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Trevor and Michele Matthews
c/- MacCormick and Associates
13 Victoria Street
Queens Park NSW 2022

Attention: Mr Michael MacCormick

Email: Michael@maccormickarchitects.com.au

Dear Sirs

Geotechnical Assessment, Proposed Secondary Residence
13a Ocean Road, Palm Beach

1. Introduction

This letter report presents a geotechnical assessment of the site of proposed secondary residence at 13a Ocean Road, Palm Beach. The work was carried out for Michele and Trevor Matthews, property owners, acting under instructions from MacCormick and Associates Architects.

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

The assessment comprised a geotechnical inspection of the property and adjacent areas. Reference has also been made to the following documents:

- Design Drawings Project 1408, DA00.01, 00.02, 01.01, 01.02, 02.01, 02.02 and 04.02 (all Revision P5) MacCormick and Associates Architects;
- Site Survey Plan Dwg 12212detail (dated 16 February 2016) by C.M.S. Surveyors Pty Ltd; and
- Douglas Partners Pty Ltd (DP) reports and memos - Projects 11563, 11653B, 11653C and 11653D (dated between 1988 and 1993).

Comments relating to geotechnical design issues and constraints are given below and are based on the results of the inspection and the information shown in the above documents.

Colour photos 1 to 6 (attached to this report) depict the site at the time of the assessment.

2. Previous Investigations and Slope Stabilisation Works

Douglas Partners Pty Ltd (DP) has previously undertaken a geotechnical assessment and a design review in relation to the construction of the existing residence and the stabilisation of the excavated face within the hillside. The work was undertaken for a former owner of the site between 1988 and 1993.

A review of the original structural design drawings held in our files infers that the existing residence was designed to be supported by pad footings which are founded on bedrock with an allowable bearing pressure (ABP) of 800 kPa, with the front eastern wall of the residence supported on piles to bedrock. The drawings indicate that a retaining wall along the eastern site boundary is founded on a strip footing in 'clay' soils.

Geological mapping by DP at the time indicated that bedrock exposed within approximately the upper half of the excavated rockface behind the residence comprised a sandstone unit. Approximately half of the lower face was mapped as comprising interbedded sandstone, shale and siltstone (described on design drawings as 'shale').

Design drawings and notes held in our records indicate that the excavated rockface behind the residence has been protected with a 75 mm thick layer of reinforced shotcrete. The drawings and notes infer that the rockface (behind the shotcrete) has been stabilised with approximately thirty two permanent rock anchors and dowels. DP are not in possession of any 'work as executed' drawings for the anchors or dowels

A retaining wall and a dish drain are indicated to lie along the crest of the shotcrete covered face.

3. Site Description and Geology

The site is a trapezoid shaped residential lot (Lot 1 D.P. 121833), with major plan dimensions of around 55 m by 17 m. The site is located opposite the beachfront on the western (high) side of Ocean Road (refer Drawing 1 for locality and selected site features). It is bounded by residential lots to the south, south-west and north and by Sunrise Road to the west. The lower, eastern section of the lot to the north of the site is undeveloped and bush covered.

There is a total fall in elevation across the site to the east from the western boundary to the edge of the road reserve along Ocean Road in the order of 36 m (RL 42 m to RL 6 m AHD), resulting in an overall average slope angle of approximately 32°. Much of this fall in elevation occurs within a 10 m to 12 m high shotcrete covered face behind the existing residence near the Ocean Road frontage and within a 3 m to 4 m high, irregular sandstone cliff line which is located approximately mid-level on the site.

The shotcrete covered face is sub-vertical over its lowest 3 m, with a typical batter angle between 60^0 to 75^0 from horizontal above that height.

Current improvements comprise a one and two storey concrete block and steel clad residence with a metal roof which is located at the lower, eastern end of the lot. The remainder of the lot (upslope of the shotcrete covered face) is undeveloped with a scattered tree cover.

