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8 December 2020

Our ref: SYDGE279869AB-Rev.2

Mr Jelte Bakker
C/- Valdis Macens Architects
145 Oberon Street
Coogee 2034 NSW

Attention: Valdis Macens

Dear Valdis,

Geotechnical Slope Stability Assessment - 17A Crown Rd, Queenscliff NSW

1. Introduction

This report presents our assessment of geotechnical slope stability at the residential property of 17A Crown Rd, Queenscliff NSW. Coffey Services Australia Pty Ltd (Coffey) has prepared this report in response to Northern Beaches Council (Council) requirements on the landowner's Development Application (DA) which stipulates that a slope risk assessment be undertaken in accordance with the Australian Geomechanics Society (AGS) Practice Note for Landslide Risk Management (2007).

This revision (Rev 2) of the geotechnical report is slightly updated to make reference to the final DA drawings that will accompany the submission to council.

2. Project Appreciation

It is understood the owners of 17A Crown Road, Queenscliff have submitted a Development Application (ref: PLM2020/0176) to Council to make alterations and amendments to their property. These proposed works include the addition of a balcony between two existing structures, excavation of the ground in an area beneath the existing house and removal of piers to allow for a new storeroom area and excavation of ground next to an existing robe/bedroom. The planned works are detailed on the final DA drawings (references DA-01 to DA-12 issued December 2020).

Council's response to the Development Application includes a local provision due to the property's location on sloping land: "*The site is identified with 'Area C' on the Landslip Risk Map pursuant to the WLEP 2011. Accordingly, the application must be accompanied by [a] Geotechnical Report prepared by a suitably qualified geotechnical engineer/engineer[ing] geologist (as required by Clause E10 of the WDCP 2011)*.

Area C is defined by the WDCP (Warringah Development Control Plan) 2011 as a steep slope with a slope angle greater than 25° with colluvial soils, bouldery talus and detached blocks of sandstone on steep escarpment areas, developed on Hawkesbury Sandstone.

Coffey previously completed a slope stability assessment for the property (report reference S9545/1-AB, dated 08/07/1991) which found the lot to have a Moderate Risk of slope instability. The assessment determined the property was underlain by Hawkesbury Sandstone, with evidence of detached boulders on the northern half of the property where the slope was angled at about 35°. However, no evidence of recent movements or overall slope instability were observed.

3. Scope of Work

The objective of the slope risk assessment is to assess geotechnical risks to property and life in facilitating the planned construction work. A Coffey Engineering Geologist attended site on 1 October 2020 to conduct a walkover of the site, viewing the upper and lower basements, exterior façade, pier foundations and exterior retaining walls.

4. Geology

The site is located within the Triassic-aged Hawkesbury Sandstone. The exposed sandstone at the site was found to be typically medium to high strength, with thin sandy and shale seams (5 to 50 mm thick) at nominal 200 to 600 mm spacings. Sub-vertical jointing, as typically recorded within

Figure 1 Typical Hawkesbury Sandstone underlying the site. Photo taken in lower level basement.

Hawkesbury Sandstone were also observed at nominal 0.5 to 2.0 m spacings. Sub-horizontal bedding partings were observed in the lower level basement (see Figure 1).

5. Identified Hazards

Based on our site observations, Coffey have identified the following hazards:

- Loose sandstone gravel and cobbles over in-situ rock at head space under the dwelling (Level 0);

Figure 2 Loose Cobbles on Sandstone Bedrock

- A 3 to 4 m wide, 3 to 4 m high dry stone wall approximately 3 m from the edge of the house upper level (Level 3). It is understood that the dry stone wall has been in place for numerous years and no deformation has occurred.

Figure 3 Dry Stone Wall

6. Qualitative Risk Assessment

6.1. General

A qualitative risk assessment has been undertaken for the site using descriptions based upon the (AGS) Practice Note for Landslide Risk Management (2007). Extracts from the AGS guidelines are presented in Attachment A.

The risk likelihood and risk consequence have been used to determine a risk rating from the Risk Matrix provided in the guidelines.

The qualitative risk assessment has been completed to assess the risk to property damage only.

