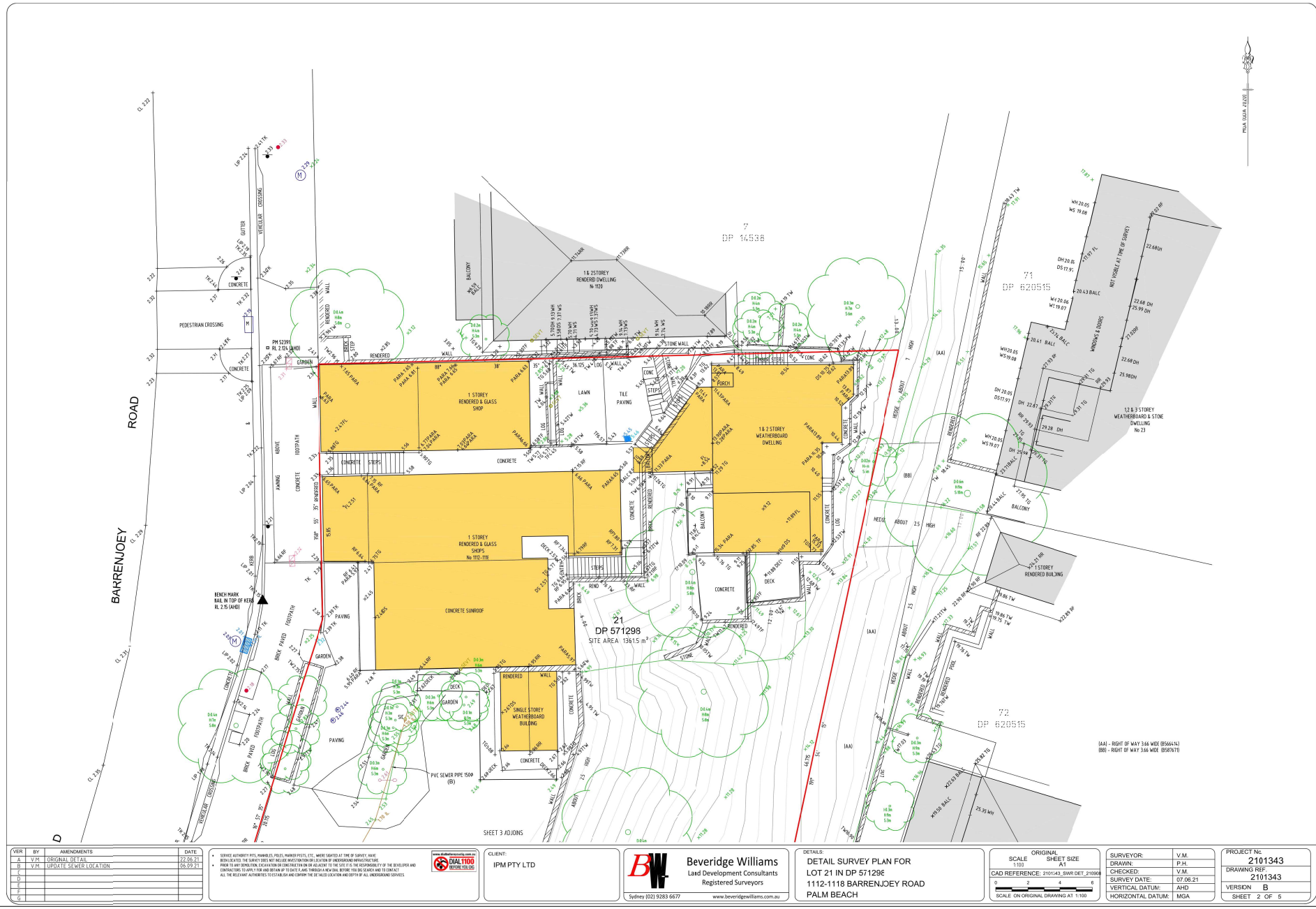
Abbreviations

AGI	Additional Geotechnical Investigation
AHD	Australian Height Datum
AS	Australian Standard
BEGL	Below Existing Ground Level
EI	EI Australia
GI	Geotechnical Investigation
GTA	Groundwater Take Assessment
LRA	Landslide Risk Assessment
RL	Reduced Level

Figures



	eiaustralia Practical Solutions for Built Environments Suite 6.01, 55 Miller Street, PYRMONT 2009 Ph (02) 9516 0722 Fax (02) 9518 5088	Drawn:	W.D.	**Palmdev Pty Ltd** Landslide Risk Assessment 1112-1116 Barrenjoey Road, Palm Beach NSW Geotechnical Slope Section	Figure: 1
		Date:	8-8-2024		Project: E25203.G14



VER	BY	AMENDMENTS	DATE
A	V.M.	ORIGINAL DETAIL	22.06.21
B	V.M.	UPDATE SEWER LOCATION	06.09.21
C			
D			
E			
F			
G			

- SERVICE AUTHORITY PITS, MANHOLES, POLES, MARKER POSTS, ETC., WERE SIGHTED AT TIME OF SURVEY, HAVE BEEN LOCATED. THE SURVEY DOES NOT INCLUDE INVESTIGATION OR LOCATION OF UNDERGROUND INFRASTRUCTURE.
- PRIOR TO ANY DEMOLITION, EXCAVATION OR CONSTRUCTION ON OR ADJACENT TO THE SITE IT IS THE RESPONSIBILITY OF THE DEVELOPER AND CONTRACTORS TO APPLY FOR AND OBTAIN UP TO DATE P. AND THROUGH A NEW DIAL BEFORE YOU DIG SEARCH AND TO CONTACT ALL THE RELEVANT AUTHORITIES TO ESTABLISH AND CONFIRM THE DETAILED LOCATION AND DEPTH OF ALL UNDERGROUND SERVICES

DIAL 1100 BEFORE YOU DIG

CLIENT: IPM PTY LTD

Beveridge Williams
Land Development Consultants
Registered Surveyors
Sydney (02) 9283 6677 www.beveridgewilliams.com.au

DETAILS: DETAIL SURVEY PLAN FOR LOT 21 IN DP 571298 1112-1118 BARRENJOEY ROAD PALM BEACH

ORIGINAL SCALE 1:100 SHEET SIZE A1
CAD REFERENCE: 2101143_SWR DET_210906
SCALE ON ORIGINAL DRAWING AT 1:100

SURVEYOR:	V.M.
DRAWN:	P.H.
CHECKED:	V.M.
SURVEY DATE:	07.06.21
VERTICAL DATUM:	AHD
HORIZONTAL DATUM:	MGA

PROJECT No. 2101343
DRAWING REF. 2101343
VERSION B
SHEET 2 OF 5

REFERENCE

Survey Plan, prepared by Beveridge Williams,
Project No. 2101343, Drawing Reference No. 2101343, Sheet 2 of 5, Ver. B, Dated 6 September 2021

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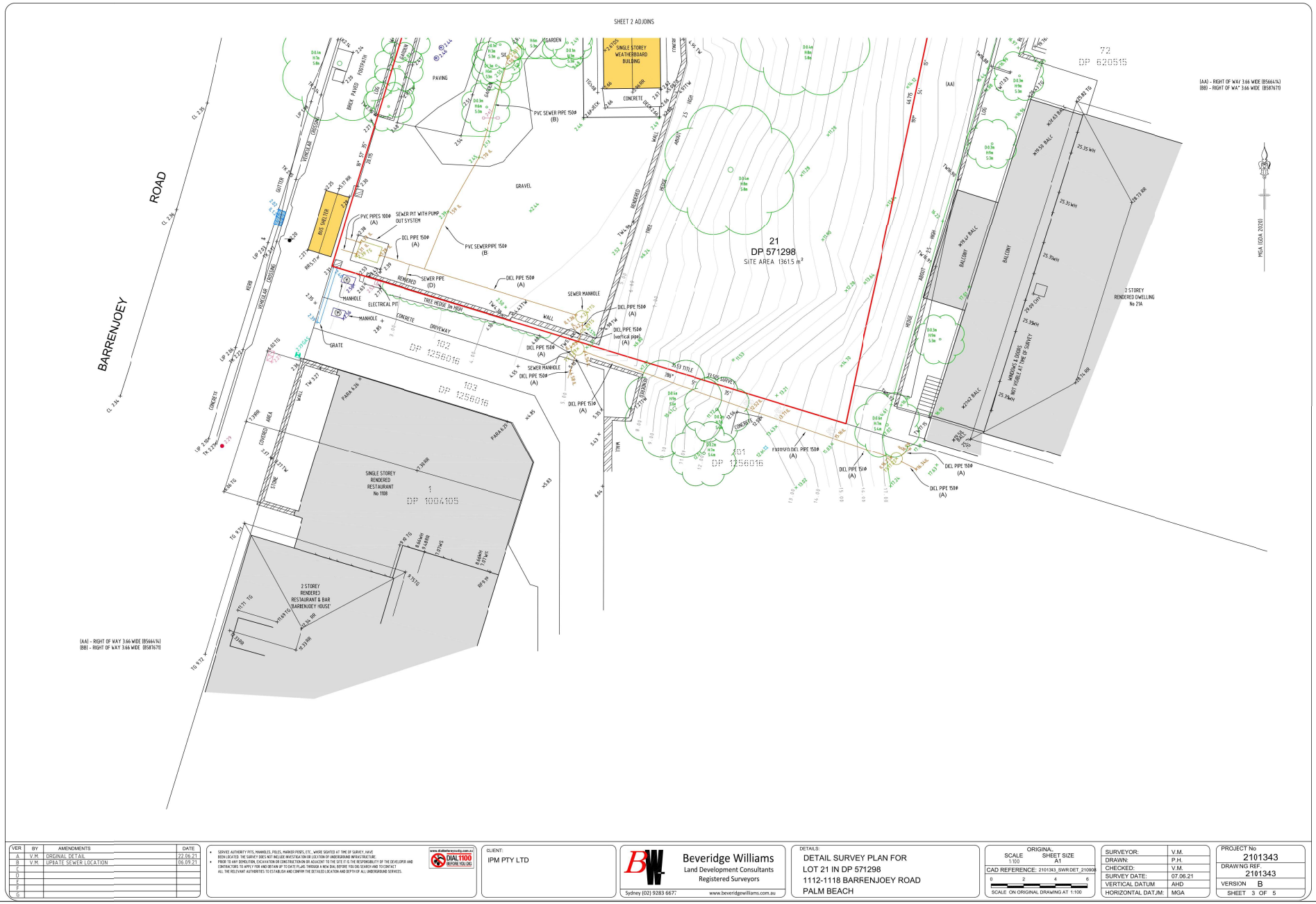
Ph (02) 9516 0722 Fax (02) 9518 5088