Reference to the Sydney 1:100 000 Geological Series Sheet 9130 indicates that the site is underlain by the Narrabeen Group of rocks but is close to the boundary with the overlying Hawkesbury Sandstone. Both formations are of Triassic age, the Narrabeen Group comprising interbedded sandstones, siltstones and shales and the Hawkesbury Sandstone generally comprising medium to coarse grained quartz sandstone.

The investigation confirmed the geological mapping with medium grained sandstone exposed within the cliff-line on the upper (western) section of the site and as detached boulders on the upper slope. This rock is considered to be consistent with the Hawkesbury Sandstone. The description of interbedded sandstone, shale and siltstone reportedly encountered within the lower section of the excavated rockface (now covered in shotcrete) is considered to be consistent with Narrabeen Group rocks.

4. Field Work

The lower and upper sections of the site have been inspected by a senior engineering geologist on 18 May 2016.

4.1 Site Observations

The main site observations made during the inspection of the lower section of the site were that:

- the 10 m to 12 m high, shotcrete covered face behind (west of) the residence appears to be in a satisfactory condition with no significant cracking observed within the visible sections;
- there was no evidence of fallen rock or shotcrete fragments along the toe of the shotcrete face;
- there is an extensive cover of coastal vine and weeds over the top 3 m to 4 m of the shotcrete face and over its full height at the southern corner;
- there are 20 mm diameter PVC pipe weep holes visible at 2 m to 3 m centres across the central section of the shotcrete face;
- there was extensive seepage down the face of the shotcrete, particularly from the central and northern sections. The seepage appeared to originate from hairline cracks within the shotcrete or from the vine covered sections of the face rather than from the weep holes;
- there was no visible evidence dowel or anchor heads protruding through the shotcrete face or obvious rust patches;
- there is some build-up of brown iron-oxide sludge in the open drains along the toe of the shotcrete face, although the drains and pits at the toe of the face appear to be functional;
- a 300 mm diameter, shotcrete covered pipe runs down the southern end of the face and discharges into a grated stormwater pit behind the south-western corner of the residence;

- a 1 m to 3 m high, concrete rendered wall supporting the excavation face to the southwest of the residence has some hair-line cracks but appears to be in a satisfactory condition;
- a 2.5 m high, cemented sandstone block wall along the southern site boundary and beside the residence appears to be in a satisfactory condition;
- there was no evidence of defects or cracking within the masonry sections of the residence that could be attributed to foundation or slope movement;

The main observations made during the inspection of the upper section of the site were that:

- the uppermost section of the site has a typical slope angle of around 30^0 to 35^0, locally increasing to 45^0;
- the upper slope has a scattered tree cover and is characterised by numerous eroded sandstone boulders. Most of the boulders appear to have detached from in-situ bedrock and rotated or slid to their present positions on the slope;
- the detached boulders on the upper slope display no evidence of imminent instability in their current configurations;
- medium to high strength sandstone bedrock is exposed within a 3 m to 4 m high, irregular cliff line located approximately mid-way between Ocean Road and Sunrise Road. The cliff line is located approximately 20 m upslope (west) of the crest of the shotcrete covered face;
- a 'mid-level' area of the site, between the irregular sandstone cliff line and the crest of the shotcrete covered face, has a typical slope angle of around 20^0 to 25^0. The area has a moderate cover of vines and scattered small trees;
- there a several detached and eroded sandstone boulders lying on the mid-level area, the most prominent of which measures some 5 m to 6 m in diameter;
- some of the smaller boulders below the cliff line display evidence of pre-split drill holes suggesting that there may have been some quarrying for building stone in the area;
- areas of the soil cover on the mid-level area around the largest boulder were saturated with surface seepage evident in some places; and
- it was not possible to safely inspect the crest of the shotcrete covered face from above due to thick growth of vines, weeds and shrubs.

5. Proposed Development

It is understood that the proposed development will comprise the construction of a rumpus room, secondary dwelling and a swimming pool on the 'mid-level' area of the site, upslope of the shotcrete covered face and surrounding the large detached boulder.

Access from the lower level will be by way of a lift shaft, excavated as a slot into the shotcrete covered face behind the southern end of the existing residence. A landscaped pathway will be constructed up the slope from the new development to the level of Sunrise Road.