6.2. Likelihood and Consequences of Failure

The likelihood and consequences of failure for the two identified risk hazards outlined in Section 5 are provided in Table 2. These ratings are qualitative assessments of how probable (or likely) a failure is, and the consequences of such failures on adjoining property, and have been determined based on our site observations and engineering experience with similar instances.

6.3. Risk Rating

The matrix in Table 1 has been used to rate each of the risks identified based on the likelihood and consequence determined. The risk matrix is based on the AGS Guidelines for Landslide Risk Assessment, 2007.

Table 1 Risk Rating Matrix

		Consequences				
		Catastrophic	Major	Medium	Minor	Insignificant
Likelihood	Almost Certain	VH	VH	VH	H	M or L
	Likely	VH	VH	H	M	L
	Possible	VH	H	M	M	VL
	Unlikely	H	M	L	L	VL
	Rare	M	L	L	VL	VL
	Not Credible	L	VL	VL	VL	VL

Table 2 Risk Rating

Type of Failure	Initial Risk Rating			Control Measures	Residual Risk Rating		
	Likelihood	Consequence	Risk Rating		Likelihood	Consequence	Risk Rating
Loose cobbles falling from top of rock due to vibrations during construction	Possible – Disturbance during construction activities has the potential to cause cobbles to shift and fall	Insignificant	Very Low	--	--	--	--
Collapse of Dry Stone Wall	Unlikely – the sandstone blocks within the wall appear to be stacked on one another. A significant rainfall event, earth-tremor or construction vibrations may have potential to move some of the blocks and result is partial wall failure	Medium – Wall is 3 m from house and may cause damage. Entire wall may need replacement if movement occurs and potential exists to impact adjacent property	Low	• Monitor wall during any works • Seek geotechnical advice if movement (even minor) is observed	Rare	Medium	Low

7. Risk to Life Assessment

Where there is potential to cause harm to individuals, a qualitative assessment is undertaken to estimate the risk of 'loss of life' to an individual using the site. The individual is taken to be the 'person most at risk', who typically has the greatest exposure to the risks (i.e. greatest spatial temporal probability). The risk of 'loss of life' to an individual is calculated from:

$$\mathbf{R}_{(LoL)} = \mathbf{P}_{(H)} \times \mathbf{P}_{(S:H)} \times \mathbf{P}_{(T:S)} \times \mathbf{V}_{(D:T)}$$

Where:

$\mathbf{R}_{(LOL)}$ is the risk (annual probability of death of an individual).

$\mathbf{P}_{(H)}$ is the annual probability of the hazard occurring (event).

$\mathbf{P}_{(S:H)}$ is the probability of spatial impact of the event impacting an individual taking into account the travel distance and travel direction given the event. For example, if a rockfall occurs at a site when an individual is present, the individual may be located at another part of the site and therefore will not be affected.

$\mathbf{P}_{(T:S)}$ is the temporal spatial probability (e.g. of the building or location being occupied by the individual) given the spatial impact and allowing for the possibility of evacuation given there is warning of the event occurrence.

$\mathbf{V}_{(D:T)}$ is the vulnerability of the individual (probability of loss of life of the individual given the impact).

Loose Cobbles Falling from top of rock during construction

$\mathbf{R}_{(LOL)} = 0.1 \times 0.5 \times 2.7\times10^{-4} \times 0.2 = 2.8 \times 10^{-6}$

$\mathbf{P}_{(H)}$ has been derived from the probability of cobbles rolling due to construction vibrations

$\mathbf{P}_{(S:H)}$ based on a confined area in front of the slope for people to travel within

$\mathbf{P}_{(T:S)}$ based on 10 movements of people walking in front of the slope per day

$\mathbf{V}_{(D:T)}$ based on potential for cobble impact to cause loss of life

Collapse of Dry Stone Wall

$\mathbf{R}_{(LOL)} = 0.1 \times 0.33 \times 1.25\times10^{-4} \times 0.8 = 3.3 \times 10^{-6}$

$\mathbf{P}_{(H)}$ has been derived from the probability of wall collapse (1 in 20 year storm or vibrations)

$\mathbf{P}_{(S:H)}$ based on a confined area in front of the slope for people to travel within

