Douglas Partners

Geotechnics | Environment | Groundwater

Integrated Practical Solutions

Report on
Geotechnical Investigation

Proposed Additions and Alterations
35 Kanimbla Crescent, Bilgola Plateau

Prepared for
Adam and Hilde Rutherford

Project 99804.00
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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
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Report on Geotechnical Investigation
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1. Introduction

This report presents the results of a geotechnical investigation undertaken for the proposed additions and alterations at 35 Kanimbla Crescent, Bilgola Plateau. The investigation was commissioned in an email dated 25 August 2020 from Tom Dunsford of Utz Sansby Architects, acting for the owners, Adam and Hilde Rutherford. The investigation was undertaken in accordance with Douglas Partners' proposal SYD200951 dated 1 September 2020.

It is understood that this report will accompany a Development Application (DA) to Northern Beaches Council and has therefore been compiled to comply with (Pittwater) Council's 'Geotechnical Risk Management Policy' (GRMP) dated July 2009 (Reference 1). The GRMP-2009 identifies the entire property as lying within Hazard Zone H1.

It is understood that the proposed works consist of:

- The addition of a new level to the existing residence to create a three-level residence including a car port at road side; and
- Excavating to a maximum depth of about 3 m into the slope to create further living space within the lowest level;

The investigation comprised a site walkover and five Dynamic Cone Penetrometer (DCP) tests. Details of the field work are given in the report, together with relevant comments relating to design and construction practices including excavation, excavation support and foundations. Reference has also been made to the following documents:

- Design drawings by Utz Sansby Architect, job number 1920, 9, 10, DA-000, DA-100, DA-101, DA102, revision number DA-A dated 05.7.21

2. Site Description and Geology

The property is located on the lower, south-westerly side of Kanimbla Crescent and slopes down from the road to the neighbouring property at 12 Hillslope Road. The site is approximately rectangular in shape with a width of about 18 m (parallel to the road) and a length of about 42 m. The site is bounded by residential houses to the north and south.

The site falls steeply from the road down to the neighbouring property, in a south-westerly direction. An existing house on the property is located on exposed rock within upper part of the site. Existing slopes observed are typically sloping at between 37 to 24 degrees from horizontal. Above the property the slope gradient decreases to 11 degrees and carries up to the crest of the hill along Monterey Road.

From the road frontage a concrete driveway leads to a one level elevated detached carport and sleepout room on the uphill side of the house. The area to the west and north between the carport and house has been terraced with a series of mixed wood and masonry walls creating garden and entertaining spaces. Access to the main entrance of the house is via wooden steps through the terraced garden area. Around the south of the residence a deck has been built on the first level of the house. Steps lead down from the northern end of the deck and pass sandstone outcrops located beneath the first and lower levels of the residence to a grassed sloped area beneath the house. There is a sandstone rock face at the back of the utility room on the lower level. Sandstone outcrops are also present beneath the lower level of the house. A retaining wall runs along the southern half of the sandstone outcrop beneath the house to level off the area. Sandstone outcrops are also present beneath the neighbouring property- foundations to the north and south. Sandstone outcrops and large sandstone boulders are present further down the grassed slope below the residence. At the base of the grassed slope an unfinished steel posted retaining wall is currently being constructed.

The two-storey brick and timber house is in good condition with minimal evidence of cracking or movement. It appears that most of the residence foundations are brick footings founded on top of rock.

Reference to the Geological Survey of NSW 1:100 000 Geological Series Sheet for Sydney indicates that the site is underlain by Hawkesbury Sandstone of the Triassic Period, which comprises medium to coarse, quartz sandstone with minor shale lenses. The Hawkesbury Sandstone is typically pale to mid-grey in colour when fresh and has both massive and cross-bedded units with strength properties mainly in the medium to high strength range. The rock is prone to weathering with red-brown or brown iron-staining of the upper beds.

The Hawkesbury Sandstone typically contains two main joint sets, being:

- SET 1 – NNE-striking joints dipping 80° to 90° generally to the west (although some dip to the east), spaced between about 1 m and 10 m and persistent over many metres; and
- SET 2 – ESE-striking joints dipping 80° to 90° to the north and south, generally spaced greater than 2 m to 3 m and generally discontinuous and strata-bound.

Low-angle (25° to 35°) thrust faults, commonly dipping to the north or south are present locally, as are thin (0.5 m to 1.0 mwide), highly weathered dykes of igneous rocks.

Colour photographs in Appendix B depict the site at the time of the field work (September 2020).

3. Field Work

3.1 Field Work Methods

The field work comprised a detailed inspection of the property and five Dynamic Cone Penetrometer (DCP) tests. The inspection was undertaken by a geotechnical engineer on 3 September 2020. The locations and elevations of tests were estimated from the survey drawings. The locations of the DCPs are shown on Drawing 1, in Appendix B.