The approximate footprint of the proposed new developments on site is shown on Drawing 1.

6. Comments

6.1 Geological Model

The interpreted geological model for the site comprises a moderate to steeply sloping site, which has been previously modified by the excavation into the lower slope to permit the construction of the existing residence. The excavated face has been stabilised by rock anchors and dowels and protected by reinforced shotcrete.

The upper section is underlain by sandstone bedrock with some outcropping ledges and a cliff line, with soils depths away from outcrop expected to be typically less than 1 m to 1.5 m. There are detached sandstone boulders on the upper section of the site that have evidently slid or rotated to their present positions during geological time. The base of the sandstone bedrock reportedly extends partially down the excavated rockface (which is now shotcrete covered).

The lower section of the excavated rockface and the area occupied by the existing residence is reportedly underlain by interbedded siltstone, shale and sandstone bedrock. The existing residence was designed to be supported by spread or piled footings founded on bedrock.

6.2 Stability Assessment

Inspection of the general slope on the site indicated no evidence of defects attributable to significant slope instability since the construction of the shotcrete wall.

6.3 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 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 existing and proposed residential structures after completion of construction which has had appropriate engineering design and construction methodologies.

Table 1: Property Slope Instability Risk Assessment for Existing and Proposed Developments

Hazard	Likelihood	Consequence	Risk
Collapse of the existing stabilised rockface during excavation of the proposed lift shaft	Unlikely – provided that regular geotechnical advice is sought in relation to replacing shotcrete and anchors/dowels that are disturbed during the works or are found to be defective	Medium	Low
Downhill creep or rapid failure of footings supporting the proposed new works	Rare – if footings are founded on strata assessed by geotechnical personnel to appropriate with respect bearing pressure and stability	Medium to Major	Low
Rapid collapse of the large detached boulder on the 'mid-level' area of the site	Rare – if trial excavations are undertaken around the base of the boulder and the boulder underpinned as necessary	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 (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 Existing and Proposed Developments

Hazard	$P_{(H)}$ (1)	$P_{(S:H)}$	$P_{(T:S)}$	$V_{(D:T)}$	Risk $R_{(LoL)}$
Collapse of the existing stabilised rockface during excavation of the proposed lift shaft	10^{-4}	0.5	0.25	0.05	6.25×10^{-7}
Downhill creep or rapid failure of footings supporting the proposed new works	10^{-5}	1	0.25	0.2	5×10^{-7}
Rapid collapse of the large detached boulder on the 'mid-level' area of the site	10^{-5}	1	0.25	0.2	5×10^{-7}

Note: (1) – $P_{(H)}$ is subject to the same conditions outlined for the likelihood of each hazard in Table 1 above

When compared to the requirements of the Pittwater Council and the AGS, it is considered that the existing site and the proposed development meet 'Acceptable Risk Management' criteria with respect to property and life under current and foreseeable conditions.

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

6.4 Site Preparation

Given the extremely limited access to the site behind the existing residence, it is expected that site works will need to be undertaken using small and/or portable excavation equipment.

Based on the records held by our office, it is expected that much of the excavation into the shotcrete covered face for the lift shaft will be within sandstone, siltstone or shale bedrock. It is also likely that the excavation will intersect rock anchors or dowels that have been installed into the rock face behind the shotcrete.

Care will be required when rock anchors are encountered to ensure that the anchors have been distressed prior to the cutting of any strands. Additional slope support measures may be required within the lift shaft excavation and these will need to be installed progressively as the excavation is deepened.

Any anchors/dowels or shotcrete reinforcement mesh that are uncovered but are not removed during the site works will need to be assessed structurally and either replaced or protected to prevent future corrosion. Vine and weed growth should be removed to allow a structural assessment to be undertaken of the upper section of the shotcrete covered face (including the wall and drain that is reportedly constructed along its crest).

The builder should excavate trial pits around the sides of the large detached boulder that is lying on the mid-level area of the site. Underpinning of the boulder to in-situ bedrock may be required if the pits indicate that it is currently bearing in soil.

