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

Development Application for Roger & Helen Matthews
Name of Applicant

Address of site **51 Park Avenue, Avalon**

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

I, Peter Thompson (insert name) *on behalf of* Hodgson Consulting Engineers Pty Ltd (Trading or Company Name)

on this the 22nd June, 2020 certify that I am a geotechnical engineer or engineering geologist or coastal engineer as defined by the Geotechnical Risk Management Policy for Pittwater - 2009 and I am authorised by the above organisation/company to issue this document and to certify that the organisation/company has a current professional indemnity policy of at least $2million.

Please mark appropriate box

☒ Prepared the detailed Geotechnical Report referenced below in accordance with the Australia Geomechanics Society's Landslide Risk Management Guidelines (AGS 2007) and the Geotechnical Risk Management Policy for Pittwater - 2009

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

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

☐ Have examined the site and the proposed development/alteration in detail and 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 Geotechnical Risk Management Policy for Pittwater – 2009 requirements for Minor Development/Alterations.

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

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

Geotechnical Report Details:

Report Title: RISK ANALYSIS & MANAGEMENT FOR PROPOSED SECONDARY DWELLING AT 51 PARK AVENUE, AVALON– QY 00120

Report Date: 22nd June, 2020

Author : GARTH HODGSON
Reviewer: PETER THOMPSON

Author's Company/Organisation : HODGSON CONSULTING ENGINEERS PTY LTD

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

Architectural drawings prepared by JJ Drafting, Job No: 792/20, Dwg No: DA.01 to DA.11 and dated April 2020.

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 Peter Thompson

Chartered Professional Status MIE Aust CPEng

Membership No. 146800

Company Hodgson Consulting Engineers Pty Ltd

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

Development Application for Roger & Helen Matthews
Name of Applicant

Address of site **51 Park Avenue, Avalon**

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: RISK ANALYSIS & MANAGEMENT FOR PROPOSED SECONDARY DWELLING AT 51 PARK AVENUE, AVALON– QY 00120

Report Date: 22nd June, 2020

Author : GARTH HODGSON
Reviewer: PETER THOMPSON

Author's Company/Organisation: HODGSON CONSULTING ENGINEERS PTY LTD

Please mark appropriate box

☒ Comprehensive site mapping conducted ..... (date)
☒ Mapping details presented on contoured site plan with geomorphic mapping to a minimum scale of 1:200 (as appropriate)
☒ Subsurface investigation required
- ☐ No Justification .....
- ☒ Yes Date conducted 28/05/2020

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

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

☒ Risk calculation
☒ Risk assessment for property conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
☒ Risk assessment for loss of life conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
☒ Assessed risks have been compared to "Acceptable Risk Management" criteria as defined in the Geotechnical Risk Management Policy for Pittwater - 2009
☒ Opinion has been provided that the design can achieve the "Acceptable Risk Management" criteria provided that the specified conditions are achieved.
☒ Design Life Adopted:
- ☒ 100 years
- ☒ Other 15 to 20 specify

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

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

Signature 

Name Peter Thompson

Chartered Professional Status MIE Aust CPEng

Membership No. 146800

Company Hodgson Consulting Engineers Pty Ltd

RISK ANALYSIS & MANAGEMENT
FOR
PROPOSED SECONDARY DWELLING
AT
51 PARK AVENUE, AVALON

1. INTRODUCTION.

1.1 This assessment has been prepared to accompany an application for Development Approval with Northern Beaches Council - Pittwater. The requirements of the Geotechnical Risk Management Policy for Pittwater, 2009 have been met.

1.2 The definitions used in this Report are those used in the Geotechnical Risk Management Policy for Pittwater, 2009.

1.3 The methods used in this Assessment are based on those described in Landslide Risk Management March 2007, published by the Australian Geomechanics Society and as modified by the Geotechnical Risk Management Policy for Pittwater, 2009.

1.4 The experience of the principal of Hodgson Consulting Engineers spans a time period over 25 years in the Northern Beaches Council area and Greater Sydney Region.