3.2 Site Observations

The main site observations are:

- The external brick walls of the garage and house display no significant movement or deflection;
- The retaining walls on the uphill side and the decking areas to the south of the house display no visible signs of movement and appear stable;
- From what could be seen beneath the house it appears that the small brick footings are founded on bed rock. The footings appear to be in good condition (refer to Photo 1 & 2);
- An unfinished steel post retaining wall is located at the base of the slope (refer to Photo 3);
- The decking structure appears to be supported by steel posts founded on bedrock (Refer to Photo 4);
- A concrete post and wood retaining wall founded on bedrock beneath the house appears to be in good condition (refer to photo 5). This retaining wall appears to have been constructed to allow a bench to be formed beneath the house;
- Sandstone outcrops and boulders are located down slope of the house (refer to Photo 6). A large boulder that is 5 m by 4 m wide is located along the northern boundary, directly above the unfinished retaining wall;
- An existing steel storm-water pipe discharges water directly above the large sandstone boulder (refer to drawing 1 for location); and
- Medium strength sandstone is exposed as outcrops along Kanimbla Crescent to the north of the property.

3.3 Dynamic Cone Penetrometer Results

A total of five DCPs were undertaken at the locations shown on Drawing 1. The tests were terminated at depths between 0.3 m to 2.2 m where refusal was encountered. The detailed results of the DCPs are given in Appendix B. It should be noted that, while the DCPs are expected to reach refusal on rock, they may also refuse on cobbles or boulders included within the soil profile.

4. Proposed Development

The footprint of the proposed new development is indicated on Drawing 1. It is understood that the proposed development will comprise:

- An extra floor is to be added above the existing house with the current first and lower floors being retained within the new design, giving rise to a three-level timber and metal-clad residence;
- The residence will be excavated a maximum of 3 m into the existing slope below the relocated carport and 2.5 m into the existing slope behind the existing lower level to create further living space; and
- Stormwater drainage will be directed via pipes and appropriately sized detention tanks into the council stormwater system running along the base of the property.

5. Comments

5.1 Interpreted Geotechnical Model

Based on the observations made on site and the results of probing with the DCPs, the interpreted geological model for the property comprises a steep sloping site, with sandstone bedrock beneath the footprint of the existing residence. Down-slope of the residence there is possibly up to 2.2 m deep soil including filling or colluvium, overlying sandstone bedrock. It should be noted that the the slope below the residence contains areas of rock outcrop and or large boulders at the at the surface of the slope.

The DCPs indicate that typically the upper 0.3 m to 1.0 m is loose filling and the underlying colluvial clay soils are typically stiff. The depth to rock is expected to be deeper where filling has been placed and shallower where sandstone outcrops and boulders are in close-by. An inferred geological cross-section is show in Drawing 2.

5.2 Stability Assessment

Visual inspection of the site and surrounding areas, visible retaining walls, external house walls and garage walls did not identify any features or defects that could be attributable to significant slope instability.

5.3 Slope Risk Analysis

The hazards above, below and beside the site have been assessed for risk to property and life using the general methodology outlined by the Australian Geomechanics Society (Landslide Risk Management AGS Subcommittee 2007).

For the purposes of this assessment, an acceptable level of geotechnical risk for the property is “Low” while an accepted annual probability of loss of life is 1×10^{-6}.

Identified hazards within and adjacent to the site are summarised in Table 1, together with qualitative assessments of likelihood, consequence and slope instability risk to the proposed residential structure after completion of construction which has had appropriate engineering design and construction methodologies.

Table 1: Property Slope Instability Risk Assessment of Proposed Development

Hazard	Likelihood	Consequence	Risk
Significant failure of the steep slope on the property.	Rare	Major	Low

For loss of life, the individual risk can be calculated from:

$R_{(LoL)} = P_{(H)} \times P_{(S:H)} \times P_{(T:S)} \times V_{(D:T)}$

where:

$R_{(LoL)}$ is the risk (annual probability of loss of life (death) of an individual);

$P_{(H)}$ is the annual probability of the hazardous event occurring (e.g. failure of the residence footings);

$P_{(S:H)}$ is the probability of spatial impact by the hazard (e.g. of the failure reaching the residence, taking into account the distance of a given event from the residence);

$P_{(T:S)}$ is the temporal probability (e.g. of the residence being occupied by the individual) at the time of the spatial impact;

$V_{(D:T)}$ is the vulnerability of the individual (probability of loss of life of the individual given the impact).

The assessed individual risk to life (person most at risk) resulting from slope instability is summarised in Table 2.