All site works will need to be the subject of regular geotechnical inspections.

6.5 Foundations

All new foundations for the new residence, swimming pool and retaining walls should be socketed into in in situ weathered sandstone, siltstone or shale bedrock of at least low strength and proportioned for an allowable bearing capacity of 800 kPa. An allowable shaft adhesion of 150 kPa (compression) and 100 kPa (uplift) for sockets greater than 500 mm long is recommended in the same strata. Furthermore, the foundations for the swimming pool will need to be drilled to sufficient depth to not impose any additional load on the shotcrete wall or more rock bolts will need to be installed to ensure that the loads are carried uniformly on rock which has not residual defects and will act as a monolithic slab.

Based on the results of the site inspection, it is expected that in-situ bedrock will probably be encountered with around 1 m to 1.5 m of the surface on the upper and mid-level sections of the site. Subject to geotechnical inspection, it may be possible to leave some of the smaller detached boulders in place and locate footings for the new residence between the boulders. It is probable that a combination of spread and pile footings may be required to minimise the potential for differential settlement across the new structures.

All excavations for new footings should be inspected by an engineering geologist prior to placement of reinforcement and concrete pouring, so as to confirm that intact strata of sufficient bearing capacity and stability has been reached.

A further detailed review of records and notes relating to the design of the shotcrete covered face will be required to determine if supplementary rock anchors are required below the location of the proposed swimming pool at its crest.

6.6 Stability of Cut Face and Retaining Structures

Clayey soils exposed along the crest of any excavations above the level of very low to low strength bedrock cannot be relied upon to stand with temporary batter slopes exceeding 1.5:1 (H:V). Additional support of the soils will be required where such a batter slope cannot be achieved.

Engineer-designed retaining walls should be used to retain all soils, filling or weathered bedrock where space within the boundaries or the prevailing slope angle does not permit permanent batter slopes of 2:1 (H:V) and/or the vertical soil/EW rock face to be retained is more than 1 m in height. The following retaining wall design parameters are suggested where the top of backfill is horizontal:

Table 3: Recommended Retaining Wall Design Parameters

Material	Earth Pressure Coefficient		Bulk Density
	Short term	Long term	
Filling or sandy soils	0.3	0.4	20 kN/m^3
Siltstone or Sandstone - very low to low strength	0.1	0.15	22 kN/m^3
Siltstone or Sandstone – medium strength or stronger	0.0	0.1	22 kN/m^3

It should be noted that no provision has been made in the above design parameters for surcharge loading from sloping backfill or from existing or proposed structures (both on the subject lot or adjacent lots). Similarly, the above design parameters do not allow for water pressures acting on the walls or for adversely orientated jointing within bedrock. Drainage measures such as free draining backfill and discharge points through the wall should be incorporated in any wall design.

6.7 Stormwater Disposal and Site Drainage

There is a potential for significant groundwater seepage from all levels of the hillside, particularly during and following extended periods of wet weather. Some of the soils on the mid-level area of the site were saturated at the time of the site inspection and there was seepage evident down the shotcrete covered face.

Therefore, it will be necessary to provide adequate sub-soil drainage on the slope to minimise moisture build-up around the new and existing developments.

It is recommended that all stormwater generated from the new developments on the site and seepage intercepted on the slope be piped to the Council system along Ocean Road. New drainage lines above and down the shotcrete covered face will be required where the existing lines are removed to allow construction of the lift shaft and swimming pool.

The builder and designers should, as a minimum, expose and assess the functionality of the existing pits and pipe work. Modification or replacement of the existing stormwater system may be required if it be deemed to be deficient for the stormwater volumes from the new development.

A long term build-up of orange-brown gelatinous sludge has been observed within the existing drains at the base of the shotcrete covered face where iron oxides have precipitated out of groundwater upon exposure to the atmosphere. This natural phenomenon is particularly common from groundwater or seepage emanating from shales or siltstones. Therefore, provision should be made in any new or existing drainage lines on this site for access ports to allow for periodic cleaning or flushing out (or “rodding”).