$\mathbf{P}_{(T:S)}$ based on 3 movements of people walking in front of the slope per day

$\mathbf{V}_{(D:T)}$ based on potential for wall collapse to lead to loss of life

Loss of Life Assessment

The estimated risk of "Loss of Life" for an individual at the site is a sum of the hazard $\mathbf{R}_{(LOL)}$ identified at the site. This is 6.1×10^{-6} for this site. Table 1 of the AGS Guidelines for Landslide Risk Assessment (2007) suggests a 'tolerable' loss of life risk as 10^{-4} per annum for existing slopes/developments and 10^{-5} for newly constructed slopes or developments. 'Acceptable' risks are usually considered to be one order of magnitude lower than tolerable risks. Under this guidance, the site is assessed as having an Acceptable Risk of Loss of Life.

8. Geotechnical Risk Control Measures

8.1. Risk control measures under existing conditions

- It is recommended that obviously loose cobbles identified on the sandstone bedrock in the basement be cleared using handheld tools, to reduce risk to both property and persons from rock impact;
- Check dry stone wall for any obvious signs loose blocks or bulging after periods of excessive rain, earth-tremors or other external factors, such as construction on adjoining property;
- It should be noted that this report does not comment on the potential effects the works may have on the structural integrity of the existing dwelling.

8.2. Risk control measures prior to and during construction

- To reduce vibration during the proposed works, it is recommended that the excavation of rock is carried out using hand-tools;
- Should the assessed risk be acceptable, if there be any obvious signs of instability either on or in the immediate vicinity of the dry-stone wall, geotechnical advice should be immediately sought;
- Any proposed new foundations should be founded on competent sandstone that lies at a shallow depth/outcrops on the site.

9. Closure

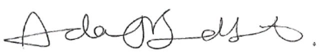
This report outlines our observations of geotechnical site features and assessment of rock fall hazards observable at the time of the fieldwork. Natural features will change and may deteriorate over time, which could change existing hazards or create new ones.

We recommend that decisions about acceptable risk and risk management be based on the AGS (2007) Landslide Risk Management Guidelines, according to standard industry practice. The level of acceptable or tolerable risk for both loss of life and property, depends on many factors. Coffey can work with you or your stakeholders to help you decide on a level of risk that is acceptable or tolerable.

Additional investigations may be required to further assess landslide hazards, risk mitigation measures, ongoing monitoring and maintenance requirements. The attached document entitled "Important information about your Coffey report" forms an integral part of this report and presents additional information about it uses and limitations.

Should you have any further queries, please contact the undersigned on 0436 346 652.

Kind Regards,



Adam Broadbent
Associate Engineering Geologist

Cc

Important information about your Coffey report

Attachment A – Coffey Practice note: Important information about AGS2007

Important information about your **Coffey** Report

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

Data should not be separated from the report

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way. Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment. Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

Landslide Risk Management

Important Information about AGS 2007 Appendix C (1 of 2)

INTRODUCTION

This sheet provides important information on the following Appendix C which has been copied from "Practice note guidelines for landslide risk management 2007". The "Practice Note" and accompanying "Commentary" (References 1 & 2, hereafter referred to as AGS2007) are part of a series of documents on landslide risk management prepared on behalf of, and endorsed by, the Australian Geomechanics Society. These documents were primarily prepared to apply to residential or similar development.

It should be noted that AGS2007 define landslides as "the movement of a mass of rock, debris or earth down a slope". This definition includes falls, topples, slides, spreads and flows from both natural and artificial slopes.

LANDSLIDE LIKELIHOOD ASSESSMENT

The assessment of the likelihood of landsliding requires evidence-based judgements.

Judging how often and how much an existing landslide will move is difficult. Judging the likelihood of a new landslide occurring is even harder. Records of past landslides can provide some information on what has happened, but are invariably incomplete and often provide little or no guidance on less frequent events that may occur. Often judgements have to be made about the likelihood of infrequent events with serious consequences, with little or no help from historical records. Slope models, which reflect evidence-based knowledge of how a slope was formed, how it behaved in the past and how it might behave in the future, are used to support judgements about what might happen. Because of the difficulties in assessing landslide likelihood, different assessors may make different judgements when presented with the same information.