Table 2: Life Risk Assessment for Proposed Development

Hazard	$P_{(H)}$ [1]	$P_{(S:H)}$	$P_{(T:S)}$	$V_{(D:T)}$	Risk $R_{(LoL)}$
Significant failure of the steep slope on the property.	1×10^{-5}	0.3	0.5	0.5	7.5×10^{-7}

Note: 1 – The probability assumes that the works are undertaken in accordance with the recommendations in this report

When compared to the Landslide Risk Management Guidelines of the AGS, it is considered that the site meets ‘Acceptable Risk Management’ criteria with respect to both property and life for new and existing developments under current and foreseeable conditions.

Provided construction is undertaken in accordance with the recommendations contained in this report, construction of the proposed development is not expected to affect the overall stability of the site or negatively influence the geotechnical hazards identified in Tables 1 and 2.

5.4 Excavation

The soils and rock up to low strength should be readily removed using conventional earth moving equipment such as a mini-excavator. Small equipment or hand held methods may be required if excavations are required in restricted access areas.

If the excavation encounters medium strength rock or stronger then rock sawing, rotary milling heads, hydraulic rock breaking equipment or jack-hammers will be required.

5.5 Ground Vibration

During excavation it will be necessary to use appropriate methods and equipment to keep ground vibration at adjacent buildings and structures within acceptable limits. Excavations within soil and extremely low to low strength rock are not expected to generate excessive vibration. Unless medium strength rock or stronger is to be excavated, vibration is considered not to be an issue for the site.

Ground vibration can be strongly perceptible to humans at levels above 2.5 mm/s peak particle velocity (PPVi). This is generally much lower than the vibration levels required to cause structural damage to buildings. The Australian Standard AS2670.2-1990 “Evaluation of human exposure to whole-body vibrations – continuous and shock induced vibrations in buildings (1-80 Hz)” indicates an acceptable day time limit of 8 mm/s PPVi for human comfort.

Based on previous experience and with reference to AS2670, it is suggested that a maximum PPVi of 8 mm/s (applicable at the foundation level of existing buildings/structures) be adopted at this site for both architectural and human comfort considerations, although this vibration limit may need to be reduced if there are sensitive buildings, structures or equipment in the area.

5.6 Excavation Support

The proposed excavations will require a maximum excavation depth of about 3 m. Within the upper excavation it is anticipated that some fill and soil will be encountered.

The rest of the excavations are likely to encounter low to medium strength sandstone that can stand vertically unsupported providing that there are no adversely oriented joints. The excavated faces should be inspected by a geotechnical engineer to check for such joints, which if present, will require support by rock bolts.

Where excavations on site appear not to be in rock and where excavation depths are less than about 3 m and room permits, material can be temporarily battered at 1.0 Horizontal to 1.0 Vertical until permanent retaining walls are constructed.

If there is not sufficient space to batter the excavations to safe angles, ground support should be installed along the line of the cut face before any excavation commences. Possible shoring options include soldier piles with shotcrete infill panels or contiguous pile retaining walls. If shoring is required under the house then cantilevered reinforced shotcrete retaining walls may be necessary, constructed in hit-and-miss panels.

Table 3 provides suggested earth pressure coefficients for design of retaining walls, assuming a level surface behind the wall. If there is a slope behind the wall, then the earth pressure coefficients will increase.

Table 3: Recommended Retaining Wall Design Parameters

Material	Active Earth Pressure Coefficient		Bulk Density
	Short Term	Long Term	
Filling or Soil	0.3	0.4	20 kN/m^3

It should be noted the above design parameters do not allow for water pressures acting on the walls and drainage measures, such as free draining backfill and discharge points through the wall, should be incorporated in the wall design.

5.7 Disposal of Excavated Material

All excavated materials will need to be disposed of in accordance with current NSW Environment Protection Authority (EPA) regulations. Under the NSW EPA Waste Classification Guidelines (2014) a waste/fill receiving site must be satisfied that materials received meet the environmental criteria for proposed land use. This includes filling and virgin excavated natural materials (VENM), such as may be removed from this site. Accordingly, environmental testing will need to be carried out to classify spoil prior to disposal. The type and extent of testing undertaken will depend on the final use or destination of the spoil and requirements of the receiving site.

It should be noted that some receiving sites, such as those operated by Councils or other bodies might have their own special environmental criteria to be met before admitting any materials. The scope of this investigation did not include sampling and testing for Waste Classification or Contamination Assessment purposes though Douglas Partners can carry out such testing if requested.

5.8 Foundations

All footings for the proposed development should be founded on insitu bedrock.

Based on the ground testing and site observations, it is expected that the excavation for the lower level will intersect low to medium strength bedrock. Footings are to be all supported on low to medium strength rock and may be designed assuming a maximum allowable bearing pressure of 1000 kPa.