2. PROPOSED DEVELOPMENT.

2.1 Construction of new secondary dwelling at the rear of the existing property.

2.2 Details of the proposed development are shown on a series of architectural drawings prepared by JJ Drafting, Job No: 792/20, Dwg No: DA.01 to DA.11 and dated April 2020.

3. DESCRIPTION OF SITE & SURROUNDING AREA.

3.1 The site was inspected on the 28th May, 2020.

3.2 This averaged sized rectangular shaped block is located on the low side of the road and has a south-westerly aspect. It is located near the toe of the main slope that rises steeply to the north west at average angles of some 15 to 25

DIRECTOR: G. HODGSON
PO Box 389 Mona Vale NSW 1660
Telephone: 0410 664 359
ABN 92 164 537 973

3. DESCRIPTION OF SITE & SURROUNDING AREA. (Continued)

degrees from Central Road to above the subject property where the crest is near Stapleton Park. There is also a cross fall slope falling from the north east to the south west along the block at an approximate average angle of some 10 degrees.

3.3 Access to the property is via the existing concrete crossing from Sanctuary Avenue near the top south eastern comer of the subject property via gravel driveway. The driveway crosses a pathway that leads from the top of the property down to the main entry of the existing residence, Photo 1. A level paved partially roofed patio area is to the east of the main entry and is surrounded by stable concrete block retaining walls, Photo 2. Access to the rear of the property is via paved pathway of the northern side of the existing residence and unpaved pathway of the southern side, Photos 3 & 4 respectively. A moderately sloped lawn area is to the west of the timber deck at the rear of the existing residence, Photo 5. A landscaped set of stairs through a treated timber retaining wall provides access to the lower parking platform, Photo 6. The treated timber retaining wall supports the rear lawn area and is fair to good condition. We observed some movement out of vertical in the retaining wall, Photo 7. The lower concrete parking slab is accessed via the concrete strip driveway from Sanctuary Avenue near the south western corner of the property, Photo 8. No significant signs of movement or slope instability were identified onsite at the time of inspection.

3.4 The single-storey timber clad residence and is supported on concrete strip and pad footings and is good condition. No signs of significant movements attributed slope instability were observed in the existing residence.

3.5 The lower two thirds of the subject property and adjoining properties are mapped as H1 hazard areas on the Council Geotechnical Hazard Map. Our observations indicate the surrounding slopes do not present a significant risk of instability to the subject property.

4. GEOLOGY OF THE SITE.

4.1 The Sydney geological series sheet, at a scale of 1:100,000 indicates the site is predominately underlain by interbedded sandstones, siltstones and shales of the Upper Narrabeen Group. The junction between the Hawkesbury Sandstone and the Narrabeen Group Rocks is just above the subject property. The Narrabeen Group Rocks are Late Permian to Middle Triassic in age with the early rocks not outcropping in the area under discussion. The materials from which the rocks were formed consist of gravels, coarse to fine sands, silts and clays. They

4. GEOLOGY OF THE SITE. (Continued)

were deposited in a riverine type environment with larger floods causing fans of finer materials. The direction of deposition changed during the period of formation. The lower beds are very variable with the variations decreasing as the junction with the Hawkesbury Sandstones is approached. This is marked by the highest of persistent shale beds over thicker sandstone beds which are similar in composition to the Hawkesbury Sandstones.

4.2 The slope materials are colluvial in origin at the surface and become residual with depth. They consist of topsoil over sandy clays and clays that merge into the weathered rock at depths varying from 1.0 to 2.0 metres or deeper where filling has been carried out.