7. 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:

Form 2B

- review the geotechnical content of all structural drawings.

Form 3

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

8. Design Life and Requirement for Future Geotechnical Assessments

Douglas Partners Pty Ltd interprets the reference to design life requirements specified within the IGRMP 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:

- proposed stormwater surface drains and buried pipes leading to the Council stormwater disposal system on Ocean Road;
- existing and proposed retaining walls on the site (including an assessment of the retaining system associated with the shotcrete covered face).

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 program given in Table 4 is provisional and is subject to review or deletion at the conclusion of construction.

Table 4: Recommended Maintenance and Inspection Program

Structure	Maintenance/Inspection Task	Frequency
Stormwater drains, subsoil drains, pipes and pits	Owner to inspect to ensure that the drains, pipes and pits are free of debris and sediment build-up. Clear surface grates of vegetation/litter build-up.	Every year or following each significant rainfall event.
Existing or proposed retaining walls	Owner to check wall for deviation from as-constructed condition.	Every two to three years or following each significant rainfall event.
Shotcrete covered rockface	Owner to inspect shotcrete for any signs of deterioration of the concrete cover or of rust stains.	At least every two years. If there are any signs of deterioration or particularly rust stains they should be inspected by a geotechnical professional or structural engineer to provide advice on any remedial measures required.

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).

9. References

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

10. Limitations

Douglas Partners Pty Ltd (DP) has prepared this letter report for this project at 13a Ocean Road, Palm Beach in accordance with instructions received from MacCormick and Associates Architects. The work was carried out under DP Conditions of Engagement. This report is provided for the exclusive use of MacCormick and Associates Architects and their agents for the specific project and purpose as described in the report. It should not be used by or 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 conditions on the site and only to the depths investigated, and then only at the time the work was carried out. Site 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 observations have 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 test locations. The advice may also be limited by site accessibility.

This report must be read in conjunction with all of the attached notes 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 Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction of all works (not just geotechnical components) and the controls required to mitigate risk. This report does, however, identify hazards associated with the geotechnical aspects of development and presents the results of risk assessment associated with the management of these hazards. If a principal design company, in the preparation of its project Design Report, wishes to undertake such inclusion by use of specific extracts from this subject DP report, rather than by appending the complete report, then such inclusion of extracts should only be undertaken with DP's express agreement, following DP's review of how any such extracts are to be utilised in the context of the project Safety Report.

We trust that these comments are sufficient for your present requirements. If further assistance is required, please do not hesitate to contact the undersigned.

Yours faithfully
Douglas Partners Pty Ltd

Reviewed by

David Murray
Senior Associate

Michael J Thom
Principal

Attachments: Notes about this report
"Landslide Risk Management Concepts and Guidelines"
Drawings 1 and 2

About this Report

Douglas Partners

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.