Drawn:	L.L.
Approved:	K.X.
Date:	8-8-2024

Palmdev Pty Ltd
Landslide Risk Assessment
1112-1116 Barrenjoey Road, Palm Beach NSW
Survey Plan, Sheet 1 of 2

Figure: 2.1

Project: E25203.G14



VER	BY	AMENDMENTS	DATE
A	V.M.	ORIGINAL DETAIL	22.06.21
B	V.M.	UPDATE SEWER LOCATION	06.09.21
C			
D			
E			
F			
G			

- SERVICE AUTHORITY PITS, MANHOLES, POLES, MARKER POSTS, ETC., WHERE SIGHTED AT TIME OF SURVEY, HAVE BEEN LOCATED. THE SURVEY DOES NOT INCLUDE INVESTIGATION OR LOCATION OF UNDERGROUND INFRASTRUCTURE.
- PRIOR TO ANY DEMOLITION, EXCAVATION OR CONSTRUCTION ON OR ADJACENT TO THE SITE IT IS THE RESPONSIBILITY OF THE DEVELOPER AND CONTRACTORS TO APPLY FOR AND OBTAIN UP TO DATE PLANS THROUGH A NEW DIAL BEFORE YOU DIG SEARCH AND TO CONTACT ALL THE RELEVANT AUTHORITIES TO ESTABLISH AND CONFIRM THE DETAILED LOCATION AND DEPTH OF ALL UNDERGROUND SERVICES.

DIAL 1100 BEFORE YOU DIG

CLIENT: IPM PTY LTD

Beveridge Williams
Land Development Consultants
Registered Surveyors
Sydney (02) 9283 6677 www.beveridgewilliams.com.au

DETAILS:
DETAIL SURVEY PLAN FOR
LOT 21 IN DP 571298
1112-1118 BARRENJOEY ROAD
PALM BEACH

ORIGINAL:
SCALE 1:100 SHEET SIZE A1
CAD REFERENCE: 2101343_SWR.DET_210908
0 2 4 6
SCALE ON ORIGINAL DRAWING AT 1:100

SURVEYOR:	V.M.
DRAWN:	P.H.
CHECKED:	V.M.
SURVEY DATE:	07.06.21
VERTICAL DATUM	AHD
HORIZONTAL DATUM:	MGA

PROJECT No 2101343
DRAWING REF 2101343
VERSION B
SHEET 3 OF 5

REFERENCE

Survey Plan, prepared by Beveridge Williams,
Project No. 2101343, Drawing Reference No. 2101343, Sheet 3 of 5, Ver. B, Dated 6 September 2021

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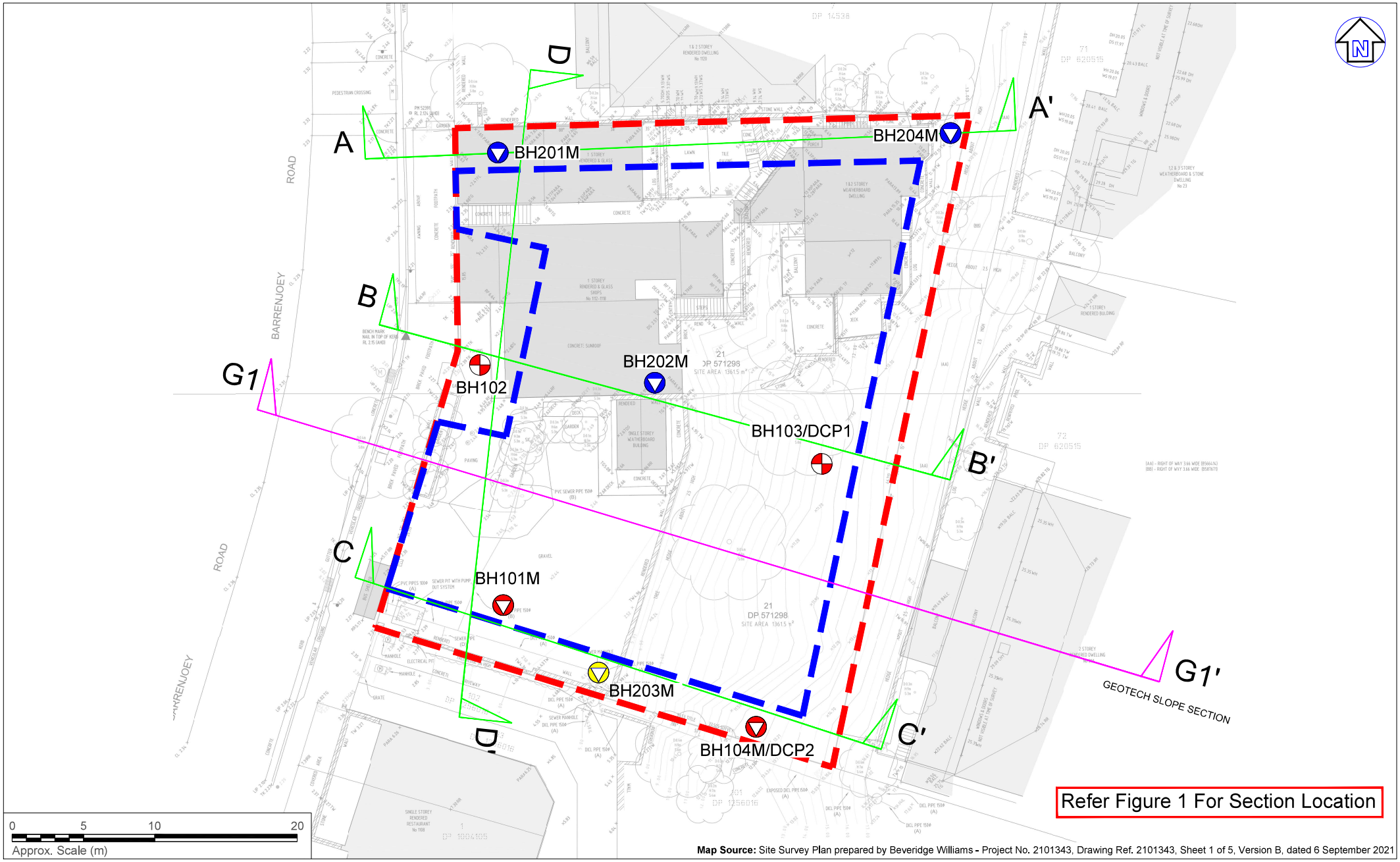
Drawn:	L.L.
Approved:	K.X.
Date:	8-8-2024

Palmdev Pty Ltd
Landslide Risk Assessment
1112-1116 Barrenjoey Road, Palm Beach NSW
Survey Plan, Sheet 2 of 2

Figure: 2.2

Project: E25203.G14



Map Source: Site Survey Plan prepared by Beveridge Williams - Project No. 2101343, Drawing Ref. 2101343, Sheet 1 of 5, Version B, dated 6 September 2021

LEGEND (Note: All locations are approximate)

- Site boundary
- Proposed basement boundary
- Location of Borehole (EI Australia, Geotechnical Investigation 2021)
- Location of Monitoring Well (EI Australia, Geotechnical Investigation 2021)
- Location of Borehole and Monitoring Well (EI Australia, Additional Geotechnical Investigation 2023)
- Location of Monitoring Well Only (EI Australia, Additional Geotechnical Investigation 2023)

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Drawn:	L.L.
Approved:	K.X.
Date:	8-8-2024

Palmdev Pty Ltd
Landslide Risk Assessment
1112-1116 Barrenjoey Road, Palm Beach NSW
Geotechnical Slope Section Plan

Figure: 3

Project: E25203.G14

Appendix A – Landslide Risk Assessment and Management

APPENDIX A

LANDSLIDE RISK ASSESSMENT & MANAGEMENT
PROPOSED DEVELOPMENT
1112 – 1116 BARRENJOEY RD PALM BEACH NSW

A1 Geotechnical Constraints/Suitability of Development

The geotechnical constraints assessed for residential development on this site comprise hazards related to slope instability risk and foundation/footing conditions for pool structures. These are discussed below.