5. SUBSURFACE INVESTIGATION AND SITE CLASSIFICATION.

5.1 Four Dynamic Cone Penetrometer (DCP) tests were conducted in the locations shown on the site plan. The tests were conducted to the Australian Standard for ground testing: AS 1289.6.3.2 – 1997 (R2013). The results of these tests are as follows:

NUMBER OF BLOWS - Conducted using a 9kg hammer, 510mm drop and conical tip -				
DEPTH (m)	**DCP#1**	**DCP#2**	**DCP#3**	**DCP#4**
0.0 to 0.3	3	2	7 drop 0.05	4
0.3 to 0.6	5	4	5	5
0.6 to 0.9	7	3	7	4
0.9 to 1.2	8	8	36	40
1.2 to 1.5	5	**11/0.059**	72	**38/0.253**
1.5 to 1.8	25		50	
1.8 to 2.1	**25/0.077**		**8/0.040**	
End of Test Depth	**1.877**	**1.259**	**1.840**	**1.453**
~ RL top of test AHD	**38.70**	**38.50**	**37.55**	**37.10**
~ RL end of test AHD	**36.823**	**37.241**	**35.71**	**35.647**

DCP TESTING NOTES:

DCP#1	25 Blows for 0.077m then 8 blows for 0.013m. Slight Double Bounce. Refusal in weathered rock or floater. Tip dry with white sandstone on very tip.
DCP#2	11 Blows for 0.059m then 8 blows for 0.012m. Double Bounce. Refusal in weathered rock or floater. Tip wet last 0.350m and clean.
DCP#3	Drop 0.5m at 0.2. 8 Blows for 0.040m then 8 blows for 0.010m. Strong Double Bounce. Refusal in weathered rock or floater. Tip damp last 0.900m and clean.
DCP#4	38 Blows for 0.253m then 8 blows for 0.016m. Double Bounce. Refusal in weathered rock or floater. Tip damp last 0.600m and clean.

5. SUBSURFACE INVESTIGATION AND SITE CLASSIFICATION. (Continued)

Further Notes	When ringing bouncing rock is not encountered, end of test occurs when there is less than 0.02m of penetration for 8 blows or danger of equipment damage is imminent. No significant standing water table was identified in our testing.

5.2 The equipment chosen to undertake ground investigations provides the most cost effective method for understanding the subsurface conditions. Our interpretation of the subsurface conditions is limited to the results of testing undertaken and the known geology in the area. While every care is taken to accurately identify the subsurface conditions on-site, variation between the interpreted model presented herein, and the actual conditions onsite may occur. Should actual ground conditions vary from those anticipated, we would recommend the geotechnical engineer be informed as soon as possible to advise if modifications to our recommendations are required.

5.3 SITE CLASSIFICATION.

The natural soil profile of the existing site is classified Class M, defined as 'Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes' as defined by AS 2870 - 2011. Where bedrock is encountered the site is classified as Class A.

6. DRAINAGE OF THE SITE.

6.1 ON THE SITE.

The site is naturally well drained with surface and subsurface runoff draining toward the south-western boundary and Sanctuary Avenue. No natural watercourses were observed on site.

6.2 SURROUNDING AREA.

Overland stormwater flow entering the site from the adjoining properties was not evident. Normal overland runoff could enter the site from above during heavy or extended rainfall.

7. GEOTECHNICAL HAZARDS.

Table 7.1 GEOTECHNICAL HAZARDS

HAZARDS	DESCRIPTION	POSSIBLE IMPACTS
ABOVE THE SITE	No geotechnical hazards likely to affect the subject property were observed above the property	N/A
ON THE SITE		
HAZARD ONE	The site is classed slip affected under Council's Policy and a H1 Hazard. A failure of the slope across the property is considered to be a potential hazard.	Damage to property and life.
BELOW THE SITE	No geotechnical hazards likely to affect the subject property were observed above the property	N/A
BESIDE THE SITE	The properties beside the site are at similar elevations and have similar geomorphology to the subject property. The house and grounds of the properties beside the site were in good condition as observed from the subject property and street. No geotechnical hazards likely to adversely affect the subject property were observed beside the site.	N/A

8. RISK ASSESSMENT.

Table 8.1 SUMMARY OF QUALITATIVE RISK ASSESSMENT TO PROPERTY

Hazard	Assessed Likelihood	Assessed Consequence	Risk
HAZARD ONE The main slope of the land surface falls across the subject property at approximate average angles of 15 to 25 degrees. While considered stable in its current condition the likelihood of the slope failing and impacting on the house is assessed as	'Unlikely' (10^{-4})	'Minor' (5%)	**'Low' ($5x10^{-6}$)**

NOTE: The level of these risks are **'ACCEPTABLE'** provided the recommendations given in **Section 10** are undertaken.