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

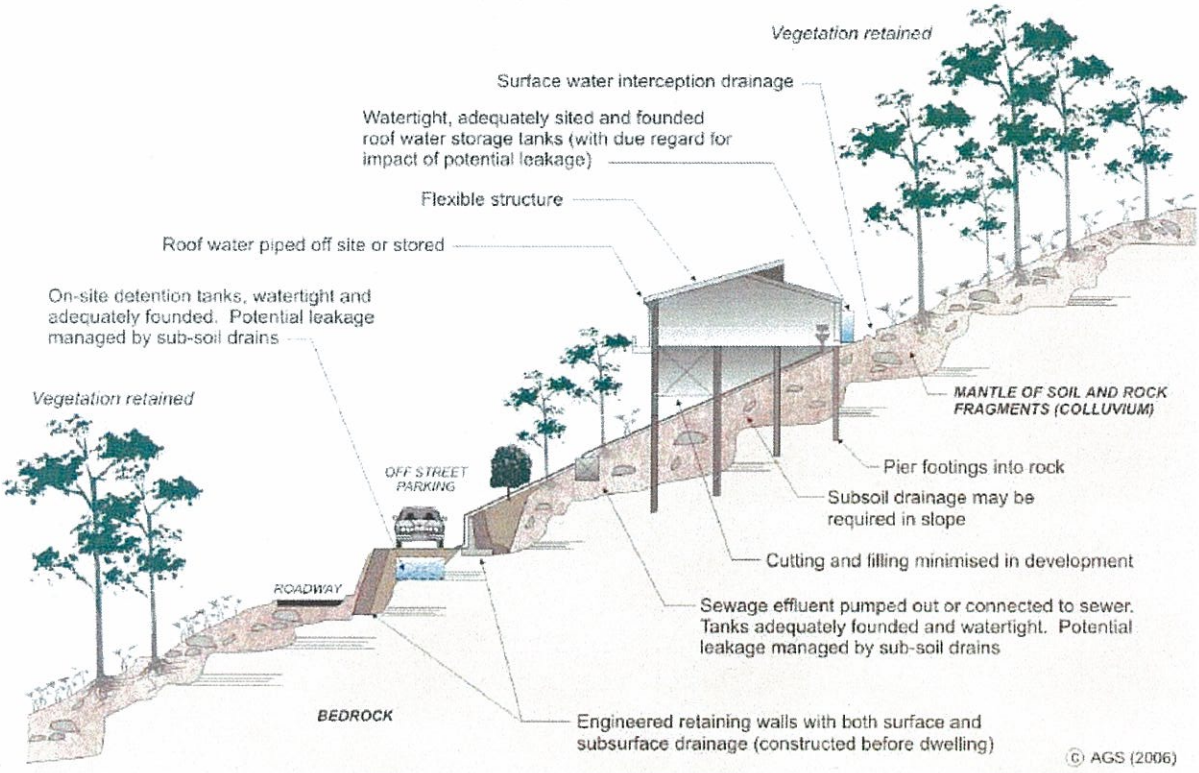
Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
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.

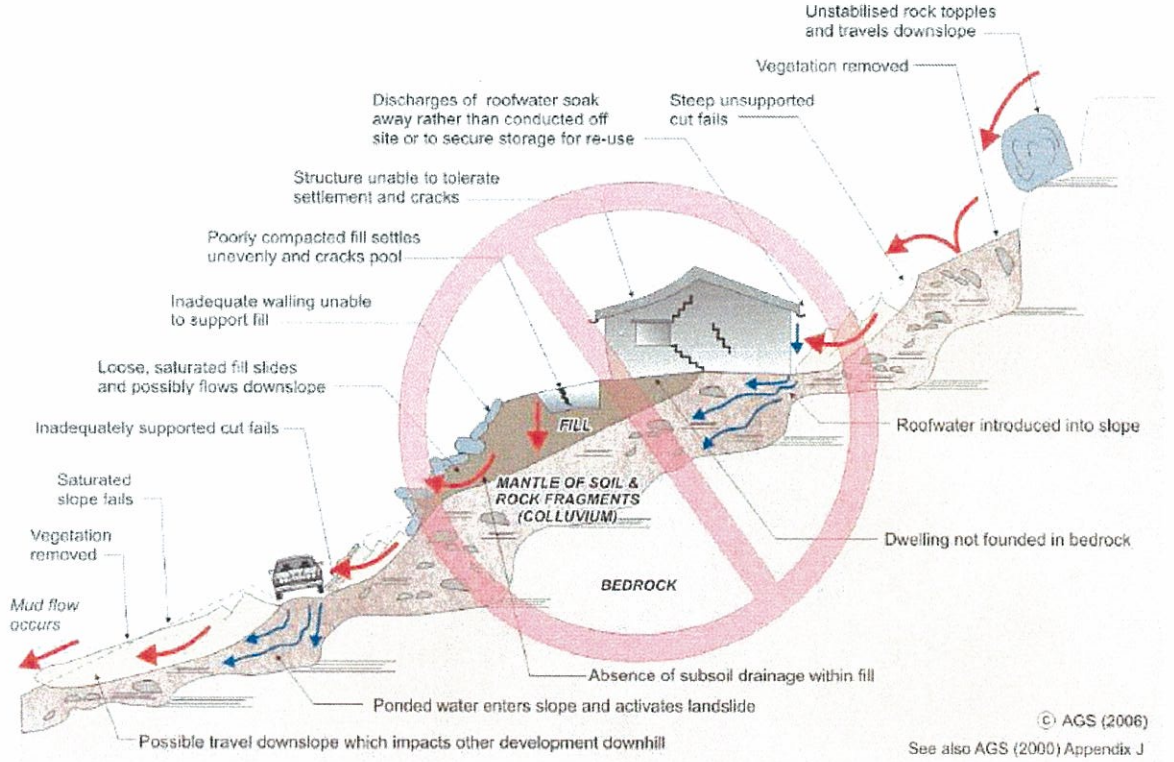
APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