All new footing should be founded on material of similar strength and should be inspected by a geotechnical professional prior to the placement of reinforcement and concrete, to confirm that intact strata of sufficient bearing capacity and stability has been reached.

5.9 Site Drainage and Groundwater

All additional stormwater from the proposed development should be piped and discharged into the council storm water system, through any tanks that may be required by the regulatory authorities.

The groundwater table is expected to be well below the base of the proposed excavation, however some seepage is expected from the slope above, typically occurring through joints and cracks in the rock, particularly after heavy rainfall.

The permanent design of the lower levels should allow for some moisture seeping through joints in the rock.

5.10 Conditions Relating to Design and Construction Monitoring

To comply with Council conditions and to enable the completion of Forms 2B and 3, required as part of the construction, building and post-construction certificate requirements of the GRMP, it will be necessary for Douglas Partners Pty Ltd to undertake the following:

Form 2B

- Review the geotechnical content of all structural drawings.

Form 3

- Inspect all new footing excavations for the new works to confirm compliance with the design, particularly with respect to allowable bearing pressure and stability.

5.11 Design Life and Requirement for Future Geotechnical Assessments

DP interprets the reference to design life requirements specified within the GRMP to refer to structural elements designed to retain the subject slope and maintain the risk of instability within acceptable limits.

Specific structures that may affect the maintenance of site stability in relation to the proposed development on this site are considered to comprise:

- Existing and proposed retaining walls on the site; and
- Existing and proposed stormwater drains.

In order to attain a structure life of 100 years as required by the Council Policy, it will be necessary for the structural engineer to incorporate appropriate construction detailing and for the property owner to adopt and implement a maintenance and inspection program. A typical program for developments on sloping sites is given in Table 4.

Note that the programme given in Table 4 is provisional and is subject to review and/or deletion at the conclusion of construction.

Table 4: Recommended Maintenance and Inspection Program

Structure	Maintenance/Inspection Task	Frequency
Proposed new retaining walls.	Owner to check wall for deviation from as-constructed condition.	Every two to three years or following each significant rainfall event.
Proposed new stormwater drains	Owner to check for drain blockages	Following each significant rainfall event

Where changes to site conditions are identified during the maintenance and inspection program, reference should be made to a relevant professional (e.g. structural engineer or geotechnical engineer).

6. References

1. Pittwater Council's Geotechnical Risk Management Policy (2009).
2. Australian Geomechanics Society (AGS), Practice Note Guidelines for Landslide Risk.

7. Limitations

Douglas Partners (DP) has prepared this report for this project at 35 Kanimbla Crescent, Bilgola Plateau in accordance with DP's proposal SYD200951 dated 1 September 2020, and acceptance received from Adam and Hilde Rutherford dated 2 September 2020. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of Adam and Hilde Rutherford for this project only and for the purposes as described in the report. It should not be used by or be relied upon for other projects or purposes on the same or another site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires a risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the geotechnical components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix A

Notes About This Report

‘Landslide Risk Management Concepts and Guidelines’

About this Report

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

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

Copyright

Borehole and Test Pit Logs

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

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

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

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

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

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

About this Report

Site Anomalies

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

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

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

AUSTRALIAN GEOGUIDE LR7 (LANDSLIDE RISK)

LANDSLIDE RISK

Concept of Risk

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

Landslide Risk Assessment

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

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

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

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

Risk to Property

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

TABLE 2: LIKELIHOOD

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

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

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

TABLE 1: RISK TO PROPERTY

Qualitative Risk		Significance - Geotechnical engineering requirements
Very high	VH	**Unacceptable** without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low. May be too expensive and not practical. Work likely to cost more than the value of the property.
High	H	**Unacceptable** without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to acceptable level. Work would cost a substantial sum in relation to the value of the property.
Moderate	M	**May be tolerated** in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as possible.
Low	L	**Usually acceptable** to regulators. Where treatment has been needed to reduce the risk to this level, ongoing maintenance is required.
Very Low	VL	**Acceptable**. Manage by normal slope maintenance procedures.

AUSTRALIAN GEOGUIDE LR7 (LANDSLIDE RISK)

Risk to Life

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

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

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

Most local councils and planning authorities that stipulate a tolerable risk to property also stipulate a tolerable risk to life. The AGS Practice Note Guideline recommends that 1:100,000 is tolerable in newly developed areas, where works can be carried out as part of the development to limit risk. The tolerable level is raised to 1:10,000 in established areas, where specific landslide hazards may have existed for many years. The distinction is deliberate and intended to prevent the concept of landslide risk management, for its own sake, becoming an unreasonable financial burden on existing communities. Acceptable risk is usually taken to be one tenth of the tolerable risk (1:1,000,000 for new developments and 1:100,000 for established areas) and efforts should be made to attain these where it is practicable and financially realistic to do so.