Table 8.2 SUMMARY OF QUALITATIVE RISK ASSESSMENT TO LIFE

For loss of life, risk can be calculated as follows:

$R_{(LoI)} = P_{(H)} \times P_{(SH)} \times P_{(TS)} \times V_{(DT)}$ (See Appendix for full explanation of terms)

$P_{(H)}$ - Annual Probability
$P_{(TS)}$ - Possibility of the Location Being Occupied During Failure
$P_{(SH)}$ - Probability of Spatial Impact
$V_{(DT)}$ - Probability of Loss of Life on Impact of Failure
$R_{(LoI)}$ - Risk Estimation

Hazard	Description		Value
HAZARD ONE	Proposed external lift excavation will require a maximum depth of excavation to be approximately 5.0m. Provided good engineering and building practices are followed and the recommendations given in Section 10 are undertaken the likelihood of the cut failing and impacting on the worksite		
	$P_{(H)}$	No evidence of significant movement was observed on the site, a slope failure is considered unlikely.	0.0001/annum
	$P_{(SH)}$	The house is situated towards the toe of the steep slope.	0.2
	$P_{(TS)}$	The average household is taken to be occupied by 4 people. It is estimated that 1 person is in the house for 20 hours a day, 7 days a week. It is estimated 3 people are in the house 12 hours a day, 5 days a week. For the person most at risk: $\frac{20}{24} x \frac{7}{7}$	0.83
	$V_{(DT)}$	Based on the volume of land sliding and its likely velocity when it hits the house, it is estimated that the vulnerability of a person to being killed in the house when a landslide hits is	0.1
	Risk $R_{(LoI)}$	0.0001 x 0.2 x 0.83 x 0.1 = 0.00000166, 1.66 x 10^{-6}/annum	**1.66 x 10^{-6}**

NOTE: The level of these risks are **'ACCEPTABLE'** provided the recommendations given in **Section 10** are undertaken.

9. SUITABILITY OF DEVELOPMENT FOR SITE.

9.1 GENERAL COMMENTS.

The proposed development is considered suitable for the site.

9.2 GEOTECHNICAL COMMENTS.

No geotechnical hazards will be created by the completion of the proposed development in accordance with the requirements of this Report and good engineering and building practice.

9. SUITABILITY OF DEVELOPMENT FOR SITE. (Continued)

9.3 CONCLUSIONS.

The site and the proposed development can achieve the Acceptable Risk Management criteria outlined in the Pittwater Geotechnical Risk Policy provided the recommendations given in **Section 10** are undertaken.

10. RISK MANAGEMENT.

10.1. TYPE OF STRUCTURE.

The proposed structures are considered suitable for this site.

10.2. EXCAVATIONS.

10.2.1 All excavation recommendations as outlined below should be read in conjunction with Safe Work Australia's *'Excavation Work – Code of Practice'*, published October, 2013.

10.2.2 Excavations for the foundations of the proposed secondary dwelling will require the use piers as necessary. These excavations for the footings will encounter fill and soil material and clays overlying the weathered rock of the Narrabeen Group to approximate depths of 1.0 to 2.0 metres or deeper where filling has been carried out.

10.2.3 A retaining will be required to support the cut for the proposed secondary dwelling. This retaining wall is to be designed and certified by a suitable qualified structural engineer.

10.2.4 All excavated materials left onsite will need to comply with the conditions in Section 10.3 or be retained by an engineer designed retaining wall or structure.

10.2.5 All excavated material is to be removed from the site in accordance with current Office of Environment and Heritage (OEH) regulations.