As noted in Section 2.2 of this report, the subject site is located within an area having known landslide risk. In accordance with Northern Beaches Council's DCP, Pittwater Geotechnical Risk Management Policy (2009), a geotechnical assessment prepared by a suitably qualified expert is required as part of the Development Assessment process.

A2 Risk Analysis

The risk of slope instability for this site has been assessed using the methods of the AGS March 2007 publication *Practice Note Guidelines for Landslide Risk Management 2007* (reference 1), as shown on the attached flow chart, and in accordance with the Pittwater Geotechnical Risk Management Policy (2009), (reference 4).

Definitions of the terminology used are provided in the attachments herewith.

Important factors relating to slope conditions and the impacts of development, which commonly influence the risks of slope instability, are discussed in Appendix B attached to this report.

The assessment has been carried out by:

- Consideration of the likely slope failure mechanisms and likely initiating circumstances which could affect the elements at the site. The type or mode of landslide failure has also been classified.
- For each case, the potential consequences with respect to any existing or future development have been considered. The current assessed probability of occurrence of each event has been estimated on a qualitative basis. The consequences and probability of occurrence have been combined for each case to provide the risk assessment.

The terms used to describe the consequences, probability of occurrence and risk are defined in the attached Appendix C extract from AGS 2007 "Landslide Risk Assessment – Qualitative Terminology for Use in Assessing Risk to Property".

Extracts are provided (attached herewith) from the AGS Guidelines to illustrate the risk assessment procedure followed for this assessment.

Reference is also made to geotechnical risk assessment procedures and background presented by Walker (2002) (reference 6).

A3 Hazard Assessment

Potential hazards or slope/structure failure mechanisms considered feasible are shown in **Plate A1** and **Plate A2**, and are discussed below.

- **Hazard H1** - *rotational slump failure of the steep slope above the proposed excavation.*

The slope above the property boundary at the rear of 1112 – 1116 Barrenjoey Rd, also above the proposed excavation, is susceptible to failure from several trigger mechanisms:-

- Uncontrolled surface or subsurface water from domestic sources (eg, downpipes, broken drainage lines, overflowing roof guttering),
- Groundwater seepage,
- Unsupported excavation across the slope.

The excavation on 1112 – 1116 Barrenjoey Rd will be 3m away from the eastern (uphill) boundary.

A premise/assumption for this LRA is that the engineering design, methodology and controls for undertaking the bulk excavation on 1112 – 1116 will be properly implemented for the construction in accordance with recommendations herein, and consequently will not result in an unacceptable risk for adjoining property.

Groundwater or uncontrolled surface water flows of magnitude that would initiate a landslide movement are more than likely associated with rainfall events.

Damage to property occasioned from a slope failure of this type and scale could affect No.21A and No.23 Palm Beach Rd at a range of consequence levels as treated below in **Table A1(a).** The spatial relationship between the proposed excavation and each of the two uphill properties is shown on the slope section presented in **Plate A1.**

Table A2(a) below provides analysis for risk to life in accordance with the AGS Guidelines.

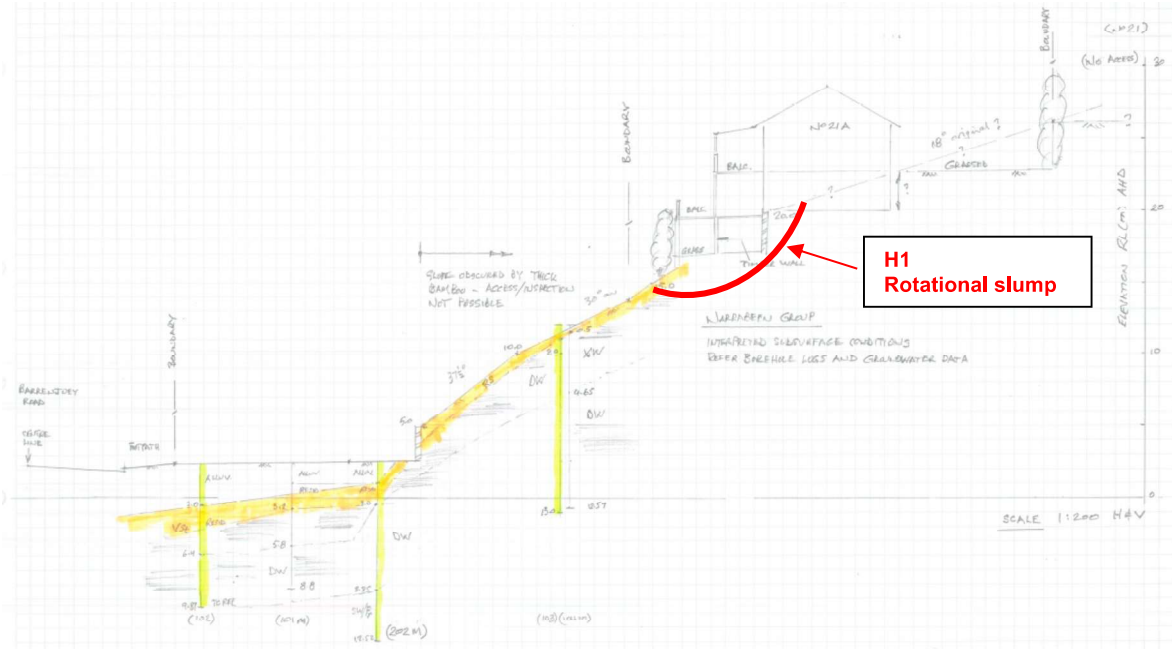

Plate A1: Hazard H1 definition.

- **Hazard H2** – *failure of temporary excavation against adjoining property boundaries*.

Notwithstanding the premise/assumption above for this LRA, namely that the engineering design, methodology and controls for undertaking the bulk excavation on 1112 – 1116 will be properly implemented in accordance with recommendations herein, potential hazards affecting the adjoining properties/developments are assessed for completeness.

The hazard assessed is a movement or failure of the pile wall excavation support system. Two scenarios are assumed:-

A. a poor standard, or no engineering controls prevail during construction, or
B. robust engineering controls are adopted and maintained during construction.

In either scenario, the wall 'failure' is assumed to occur to the scale or lateral extent away from the excavation onto the adjoining property that results in an impact on the development. The likelihood of that failure occurring is estimated for the purpose of the risk analysis.

Four excavation cross sections G2 – G5 (Plate A2 below) were selected as shown on the extract (Plate A3 below) from the site survey plan. Each cross section is discrete and has relevance to the adjoining developments as detailed in the table below.

A cross section for No.23 Palm Beach Rd was not included, as the risks associated with that property are dealt with under Hazard H1 as for No.21A Palm Beach Rd. See also **Plate A1.**

Analysis Case	Section No.	Excavation Depth (Wall Height)	Adjoining Development
H2(i)	G2	5.2m	Driveway (access to battle-axe properties) and Restaurant (“Barrenjoey House”)
H2(ii)	G3	7.0m	Driveway (access to battle-axe properties)
H2(iii)	G4	11.5m	Undeveloped slope (Lot 101) above “Barrenjoey House”
H2(iv)	G5	9.5m	House on No.1120 Barrenjoey Rd

Damage to property occasioned from a failure of the excavation support system at a range of consequence levels is treated below in **Table A1(b).** **Table A2(b)** below provides analysis for risk to life in accordance with the AGS Guidelines.