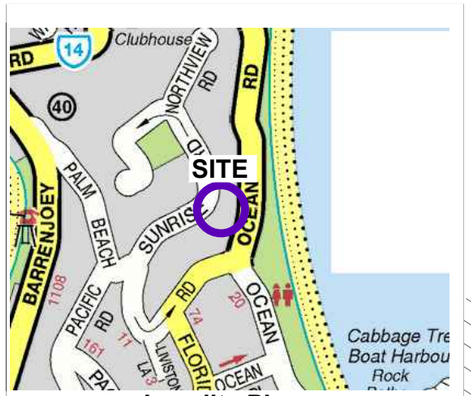
	GOOD ENGINEERING PRACTICE	*POOR ENGINEERING PRACTICE*
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical practitioner at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
PLANNING		
SITE PLANNING	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



EXAMPLES OF **POOR** HILLSIDE PRACTICE





Locality Plan

Saturated soil and some seepage on 'mid-level' area of site

Outline of proposed secondary residence

Outline of proposed swimming pool

10-12m high shotcrete covered face (crest obscured by vegetation)

Location of proposed lift shaft

3m to 4m irregular sandstone cliff line

Large detached sandstone boulder

Shotcrete covered 300mm pipe down face

Hair-line craks in concrete rendered wall

2.5m high sandstone block wall

NOTE:
1: Base drawing from C.M.S. Surveyors Pty Ltd (Dwg 12212detail, dated 16.2.2016)
2: See Drawing 2 for Cross Section A-A'

LEGEND

Bedrock Outcrop

Geotechnical Cross Section A-A'

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Michele and Trevor Matthews		TITLE: **Geotechnical Features**	PROJECT No: 85471.00
OFFICE: Sydney	DRAWN BY: PSCH	**Proposed Secondary Residence**	DRAWING No: 1
SCALE: 1:200 @ A3	DATE: 28.6.2016	**13A Ocean Road, PALM BEACH**	REVISION: 1

A

A

SUNRISE ROAD

Adjacent residence
(projected south)

Inferred level of
bedrock

3m to 4m irregular
sandstone cliff line

Large detached
sandstone boulder

Proposed
secondary residence

MAX HEIGHT 8.5m

RUMPUS ROOM
+22,500

EX. GROUND LINE

Shotcrete covered face

BENCH FOR PLANTER BELOW POOL AREA

PLANTER IN FRONT OF LIFT

Existing residence

Proposed lift-shaft
(projected north)

EX. HOUSE
+7.120

OCEAN
ROAD

LEGEND

Bedrock Outcrop

NOTE:
1: Base drawing from Maccormick & Associates Architects
(Dwg DA04.01_P5, dated 21.3.2016)
2: See Dwg 1 for location of Cross Section A-A'

0 1 2 3 4 6 8 10 15 20m

1:200 @ A3

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Michele and Trevor Matthews		TITLE: **Cross Section A-A'**	PROJECT No: 85471.00
OFFICE: Sydney	DRAWN BY: PSCH	**Proposed Secondary Residence**	DRAWING No: 2
SCALE: 1:200 @ A3	DATE: 29.6.2016	**13A Ocean Road, PALM BEACH**	REVISION: 0