TABLE 3: RISK TO LIFE

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

More information relevant to your particular situation may be found in other AUSTRALIAN GEOGUIDES:

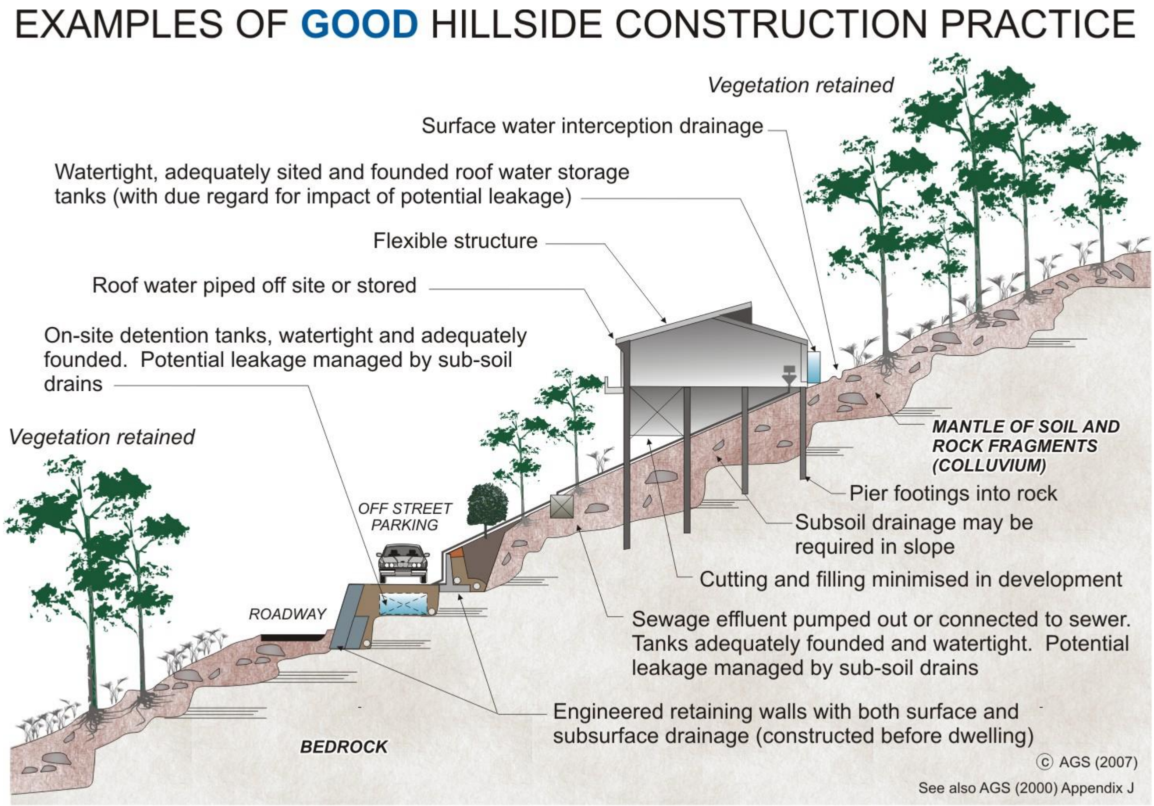
- GeoGuide LR1 - Introduction
- GeoGuide LR2 - Landslides
- GeoGuide LR3 - Landslides in Soil
- GeoGuide LR4 - Landslides in Rock
- GeoGuide LR5 - Water & Drainage
- GeoGuide LR6 - Retaining Walls
- GeoGuide LR8 - Hillside Construction
- GeoGuide LR9 - Effluent & Surface Water Disposal
  GeoGuide LR10 - Coastal Landslides
- GeoGuide LR11 - Record Keeping

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

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

HILLSIDE CONSTRUCTION PRACTICE

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



WHY ARE THESE PRACTICES GOOD?