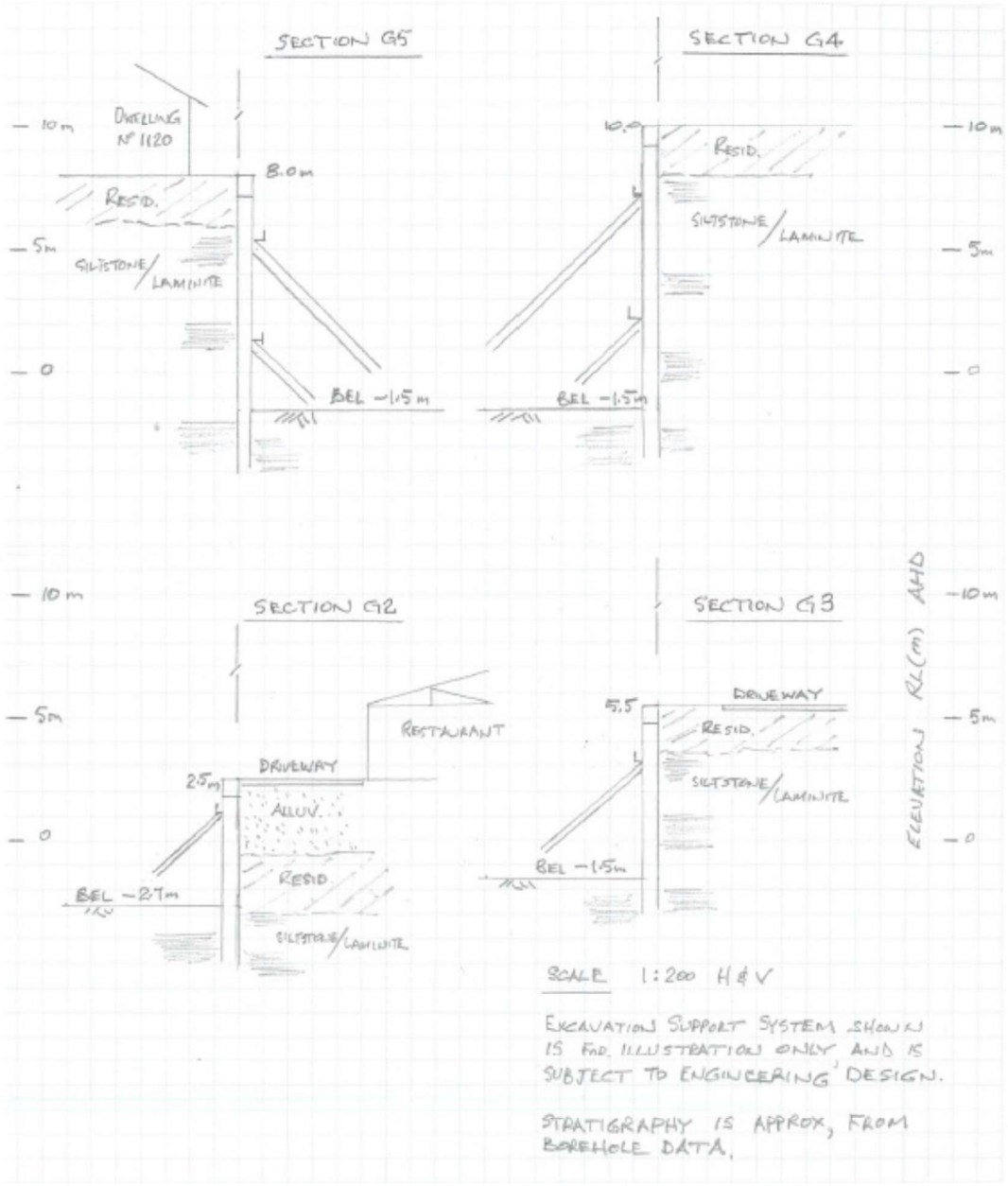

Plate A2: Hazard H2, excavation geometry, Sections G2 – G5.
[Section locations shown on **Plate A3**]

Plate A3: Section Locations (Base Survey Plan by Beveridge Williams).

- **Hazard H3 –** *failure of temporary excavation against Barrenjoey Rd boundary*.

For risk to property, this hazard is already effectively dealt with by Hazard H2(i) above. From reference to **Table A1(b)**, a risk outcome of Low Risk is determined from the estimated likelihood (Unlikely) and consequences (Minor) given good engineering controls.

For Hazard H3, if the consequence rating was increased to Medium, say to account for small-scale disruption to services in the road reserve and minor extent of pavement/footpath damage, the risk outcome remains as Low.

For pedestrians or persons in a vehicle, and good engineering controls during construction (analysis Case B), the risk for loss of life in the case of the H3 hazard increases only marginally compared to the very low level determined for H2(i), to $9x10^{-8}$ per annum (for pedestrians), as seen in **Table A2(b)**.

- **Hazard H4 –** "*larger / deep-seated slide*".

This potential hazard has been raised for consideration by Northern Beaches Council. No criteria other than the above description in quotes have been provided to define the hazard. For purposes of the risk assessment, EI assume the following:-

- the slope failure occurs on the rear (eastern) excavation face;

- the scale of failure is at least half the depth of the proposed excavation, ie, in the range of at least 6m depth or greater below the ground at the crest of excavation;
- the controlling rock structure feature is either (a) a weak seam in horizontal to sub-horizontal (say up to 5°) bedding, within the competent siltstone/laminite bedrock, having a strong persistence along and up the slope, or (b) a low-strength claystone bed, both coupled with a potential release surface forming the uphill boundary of the failure mass;
- the scale of failure causes damage to the development and the uphill property, to a Major or Catastrophic level.

Review of the borehole data available from EI's investigations (BH103, BH104M & BH204M, all located along the line of excavation at the rear boundary area of the site) reveals no evidence of a controlling weak seam or stratum in the bedrock structure.

No history of such scales of slope failure are known or have been documented by NBC in the immediate locality of the site, in the Narrabeen Group/Newport Formation geology.

In the absence of a controlling feature in the bedrock at the site, or reliable documented history of failures of this type and scale in the locality, the likelihood of such a failure occurring is considered bordering on inconceivable. Accordingly, a probability rating of Barely Credible should be taken for purposes of the risk analysis in accordance with the AGS 2007 Guidelines.

The above combination of likelihood (Barely Credible) and consequence levels (Major to Catastrophic) for the risk analysis result in a Low Risk outcome. To test the sensitivity of the AGS risk matrix, a Rare likelihood will yield no worse than a Moderate Risk outcome.

A4 Summary of Risk Outcomes

Tables A1(a), A1(b), A2(a) & **A2(b)** below and discussion in **Section A3** above provide a risk analysis and assessment for the existing development, considering credible potential geotechnical hazards.

Estimated risk levels for the proposed construction works on No.1112 – 1116 have been determined, as far as they might impact the development and adjoining property.

In summary, the outcome and conclusions of the risk assessment undertaken are as follows:

	Risk to Property Tables A1(a) & A1(b)	Risk to Life (for person most at risk) Tables A2(a) & A2(b)	Comment
Proposed Development	Very Low to Low [1]	≤ 10^{-5} *per annum* [2]	Tolerable to Acceptable

Note 1: Estimated risk levels, with good engineering controls.
Note 2: Estimated risk levels, includes some with poor engineering controls.

EI notes that acceptance criteria for landslide risk are defined in the Pittwater Geotechnical Risk Management Policy, Section 4.0 'Definitions'.

For the proposed improvement works, risks determined from this assessment, as summarised in the table above, are judged to be "**Tolerable** to **Acceptable**", based on usually accepted risk levels (up to Low Risk for property, and ≤10^{-6} per annum for Loss of Life) as recommended in AGS 2007 Table 1 and commentary therein, for 'New Development'.

In EI's opinion, appropriate engineering design and rigorous engineering controls for the basement excavation can be adopted, and should be conditioned as part of the development approval, that will achieve an **Acceptable Risk Outcome** for the development.

It is noted that the risk assessment and analyses presented for this report, and consideration of the outcome in terms of acceptance criteria, are based on the normally accepted risk levels in accordance with recommendations of AGS 2007, namely for "*the person most at risk*".

The assessed risks are subject to maintenance and/or improvement of the present site conditions as discussed in the attached report, and to further geotechnical review should these conditions alter significantly in the future.

The engineering design and construction controls for the development must have regard for the potential that higher risks than usually accepted or specified by the regulatory authority may result from a poor standard of design or a failure during construction to follow and implement minimum standards and requirements discussed in the report for safety and risk reduction.

A5 Ongoing Site Management / General Slope Maintenance / Risk Reduction

1. Drainage structures, retaining walls and general slope conditions within the property are to be inspected and maintained by the owner/proprietor in accordance with the recommendations in the table below.

Recommended Maintenance and Inspection Programme

Structure/Feature	Maintenance/Inspection Task	Frequency
Drainage Lines	Inspect to ensure line is flowing and not blocked	Every year or during and following each significant rainfall event
Drainage Pits	Inspect to ensure that pits are free of debris and sediment build-up. Clear surface grates of vegetation and litter	During normal grounds maintenance and during and following each significant rainfall event, but not less frequently than every year
Retaining Walls	Inspect walls for deviation from as-constructed condition (tilting, rotation, lateral movement), and for signs of structural distress	Every 5 years or following each significant rainfall event
	Inspect and flush drainage lines behind wall	
	Maintain collector drain along top of wall	Every year or during and following each significant rainfall event
	Maintain sealed ground surface at top of wall to prevent infiltration of surface water into drainage behind wall	
General slope areas	Inspect for possible erosion, tension cracks, fretting of rock faces or block rotation on ledges or cliff lines	Every 5 years or following each significant rainfall event

2. Maintain the functional performance of all retaining walls, and their associated drainage components, in general in accordance with the design requirements and maintenance specified on the structural drawings or other supplied details.

3. In the case of (a) retaining walls or their essential components, (b) drainage essential to slope stabilisation, or (c) other components of the development that determine the geotechnical hazards, where the structural or civil engineer responsible for design has indicated a design life of less than 100 years, the structure and/or its structural elements must be inspected by a structural or civil engineer (as appropriate) at the end of the design life. The engineer shall issue a written report identifying the required remedial measures to extend the design life of the structure and its essential components over the remaining portion of the 100 year period.