10.3. FILLS.

10.3.1 If filling is required, all fills are to be placed in layers not more than 250 mm thick and compacted to not less than 95% of Standard Optimum Dry Density at plus or minus 2% of Standard Optimum Moisture Content.

10. RISK MANAGEMENT. (Continued)

10.3.2 The fill batters are to be not steeper than 1 vertical to 1.7 horizontal or they are to be supported by properly designed and constructed retaining walls.

10.4. FOUNDATION MATERIALS AND FOOTINGS.

It is recommended that all footings be supported on and socketed into the underlying weathered rock, using piers as necessary. The design allowable bearing pressures are 450 kPa for spread footings or shallow piers. All footings are to be founded on material of similar consistency to minimise potential for differential settlement.

Note: The local geology is comprised of highly variable interbedded clays, shales and sandstones, with abundant detached joint blocks and sandstone floaters at surface and in the upper profile. Conditions may alter significantly across short distances. This variability should be anticipated and accounted for in the design and construction of any new foundations.

10.5. STORM WATER DRAINAGE.

All storm water runoff from the development is to be connected to the existing storm water system for the block through any tanks or onsite detention systems that may be required by the regulating authorities. This drainage work is to comply with the relevant Australian standards (AS/NZS 3500 Plumbing and Drainage).

10.6. SUBSURFACE DRAINAGE.

Any retaining walls are to be back filled with non-cohesive free draining material to provide a drainage layer immediately behind the wall. The free draining material is to be separated from the ground materials by geotextile fabric. Standard under pool drainage is acceptable.

10.7. INSPECTIONS.

It is essential that the foundation materials of all footing excavations be inspected and approved before concrete is placed. This includes retaining wall footings. Failure to advise the geotechnical engineer for these inspections could delay or stop the issuance of relevant certificates.

11. GEOTECHNICAL CONDITIONS FOR ISSUE OF CONSTRUCTION CERTIFICATE.

It is recommended that the following geotechnical conditions be applied to the Development Approval:-

The work is to be carried out in accordance with the Risk Management Report QY 00120 dated 22nd June, 2020.

The Geotechnical Engineer is to inspect and approve the foundation materials of any footing excavations before concrete is placed.

12. GEOTECHNICAL CONDITIONS FOR ISSUE OF OCCUPATION CERTIFICATE.

The Geotechnical Engineer is to certify the following geotechnical aspects of the development:-

The work was carried out in accordance with the Risk Management Report QY 00120 dated 22nd June, 2020.

The Geotechnical Engineer inspected and approved the foundation material of all footing excavations.

DIRECTOR: G. HODGSON
PO Box 389 Mona Vale NSW 1660
Telephone: 0410 664 359
ABN 92 164 537 973

13. RISK ANALYSIS SUMMARY.

HAZARDS	Hazard One
TYPE	The site is classed slip affected under Council's Policy and a H1 Hazard. A failure of the slope across the property is considered to be a potential hazard.
LIKELIHOOD	'Unlikely' (10^{-4})
CONSEQUENCES TO PROPERTY	'Minor' (5%)
RISK TO PROPERTY	'Low'(5×10^{-6})
RISK TO LIFE	1.66×10^{-6}/annum
COMMENTS	This level of risk is **'ACCEPTABLE'** provided the conditions in **Section 10** are followed.

HODGSON CONSULTING ENGINEERS PTY. LTD.

Author

Garth Hodgson MIE Aust
Member No. 2211514
Civil/Geotechnical & Structural Engineer

Reviewer

Peter Thompson MIE Aust CPEng
Member No. 146800
Civil/Geotechnical Engineer

Photo 1

Photo 2

DIRECTOR: G. HODGSON
PO Box 389 Mona Vale NSW 1660
Telephone: 0410 664 359
ABN 92 164 537 973

Photo 3

Photo 4

DIRECTOR: G. HODGSON
PO Box 389 Mona Vale NSW 1660
Telephone: 0410 664 359
ABN 92 164 537 973