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

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

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

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

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

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

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

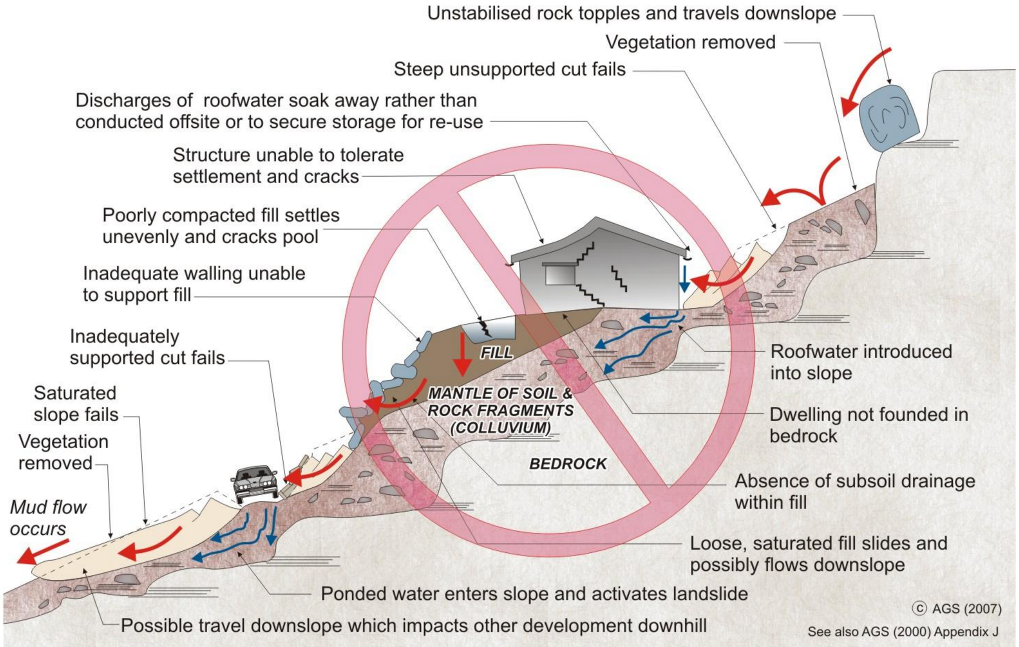
Vegetation clearance - on soil slopes has been kept to a reasonable minimum. Trees, and to a lesser extent smaller vegetation, take large quantities of water out of the ground every day. This lowers the ground water table, which in turn helps to maintain the stability of the slope. Large scale clearing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

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

ADOPT GOOD PRACTICE ON HILLSIDE SITES

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

EXAMPLES OF POOR HILLSIDE CONSTRUCTION PRACTICE



WHY ARE THESE PRACTICES POOR?

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

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

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

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

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

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

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

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

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

- GeoGuide LR1 - Introduction
- GeoGuide LR2 - Landslides
- GeoGuide LR3 - Landslides in Soil
- GeoGuide LR4 - Landslides in Rock
- GeoGuide LR5 - Water & Drainage
- GeoGuide LR6 - Retaining Walls
- GeoGuide LR7 - Landslide Risk
- GeoGuide LR9 - Effluent & Surface Water Disposal
- GeoGuide LR10 - Coastal Landslides
- GeoGuide LR11 - Record Keeping