A Geotechnical Engineer should be engaged to undertake an assessment relating to slope instability risk, in accordance with the requirements of Northern Beaches Council, should changes occur to the natural site features or to the development on this or adjoining property that adversely affect the risk of slope instability of the land or the development thereon.

TABLE A1(a)

LANDSLIDE RISK ASSESSMENT – RISK TO PROPERTY, 21A PALM BEACH ROAD

POSSIBLE HAZARD				CONSEQUENCES (note 3)	ASSESSED LIKELIHOOD	RISK (note 1)	RISK TREATMENT, RISK REDUCTION AND COMMENTS
FAILURE ENVISAGED (note 2)		SCALE OF FAILURE (note 4)	INITIATING CIRCUMSTANCES				
H1	Rotational slump of steep slope	Small to Medium scale, say 10m x 3m x 5m = 150m^3	Uncontrolled surface water or seepage introduced to slope. a) Lack of slope maintenance on adjoining property b) Lack of slope maintenance on No.21A	MINOR MEDIUM	POSSIBLE UNLIKELY	M L	Maintain/improve slope and stormwater drainage.
			Excavation on No.1112 – 1116, and a failure of the support system: c) Collapse of several piles and limited slump of retained soil/XW siltstone	MEDIUM	UNLIKELY	L	Ensure robust engineering controls are employed for the design, construction and monitoring of the excavation support system, in accordance with the DA Consent.
			d) Excessive lateral movement, but under management	INSIGNIFICANT MINOR	POSSIBLE	VL M	
			e) With robust engineering controls	NIL to INSIGNIFICANT	RARE	VL	

Notes

1 The above risk assessment addresses the consequences to property from potential landslide events considered relevant to the subject site and the proposed development. The risk assessment is based on a limited visual appraisal only (where undertaken), as discussed in the report. Further assessment or quantification of the assessed geotechnical risks for the subject property may require additional data and/or investigation.

2 Refer above in **Appendix A** and to **Plate A1** of this report for description and illustration of possible hazards/slope failure mechanisms.

3 The consequences assessed for the proposed development assume the structure is designed, constructed and maintained in accordance with all relevant recommendations of this report.

4 Scale of Failure based on TfNSW Guide to Slope Risk Analysis 2014 (reference 9)

Refer to report and attachments for definition and explanation of terms used in the risk assessment.

TABLE A1(b)

LANDSLIDE RISK ASSESSMENT – RISK TO PROPERTY, ADJOINING DEVELOPMENTS

POSSIBLE HAZARD					CONSEQUENCE (note 3)	ASSESSED LIKELIHOOD	RISK (note 1)	RISK TREATMENT, RISK REDUCTION AND COMMENTS
FAILURE ENVISAGED (note 2)		SCALE OF FAILURE (note 5)	INITIATING CIRCUMSTANCES (note 4)					
H2	Tilting movement of excavation support wall, possibly extending to a 'failure' condition. 'Failure' condition defined as sufficient to result in a scale or lateral extent of ground movement away from the excavation onto the adjoining property that results in an impact on the development, ie a consequence level as per Column 5 in this Table.	Small to Medium scale, say 10m x 3m x 5m = 150m^3	(i)	A	INSIGNIFICANT	LIKELY	L	Maintain/improve slope and stormwater drainage. Ensure robust engineering controls are employed for the design, construction and monitoring of the excavation support system, in accordance with the DA Consent.
						POSSIBLE	VL	
					MINOR	LIKELY	M	
						POSSIBLE	M	
				B	MINOR	UNLIKELY	L	
						RARE	VL	
			(ii)	A	MINOR	LIKELY	M	
						POSSIBLE	M	
				B	MINOR	UNLIKELY	L	
						RARE	VL	
			(Iii)	A	INSIGNIFICANT	LIKELY	L	
						POSSIBLE	VL	
				B	INSIGNIFICANT	UNLIKELY	VL	
						RARE	VL	

[continued]

TABLE A1(b)

LANDSLIDE RISK ASSESSMENT – RISK TO PROPERTY, ADJOINING DEVELOPMENTS

POSSIBLE HAZARD					CONSEQUENCE (note 3)	ASSESSED LIKELIHOOD	RISK (note 1)	RISK TREATMENT, RISK REDUCTION AND COMMENTS
	FAILURE ENVISAGED (note 2)	SCALE OF FAILURE (note 5)	ANALYSIS CASE (note 4)					
H2	Tilting movement of excavation support wall, possibly extending to a 'failure' condition. 'Failure' condition defined as sufficient to result in a scale or lateral extent of ground movement away from the excavation onto the adjoining property that results in an impact on the development, ie a consequence level as per Column 5 in this Table.	Small to Medium scale, say 10m x 3m x 5m = 150m^3	(iv)	A	MEDIUM	LIKELY	H	Maintain/improve slope and stormwater drainage. Ensure robust engineering controls are employed for the design, construction and monitoring of the excavation support system, in accordance with the DA Consent.
						POSSIBLE	M	
				B		UNLIKELY	L	
						RARE	L	
				A	MAJOR	LIKELY	VH	
						POSSIBLE	H	
				B		UNLIKELY	M	
						RARE	L	
H3	Refer H2(i), above in this table						VL to M	
H4	"Larger / deep-seated slide"	Medium scale, say 6m x 10m x 20m = 1,200m^3	Controlling horizontal to sub-horizontal rock structure - weak seam/low-strength claystone bed with strong persistence along and up the slope, coupled with a potential release surface forming an uphill boundary.		MAJOR to CATASTROPHIC	BARELY CREDIBLE	L	Geotechnical investigation boreholes to inform the engineering design for temporary and permanent excavation support. Geotechnical inspection plan during staged excavation, in accordance with a detailed engineering methodology to be determined for CC purposes prior to commencement of excavation.
						RARE	M	

Notes

1 The above risk assessment addresses the consequences to property from potential landslide events considered relevant to the subject site and the proposed development. The risk assessment is based on a limited visual appraisal only (where undertaken), as discussed in the report. Further assessment or quantification of the assessed geotechnical risks for the subject property may require additional data and/or investigation.

2 Refer above in **Appendix A** and to **Plate A2** of this report for description and illustration of possible hazards/slope failure mechanisms.

3 The consequences assessed for the proposed development assume the structure is designed, constructed and maintained in accordance with all relevant recommendations of this report.

4 (i) to (iv) are explained under Hazard 2 in A3 above. (A) is "*poor standard, or no engineering controls prevail during construction*". (B) is "*robust engineering controls are adopted and maintained during construction*".

5 Scale of Failure based on TfNSW Guide to Slope Risk Analysis 2014 (reference 9)

Refer to report and attachments for definition and explanation of terms used in the risk assessment

TABLE A2(a)
LANDSLIDE RISK ASSESSMENT – RISK TO LIFE
E25203

ACCEPTANCE CRITERION

Hazard (note 2) H1	Likelihood	Indicative Annual Probability (note 3) $P_{(H)}$	Use of Affected Structure	Probability of Spatial Impact $P_{(S:H)}$	Occupancy N	Case	Proportion of Time (refer below) $P_{(T:S)}$	Probability of Not Evacuating $P_{(NE:S)}$	Vulnerability (note 4) $V_{(D:T)}$	Risk Outcome (note 5) Person Most at Risk $R_{(DI)}$	Total Risk $R_{(T)}$	Sum of Total Risks	Average of Persons Most at Risk $R_{(AV)}$	Risk Evaluation (note 6)
(a)	Possible	1.00E-03	dwelling	0.1	2	3	0.5	0.1	0.1	5.00E-07				acceptable
(b)	Unlikely	1.00E-04	dwelling	0.5	2	3	0.5	1	0.1	2.50E-06				tolerable
(c)	Unlikely	1.00E-04	dwelling	0.5	2	3	0.5	1	0.1	2.50E-06				tolerable
	Rare	1.00E-05	dwelling	0.5	2	3	0.5	1	0.1	2.50E-07		Not Determined		acceptable
(d)	Possible	1.00E-03	dwelling	0.1	2	3	0.5	0.1	0.1	5.00E-07				acceptable
(e)	Rare	1.00E-05	dwelling	0.05	2	3	0.5	0.1	0.1	2.50E-09				acceptable
									Individual Risk (total for all hazards)	6.25E-06				

[See below for Analysis Cases and Notes]