The likelihood terms in Appendix C can be taken to imply that it is possible to distinguish between low probability events (e.g. between events having a probability of 1 in 10,000 and 1 in 100,000). In many circumstances it will not be possible to develop defensibly realistic judgements to do so, and so joint terms need to be used (e.g. Likely or Possible). For further discussion on landslide likelihood and other matters see References 3, 4 and 5.

CONSEQUENCES OF LANDSLIDES

There can be direct (e.g. property damage, injury / loss of life) and indirect (e.g. litigation, loss of business confidence) consequences of a landslide. The assessment of the importance (seriousness) of the consequences is a value judgement best made by those most affected (e.g. client, owner, regulator, public). The main role of the expert is usually to understand and explain what and who might be affected, and what damage or injury might occur.

Appendix C implies that we can anticipate total cost (direct and indirect) of landslide damage to about half an order of magnitude (e.g. the difference between $30,000 and $100,000). This involves predicting the location, size, travel distance and speed of a landslide, the response of a building (often before it has been built), the nature and the extent of damage, repair costs as well as indirect consequences such as legal costs, accommodation etc. There can be other direct and indirect consequences of a landslide which can be difficult to anticipate, let alone quantify and cost. The situation is analogous to the cost of work place accidents where the hidden costs can range from less than one to more than 20 times the visible direct costs (Reference 5).

In many circumstances it will not be possible to develop defensibly realistic judgements to enable use of a single consequence descriptor from Appendix C, and so joint terms need to be used (e.g. Minor or Medium). In our experience, explicit descriptions of potential consequences (e.g. rocks up to 0.5m across may fall on a parked car) help those affected to make their own judgements about the seriousness of the consequences.

RISK MATRIX

The main purpose of a risk matrix is to help rank risks, set priorities and help the decision making process. The risk terms should be regarded only as a guide to the relative level of risk as they are the product of an evidence-based quantitative judgement of likelihood and a value judgement about consequences, both of which involve considerable uncertainty. Different assessors may arrive at different judgements on the risk level.

Using Appendix C, many existing houses on sloping land will be assessed to have a Moderate Risk.

Landslide Risk Management
Important Information about AGS 2007 Appendix C (2 of 2)

RISK LEVEL IMPLICATIONS

In general, it is the responsibility of the client and/or owner and/or regulatory authority and/or others who may be affected to decide whether to accept or treat the risk. The risk assessor and/or other advisers may assist by making risk comparisons, discussing treatment options, explaining the risk management process, advising how others have reacted to risk in similar situations, and making recommendations. Attitudes to risk vary widely and risk evaluation often involves considering more than just property damage (e.g. environmental effects, public reaction, political consequences, business confidence etc).

The risk level implications in Appendix C represent a very specific example and are unlikely to be generally applicable. In our experience the typical response of regulators to assessed risk is as follows:

Assessed risk	**Typical response of client/ owner/ regulator/ person affected**
Very High, High [1]	Treats seriously. Usually requires action to reduce risk. Will generally avoid development.
Moderate	May accept risk. Usually looks for ways to reduce risk if reasonably practicable.
Low, Very Low [1]	Usually regards risk as acceptable. May reduce risk if reasonably practicable.

1 The distinctions between Very High and High and between Low and Very Low risks are usually used to help set priorities.

REFERENCES

1. AGS (2007). "Practice note guidelines for landslide risk management 2007". Australian Geomechanics, Vol. 42, No. 1, pp 63-114.
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3. Baynes, F.J., Lee I.K. and Stewart, I.E., (2002). "A study of the accuracy and precision of some landslide risk analyses." Australian Geomechanics, Vol. 37, No. 2, pp 149-156.
4. Baynes, et. al., (2007). "Concerns about the Practice Note Guidelines for Landslide Risk Management 2007." Letter to the editor, Australian Geomechanics, Vol. 2, No. 4, pp 63-114.
5. Moon, A.T., and Wilson, R,A., (2004). "Will it happen? – Quantitative judgements of landslide likelihood". Proceedings of the Australia New Zealand conference on Geomechnics, Centre of continuing education, University of Auckland, Vol. 2, pp 754-760.