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Appendix B

Drawings 1 and 2

Site Photographs

Dynamic Cone Penetrometer Results

Northern Beaches (Pittwater) Council Forms 1 and 1A

0 1 2 3 4 6 8 10 15 20m

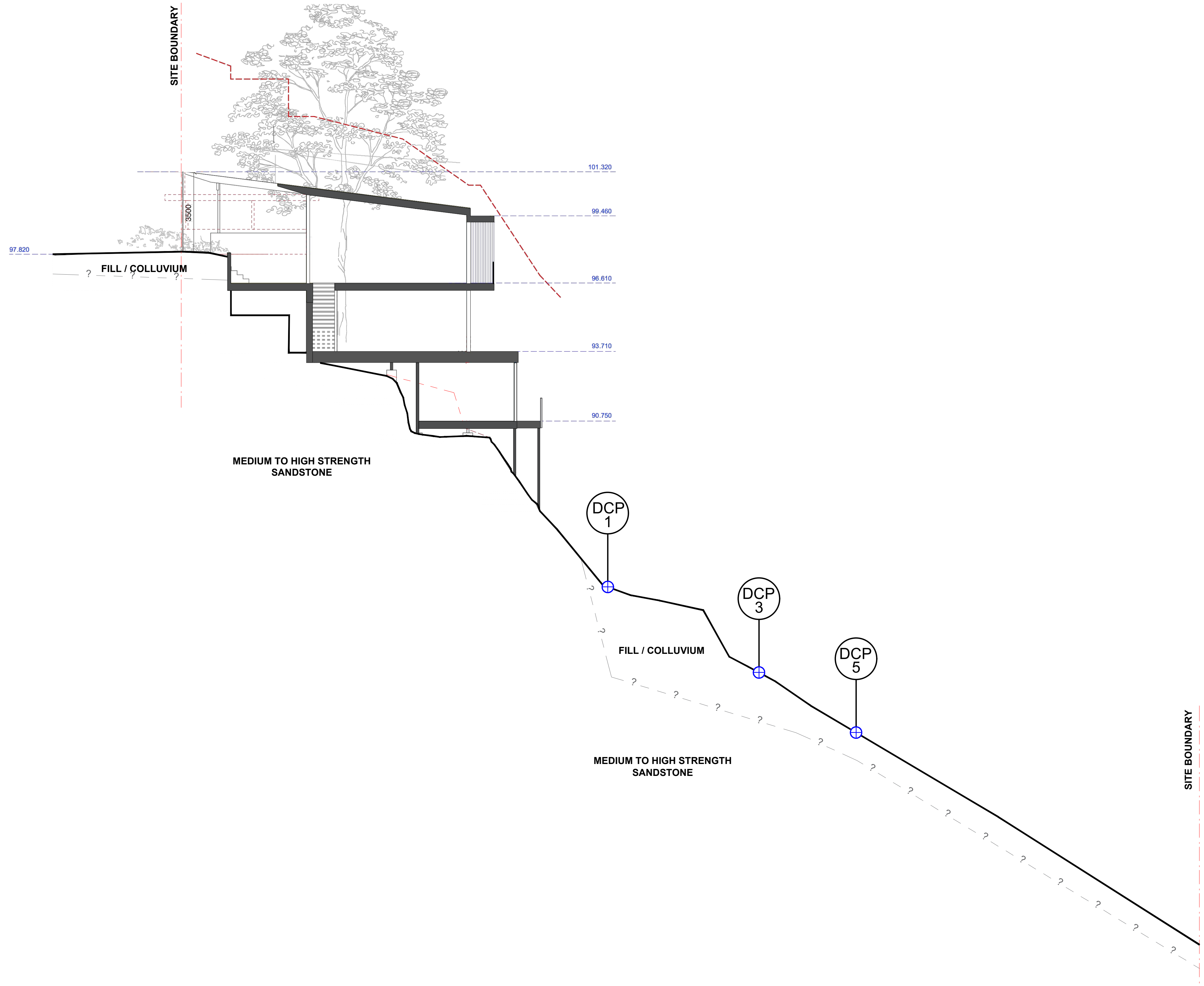
1:200 @ A3

NOTE:
1: Plan adapted from Utz Sansby Architects Drawing Number DA000 dated 07/09/2020

LEGEND

- Site Boundary
- Building Footprint
- Piped Stormwater Outflow
- DCP Location and Number
- Sandstone Outcrop
- Geological Cross Section
- Uncompleted Steel Post Retaining Wall
- Photograph number with direction of view

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Adam and Hilde Rutherford	TITLE: **Indicative Geological Site Plan**	PROJECT No: 99804.00
	OFFICE: Sydney / DRAWN BY: CJ	**35 Kanimbla Crescent,**	DRAWING No: 1
	SCALE: 1:200 @ A3 / DATE: 11.09.2020	**Bilgola Plateau**	REVISION: 0



0 1 2 3 4 6 8 10 15 20m

1:200 @ A3

NOTE:
1: Cross Section adapted from Utz Sansby Architects Drawing Number DA101 dated 07/09/2020

LEGEND

- DCP Location and Number
- Interpreted Geotechnical Boundary

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Adam and Hilde Rutherford		TITLE: **Indicative Geological Cross Section A-A'**	PROJECT No: 99804.00
	OFFICE: Sydney	DRAWN BY: CJ	**35 Kanimbla Crescent,**	DRAWING No: 2
	SCALE: 1:200 @ A3	DATE: 11.09.2020	**Bilgola Plateau**	REVISION: 0

Photo 1: View of sandstone underneath the residence (to be excavated)

Photo 2: View underneath house, footings on rock

Photo 3: View looking down slope (view south)

Photo 4: Underside of residence, western end (view north)

Photo 5: Underside of residence, eastern end (view north)

Photo 6: View of slope below residence (view east)

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Adam and Hilde Rutherford		TITLE: **Site Photographs**	PROJECT No: 99804.00
	OFFICE: Sydney	DRAWN BY: NB	**Proposed Additions & Alterations**	PLATE No: 1
	SCALE: NA	DATE: 10.09.2020	**35 Kanimbla Crescent, Bilgola Plateau**	REVISION: A

Douglas Partners
Geotechnics / Environment / Groundwater

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Phone (02) 9809 0666
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Results of Dynamic Penetrometer Tests