TABLE A2(b)
LANDSLIDE RISK ASSESSMENT – RISK TO LIFE
E25203

ACCEPTANCE CRITERION

Hazard (note 2)	Likelihood	Indicative Annual Probability (note 3) $P_{(H)}$	Use of Affected Structure	Probability of Spatial Impact $P_{(S:H)}$	Occupancy N	Case	Proportion of Time (refer below) $P_{(T:S)}$	Probability of Not Evacuating $P_{(NE:S)}$	Vulnerability (note 4) $V_{(D:T)}$	Risk Outcome (note 5) Person Most at Risk $R_{(DI)}$	Total Risk $R_{(T)}$	Sum of Total Risks	Average of Persons Most at Risk $R_{(AV)}$	Risk Evaluation (note 6)
H2(i)	Likely	1.00E-02	driveway	1	2	1 (G2)	0.007	1	0.1	7.00E-06	Not Determined			tolerable
	Unlikely	1.00E-04		1	2	1 (G2)	0.007	1	0.1	7.00E-08				acceptable
H2(ii)	Likely	1.00E-02	driveway	0.2	2	1 (G3)	0.007	1	0.1	1.40E-06				tolerable
	Unlikely	1.00E-04		0.2	2	1 (G3)	0.007	1	0.1	1.40E-08				acceptable
H2(iii)	Likely	1.00E-02	vacant land	0.1	2	2 (G4)	0.03	0.1	0.1	3.00E-07				acceptable
	Unlikely	1.00E-04		0.1	2	2 (G4)	0.03	0.1	0.1	3.00E-09				acceptable
H2(iv)	Likely	1.00E-02	dwelling	0.5	2	3 (G5)	0.5	1	0.1	2.50E-04				not tolerable
	Rare	1.00E-05		0.5	2	3 (G5)	0.5	1	0.1	2.50E-07				acceptable
H3 (4a)	A-Likely	1.00E-02	BJ Road	1	4	1 (G2)	0.09	0.1	0.1	9.00E-06				tolerable
	B-Unlikely	1.00E-04	(pedestrian)	1	4	1 (G2)	0.09	0.1	0.1	9.00E-08				acceptable
H3 (4b)	A-Likely	1.00E-02	BJ Road	0.2	4	N/A	0.04	1	0.05	4.00E-06				tolerable
	B-Unlikely	1.00E-04	(vehicle)	0.2	4	N/A	0.04	1	0.05	4.00E-08				acceptable
H4	Barely Credible	1.00E-06	dwelling	1	2	3	0.5	1	0.5	2.50E-07				acceptable
									Individual Risk (total for all hazards)	2.72E-04				

[See below for Analysis Cases and Notes]

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Analysis Cases:

Use of Area		$P_{(T:S)}$	Comments
1. Driveway	Access to 3 residential allotments above "Barrenjoey House". Assume total 60 vehicle passages per day (20/residence). Assume a 10 second exposure at the excavation each passage (1.2×10^{-4} of a year).	$60 \times 1.2 \times 10^{-4} = 0.007$	Distance of driveway from property boundary varies (refer Sections G2 and G3).
2. Vacant land Lot 101	Assume 2 persons for land maintenance 8hrs/day, 12 days/year, plus an occasional 'visitor' 1hr/day, 120 days/year	0.02 + 0.01 = 0.03	
3. Dwelling	Assume 2 persons in residence, 12hrs/day, 365 days/year	0.5	A 'worst case' assumption can be tested where the person most at risk is 'house-bound', ie, 24hrs/day, 365 days per year, and $P_{(T:S)} = 1.0$. For this case, the governing risk outcome for 'persons in the dwelling' would be $R_{(DI)} = 2.5 \times 10^{-6}$ per annum (from Table A2(a)).
4. Barrenjoey Rd	(a) Pedestrians - assume 250 persons per day and a 30 second exposure at the excavation (3.6×10^{-4} of a year).	0.09	
	(b) Person in vehicle – assume 1,000 vehicles per day passing the excavation site south-bound on BJ Road, at 30kph, and a 30m length of excavation affected by the failure extending out to the traffic lane. Time for 1 vehicle to travel 30m = 0.001hrs. Cumulative time for 1,000 vehicles = 1hr per day, say every day of a year = 1/24 of a year = 0.04	0.04	The assumed daily traffic is within the T3 category for Temporal Probability Rating of the TfNSW Guide to Slope Risk Analysis V4 2014, Figure 10 (reference 9).

Notes for Table A2(a) and Table A2(b)

1 The risk assessment addresses potential for fatality from possible landslide events considered relevant to the subject site. The risk assessment is based on a visual appraisal, as discussed in the attached report. Further assessment or more detailed quantification of the assessed risks to life would require additional data and/or further investigation.

2 Refer to **Table A1** for description of hazards.

3 $P_{(H)}$ based on values in table "Qualitative Measures of Likelihood" in Appendix C of AGS 2007.

4 Vulnerability factors derived from AGS 2007, Appendix F.

5 $R_{(DI)} = P_{(H)} \times P_{(S:H)} \times P_{(T:S)} \times P_{(NE:S)} \times V_{(D:T)}$; $R_{(T)} = R_{(DI)} \times N$; $R_{(AV)} = \Sigma R_{(T)} / \Sigma N$

6 Refer to Local Authority's Geotechnical Risk Management Policy (for the Person Most at Risk). Tolerable risk level determined for Existing Slope / Existing Development (Table 1, AGS 2007 Guidelines).

Tolerable $\leq 10^{-4}$ Acceptable $\leq 10^{-5}$ **xxx** not tolerable, treatment options to be assessed and implemented.

7 Refer to report and attachments for definition and explanation of terms used in the risk assessment.

8 The hazard/failure mechanisms adopted for the risk analysis may vary when detailed subsurface investigation is carried out. Probability and scale of failure, and conditional probabilities should the event occur, are likely to change and affect the risk outcomes. The above risk analyses should be reviewed in the light of any investigations being undertaken, or any new data becoming available.

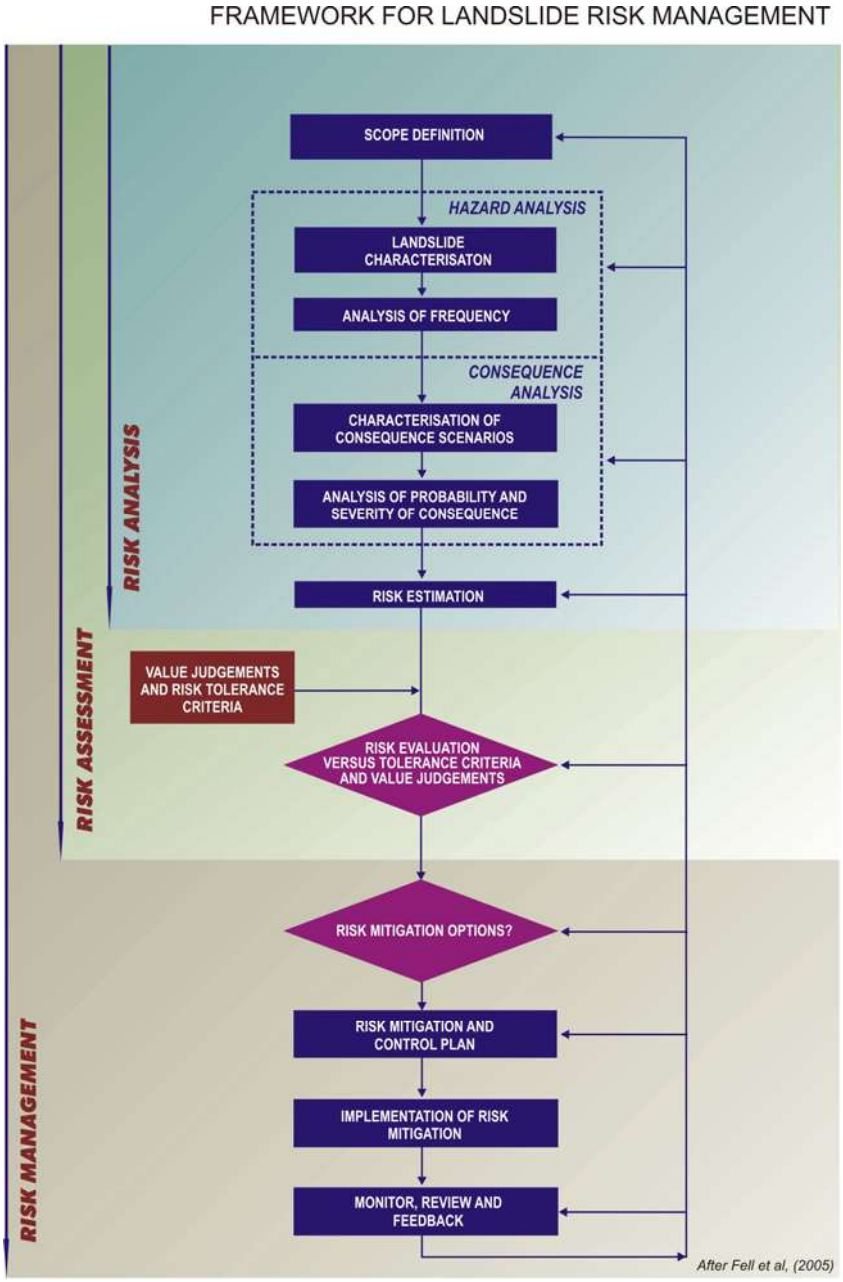


Figure 1.

The Framework for LRM presented in Figure 1 is similar to the flow chart in AGS (2000). However, it has been simplified in presentation and has been amended slightly from AGS (2000) to reflect the inclusion of Frequency Analysis as part of Hazard Analysis (in accordance with the abovementioned definition of hazard and as defined in AGS 2000).