Client Adam and Hilde Rutherford — Project No. 99804.00

Project Proposed Additions and Alterations — Date 03-09-20

Location 35 Kanimbla Crescent, Bilgola Plateau — Page No. 1 of 1

Test Location	DCP1	DCP2	DCP3	DCP4	DCP5					
Depth (m)	Penetration Resistance Blows/150 mm									
0 - 0.15	1	2	2	2	2					
0.15 - 0.30	3	5/50	4	3	3					
0.30 - 0.45	3		4	4	3					
0.45 - 0.60	2		6	4	4					
0.60 - 0.75	2		6	4	3					
0.75 - 0.90	3		7	5	4					
0.90 - 1.05	3		4	6	5					
1.05 - 1.20	7		4	6	5/100					
1.20 - 1.35	12		4	4						
1.35 - 1.50	4		6	5/100						
1.50 - 1.65	10		6							
1.65 - 1.80	7		7							
1.80 - 1.95	10		10/100							
1.95 - 2.10	12									
2.10 - 2.25	10/100									
2.25 - 2.40										
2.40 - 2.55										
2.55 - 2.70										
2.70 - 2.85										
2.85 - 3.00										
3.00 - 3.15										
3.15 - 3.30										
3.30 - 3.45										
3.45 - 3.60										

Test Method AS 1289.6.3.2, Cone Penetrometer ☑
AS 1289.6.3.3, Flat End Penetrometer ☐

Tested By NB
Checked By DEM

Remarks R = Refusal, 24/110 indicates 25 blows for 110 mm penetration, B = Bouncing

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

Development Application for Adam and Hilde Rutherford
Name of Applicant
Address of site 35 Kanimbla Crescent, Bilgola Plateau

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

I, Scott Easton (Insert Name) on behalf of Douglas Partners Pty. Ltd. (Trading or Company Name)

on this the 3 August 2021 certify that I am a geotechnical engineer or engineering geologist or coastal engineer as defined by the Geotechnical Risk Management Policy for Pittwater 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.
Douglas Partners Pty Ltd:

Please mark appropriate box

☒ Prepared the detailed Geotechnical Report referenced below in accordance with the Australia Geomechanics Society's Geotechnical Risk Management Guidelines and the Pittwater Council Policy

☒ Am willing to technically verify that the detailed Geotechnical Report referenced below has been prepared in accordance with the Australian Geomechanics Society's Geotechnical Risk Management Guidelines and the Pittwater Council Policy

☒ Have examined the site and the proposed development/alteration in detail and am of the opinion that the Development Application only involves Minor Development/Alterations that do not require a Detailed Geotechnical risk Assessment and hence my report is in accordance with the Policy requirements for Minor Development/Alterations.

☐ Provided the coastal process and coastal forces analysis for inclusion in the geotechnical report

Geotechnical Report Details:

Report Title: Proposed Additions and Alterations

Report Date: 3 August 2021

Author: Nick Burrows

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

Design drawings by Utz Sansby Architect, job number 1920, 9, 10, DA-000, DA-100, DA-101, DA102, revision number DA-A dated 05/07/21

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

Signature ....

Name Scott Easton

Chartered Professional Status CPEng/NER

Membership No. 1371997

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

Development Application for Adam and Hilde Rutherford
Name of Applicant
Address of site 35 Kanimbla Crescent, Bilgola Plateau

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

Geotechnical Report Details:

Report Title: Proposed Alterations and Additions
Report Date: 3 August 2021
Author: Nick Burrows

Please mark appropriate box

- [X] Comprehensive site mapping conducted 3 September 2020 (date)
- [X] Mapping details presented on contoured site plan with geomorphic mapping to a minimum scale of 1:200 (as appropriate)
- [X] Subsurface investigation required
  - [ ] No Justification ……………………………………………
  - [X] Yes Date conducted 3 September 2020
- [X] Geotechnical model developed and reported as an inferred subsurface type-section
- [X] Geotechnical hazards identified
  - [ ] Above the site
  - [X] On the site
  - [ ] Below the site
  - [ ] Beside the site
- [X] Geotechnical hazards described and reported
- [X] Risk assessment conducted in accordance with Council's Policy
  - [X] Consequence analysis
  - [X] Frequency analysis
- [X] Risk calculation
- [X] Risk assessment for <u>property</u> conducted in accordance with Council's Policy
- [X] Risk assessment for <u>loss of life</u> conducted in accordance with Council's Policy
- [X] Assessed risks have been compared to "Acceptable Risk Management" criteria as defined in the Geotechnical Risk Management Policy for Pittwater
- [X] Opinion has been provided that the design can achieve the "Acceptable Risk Management" criteria provided that the specified conditions are achieved.
- [X] Design Life Adopted:
  - [X] 100 years
  - [ ] Other ……………………………………………… specify
- [X] Development Conditions to be applied to all four phases as described in Pittwater Geotechnical Risk Management Policy have been specified
- [X] Additional action to remove risk where reasonable and practical have been identified and included in the report.

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

Signature ……………………………………………………

Name Scott Easton

Chartered Professional Status CPEng/NER

Membership No. 1371997