Definitions for associated terminology have also been included in Appendix A together with an explanation of Landslide Risk as presented in AGS Australian GeoGuide LR7.

PART B GUIDELINES FOR REGULATORS

3 GUIDELINES FOR REGULATORS

3.1 BACKGROUND

The term landslide denotes *"the movement of a mass of rock, debris or earth down a slope"*. The phenomena described as landslides are not limited to either "land" or to "sliding" and usage of the word has implied a much more extensive meaning than its component parts suggest. The rates of movement cover the full range from very rapid to extremely

Picarellei, L., Oboni, F., Evans, S.G., Mostyn, G. and Fell, R., (2005) *"Hazard characterization and quantification"* Proc Int Conf on Landslide Risk Management, Vancouver, 31 May-3 June 2005, AA Balkema Publ, O. Hungr, R. Fell, R. Couture and E. Eberhardt eds., pp681

Varnes, D.J. and The International Association of Engineering Geology Commission on Landslides and other Mass Movements (1984). Landslide Hazard Zonation: A review of principles and practice. Natural Hazards, Vol 3, Paris,France. UNESCO, 63p.

Standards Australia (1996) *"Residential Slabs and Footings"* Australian Standard AS2870

Standards Australia (2001) *"Concrete Structures"* Australian Standard AS3600

Standards Australia (2001) *"Steel Structures"* Australian Standard AS4100

Standards Australia (2002) *"Earth Retaining Structures"* Australian Standard AS4678.

APPENDIX A - DEFINITION OF TERMS AND LANDSLIDE RISK

RISK TERMINOLOGY

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, 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.

There 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.

(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.

ASSOCIATED TERMINOLOGY

Importance Level – of a building or structure is directly related to the societal requirements for its use, particularly during or following extreme events. The consequences with respect to life safety of the occupants of buildings are indirectly related to the Importance Level, being a result of the societal requirement for the structure rather than the reason *per se* of the Importance Level.

Authority or **Council** having statutory responsibility for community activities, community safety and development approval or management of development within its defined area/region.

The **Regulator** will be the responsible body/authority for setting Acceptable/Tolerable Risk Criteria to be adopted for the community/region/activity, which will be the basis for setting levels for Acceptable and Tolerable Risk in the application of the risk assessment guidelines.

Importance Level of Structure	Explanation	Examples (Regulatory authorities may designate any structure to any classification type when local conditions make such desirable)
1	Buildings or structures generally presenting a low risk to life and property (including other property).	Farm buildings. Isolated minor storage facilities. Minor temporary facilities. Towers in rural situations.
2	Buildings and structures not covered by Importance Levels 1, 3 or 4.	Low-rise residential construction. Buildings and facilities below the limits set for Importance Level 3.
3	Buildings or structures that as a whole may contain people in crowds, or contents of high value to the community, or that pose hazards to people in crowds.	Buildings and facilities where more than 300 people can congregate in one area. Buildings and facilities with primary school, secondary school or day-care facilities with capacity greater than 250. Buildings and facilities for colleges or adult education facilities with a capacity greater than 500. Health care facilities with a capacity of 50 or more residents but no having surgery or emergency treatment facilities. Jails and detention facilities. Any occupancy with an occupant load greater than 5,000. Power generating facilities, water treatment and waste water treatment facilities, any other public utilities not included in Importance Level 4. Buildings and facilities not included in Importance Level 4 containing hazardous materials capable of causing hazardous conditions that do not extend beyond property boundaries.
4	Buildings or structures that are essential to post-disaster recovery, or with significant post-disaster functions, or that contain hazardous materials.	Buildings and facilities designated as essential facilities. Buildings and facilities with special post-disaster functions. Medical emergency or surgery facilities. Emergency service facilities: fire, rescue, police station and emergency vehicle garages. Utilities required as back-up for buildings and facilities of Importance Level 4. Designated emergency shelters. Designated emergency centres and ancillary facilities. Buildings and facilities containing hazardous (toxic or explosive) materials in sufficient quantities capable of causing hazardous conditions that extend beyond property boundaries.

(from BCA Guidelines)

Practitioner – A specialist Geotechnical Engineer or Engineering Geologist who is degree qualified, is a member of a professional institute and who has achieved chartered professional status – being either Chartered Professional Engineer (CPEng) within the Institution of Engineers Australia, Chartered Professional Geologist (CPGeo) within the Australasian Institute of Mining & Metallurgy, or Registered Professional Geoscientist (RPGeo) within the Australian Institute of Geoscientists – specifically with Landslide Risk Management as a core competency.

A Practitioner will include persons qualified under the Institution of Engineers Australia NPER – LRM register.

It would normally be required that the Practitioner can demonstrate an appropriate minimum period of experience in the practice of landslide risk assessment and management in the geographic region, or can demonstrate relevant experience in similar geological settings.

Regulator – The regulatory authority [Federal Government/ State Government/ Instrumentality/ Regional/Local.

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}	$5x10^{-3}$	100 years	200 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	$5x10^{-4}$	1000 years	2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	$5x10^{-5}$	10,000 years	20,000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	$5x10^{-6}$	100,000 years	200,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}		1,000,000 years		The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

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

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

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

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

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

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

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 B – Important Factors Influencing the Stability of Slope for Urban/Residential Development

B1 Limitations of the Assessment Procedure

The assessment procedures carried out for this appraisal are in accordance with the recommendations of the AGS Risk Classification System described in Appendix A, and with accepted local practice. The following limitations must be acknowledged:-

- The assessment of the stability of natural slope requires a great degree of judgment and personal experience, even for experienced practitioners with good local knowledge;
- The assessment must be based on development of a sound geological model; slope processes and process rates influencing landsliding or landslide potential will vary according to geomorphological influences;
- The likelihood that landsliding may occur on a given slope is generally hard to predict and is associated with significant uncertainties;
- Different practitioners may produce different assessments of risk;
- Actual risk of landsliding cannot be determined; risk changes with time;
- Consequences of landsliding need to be considered in a rational framework of risk acceptance;
- Acceptable risk in relation to damage to property from landslide activity is subjective; it remains the responsibility of the owner and/or local authority to decide whether the risk is acceptable; the geotechnical practitioner can assist with this judgement;
- The extent and methods of investigation for assessment of landslide risk will be governed by experience, by the perceived risk level, and by the degree to which the risk or consequences of landsliding are accepted for a specific project.
- The assessment may be required at a number of stages of the project or development; frequently (due to time or budget constraints imposed by the client) there will be no opportunity for long-term monitoring of the slope behaviour or groundwater conditions, or for on-going opportunity for the slope processes and performance of structures to be reviewed during and after development; such limitations should be recognised as relevant to the assessment.

B2. Slope Instability

In most of the reported sandstone slope failures in the Sydney Basin region, the cause of failure may be traced to one of the following factors:

- Interference with natural drainage features;
- Introduction of additional water pressure behind the rock defects;
- Progressive weathering and erosion through the rock defects; and
- Addition of soil or rock to the existing slope.

There have been some slope failures with no immediately apparent cause and it is our opinion that these failures resulted from natural changes in the weathering and erosion conditions in the slope during or some time after very heavy or prolonged periods of rainfall.

B3 Development on Slopes

B3.1 General

Some risk of slope instability is always attached to the development of land on slopes. Appendix A explains the various levels of risk normally expected for development of land on such slopes.

Two attachments are provided below which provide guidance on good practice measures for developments on hillslopes.

B3.2 Effects of Construction on Slope Stability

The stability of apparently stable land may be adversely affected by various activities on the land or in the vicinity, as follows:

- The diversion of surface water onto the land by new roads, houses, landscaping, or other construction activities,
- The placing of filling either above or beside the land,
- The excavation or removal of soil or rock from the area below (downhill) of the land,
- The construction of absorption areas for stormwater or effluent, or other systems whereby liquids are introduced into the soil and rock.

B3.3 Effects of Drainage on Slope Stability

Good surface and subsurface drainage will almost always improve the stability of a slope. Where a new structure, modifications to an existing structure or landscaping is proposed over a slope, it is highly likely that some form of surface or subsurface drainage will be required to maintain or improve the stability of the slope.

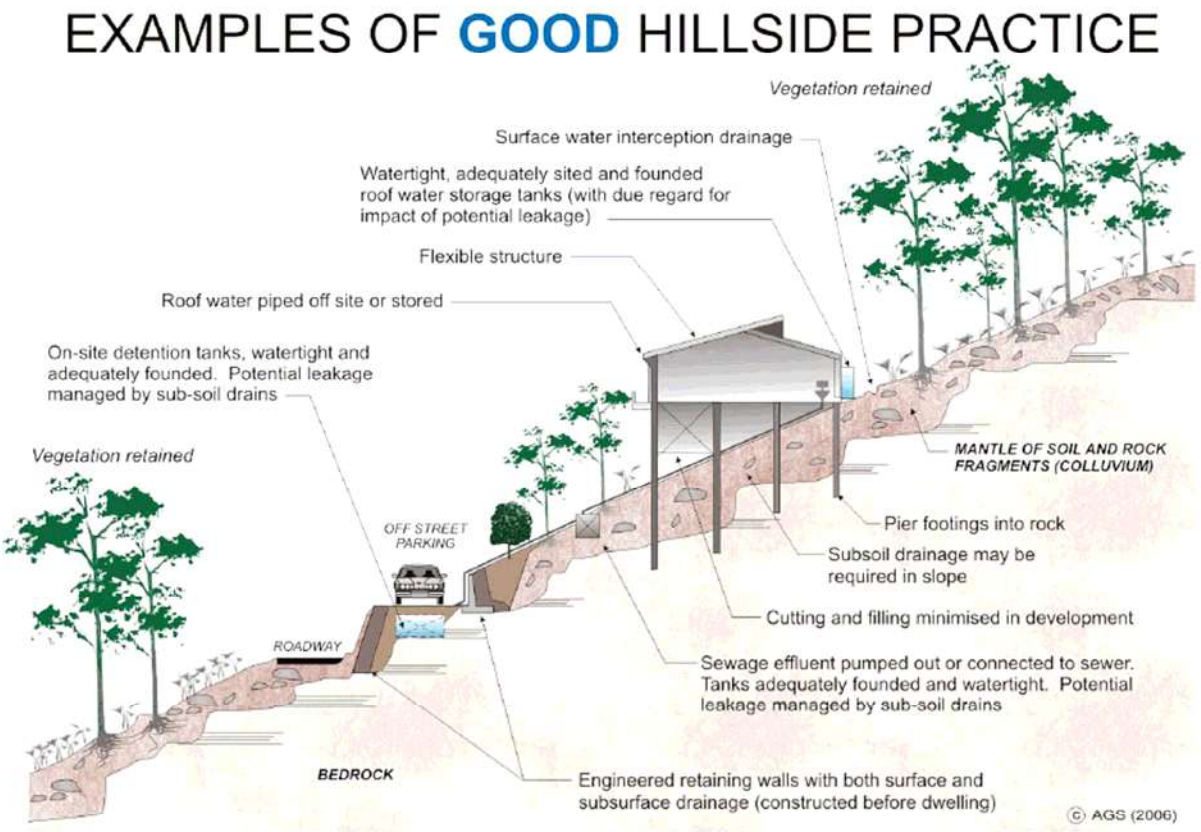
A geotechnical engineer should review all proposed construction, developments or alterations on slopes, to assess the effect on slope stability and any required drainage.

Extracts "*Some Guidelines for Hillside Construction"* and "*Examples of Good and Poor Hillside Practice"* are attached from the AGS 2007 Guidelines.

Attach: 2pp

APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

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


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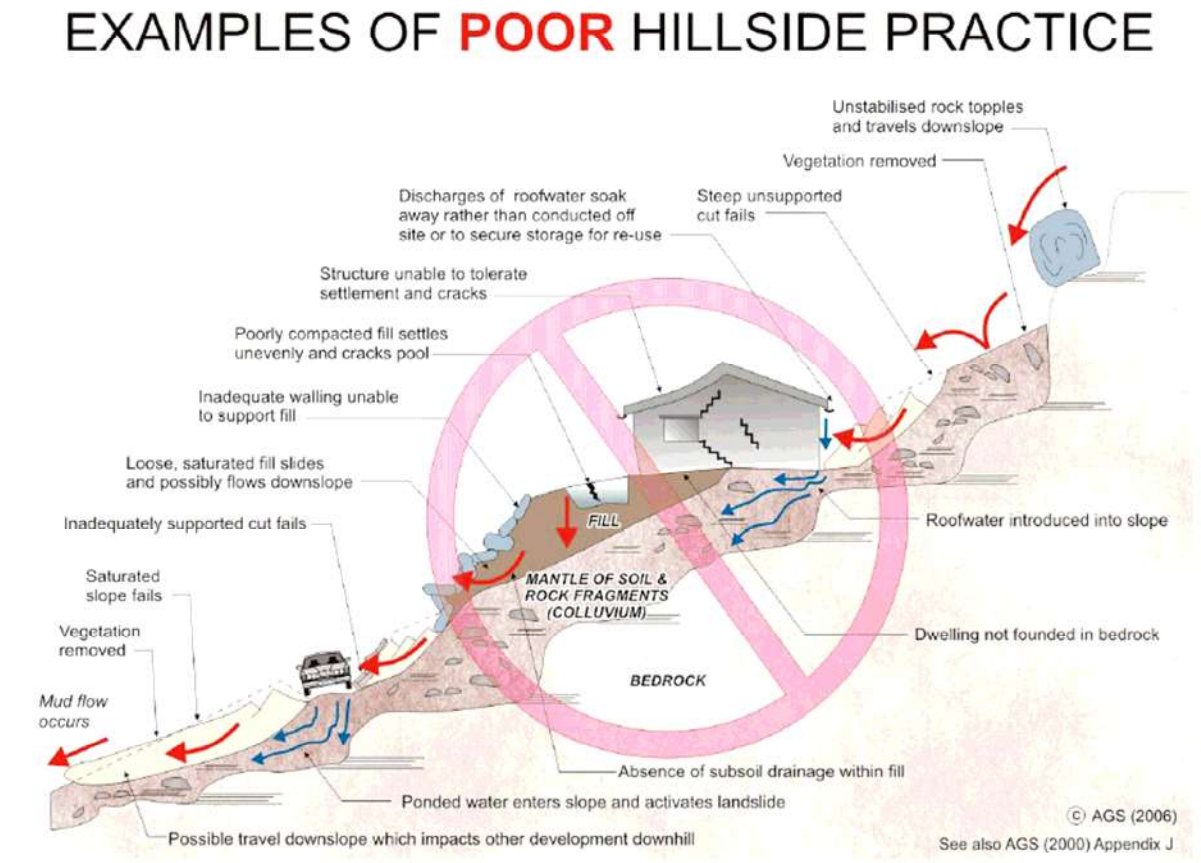
EXAMPLES OF POOR HILLSIDE PRACTICE
Unstabilised rock topples and travels downslope
Vegetation removed
Discharges of roofwater soak away rather than conducted off site or to secure storage for re-use
Steep unsupported cut fails
Structure unable to tolerate settlement and cracks
Poorly compacted fill settles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

Appendix C – Important Information

Important Information

SCOPE OF SERVICES

The geotechnical report ("the report") has been prepared in accordance with the scope of services as set out in the contract, or as otherwise agreed, between the Client And EI Australia ("EI"). The scope of work may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

RELIANCE ON DATA

EI has relied on data provided by the Client and other individuals and organizations, to prepare the report. Such data may include surveys, analyses, designs, maps and plans. EI has not verified the accuracy or completeness of the data except as stated in the report. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations ("conclusions") are based in whole or part on the data, EI will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to EI.

GEOTECHNICAL ENGINEERING

Geotechnical engineering is based extensively on judgment and opinion. It is far less exact than other engineering disciplines. Geotechnical engineering reports are prepared for a specific client, for a specific project and to meet specific needs, and may not be adequate for other clients or other purposes (e.g. a report prepared for a consulting civil engineer may not be adequate for a construction contractor). The report should not be used for other than its intended purpose without seeking additional geotechnical advice. Also, unless further geotechnical advice is obtained, the report cannot be used where the nature and/or details of the proposed development are changed.

LIMITATIONS OF SITE INVESTIGATION

The investigation programme undertaken is a professional estimate of the scope of investigation required to provide a general profile of subsurface conditions. The data derived from the site investigation programme and subsequent laboratory testing are extrapolated across the site to form an inferred geological model, and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour with regard to the proposed development. Despite investigation, the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies. The engineering logs are the subjective interpretation of subsurface conditions at a particular location and time, made by trained personnel. The actual interface between materials may be more gradual or abrupt than a report indicates.

SUBSURFACE CONDITIONS ARE TIME DEPENDENT

Subsurface conditions can be modified by changing natural forces or man-made influences. The report is based on conditions that existed at the time of subsurface exploration. Construction operations adjacent to the site, and natural events such as floods, or ground water fluctuations, may also affect subsurface conditions, and thus the continuing adequacy of a geotechnical report. EI should be kept appraised of any such events, and should be consulted to determine if any additional tests are necessary.

VERIFICATION OF SITE CONDITIONS

Where ground conditions encountered at the site differ significantly from those anticipated in the report, either due to natural variability of subsurface conditions or construction activities, it is a condition of the report that EI be notified of any variations and be provided with an opportunity to review the recommendations of this report. Recognition of change of soil and rock conditions requires experience and it is recommended that a suitably experienced geotechnical engineer be engaged to visit the site with sufficient frequency to detect if conditions have changed significantly.

REPRODUCTION OF REPORTS

 Where information from the accompanying report is to be included in contract documents or engineering specification for the project, the entire report should be included in order to minimize the likelihood of misinterpretation from logs.

REPORT FOR BENEFIT OF CLIENT

The report has been prepared for the benefit of the Client and no other party. EI assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of EI or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own inquiries and obtain independent advice in relation to such matters.

OTHER LIMITATIONS

EI will not be liable to update or revise the report to take into account any events or emergent circumstances or fact occurring or becoming apparent after the date of the report.