Photo 5

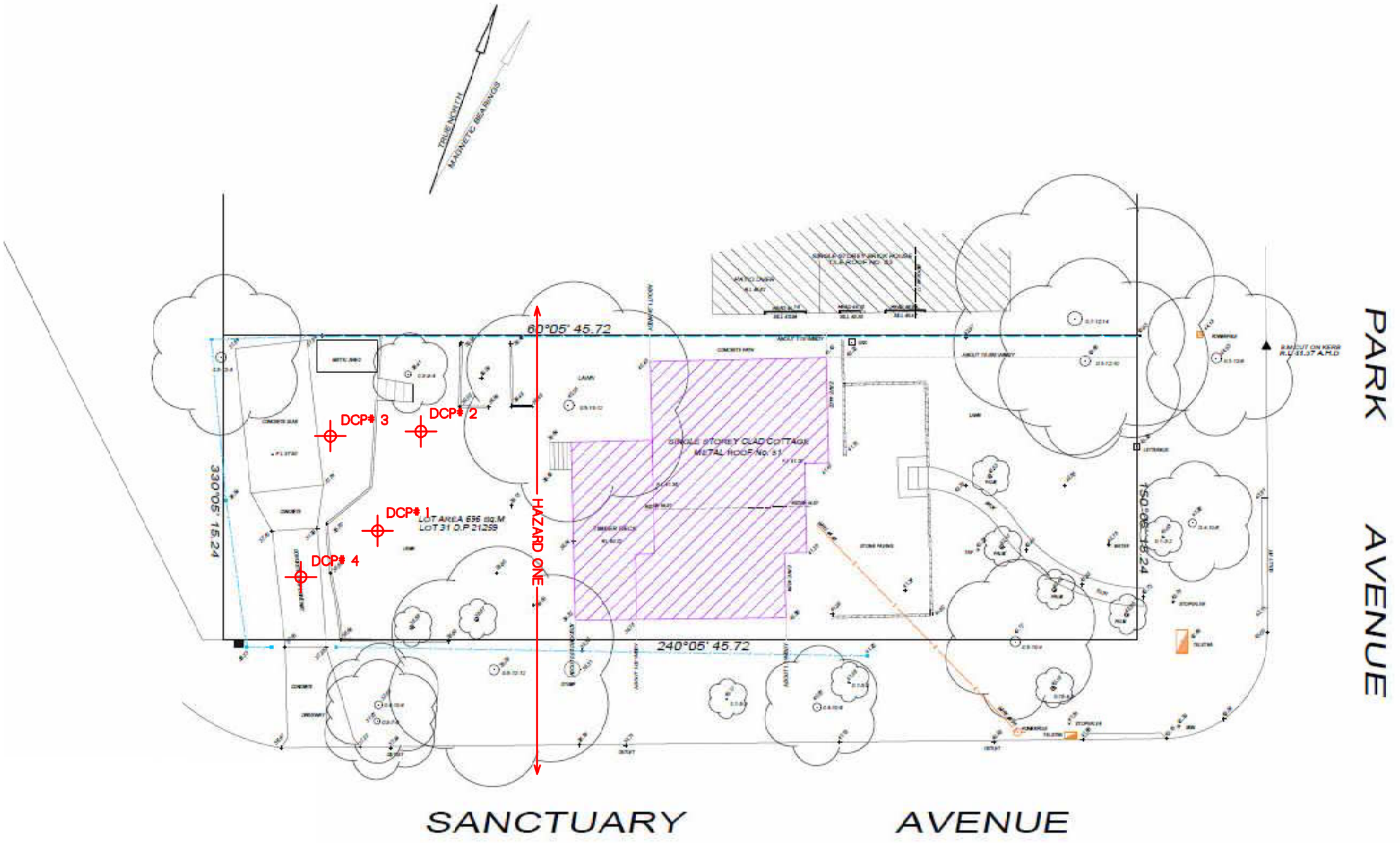
Photo 6

DIRECTOR: G. HODGSON
PO Box 389 Mona Vale NSW 1660
Telephone: 0410 664 359
ABN 92 164 537 973

Photo 7

Photo 8

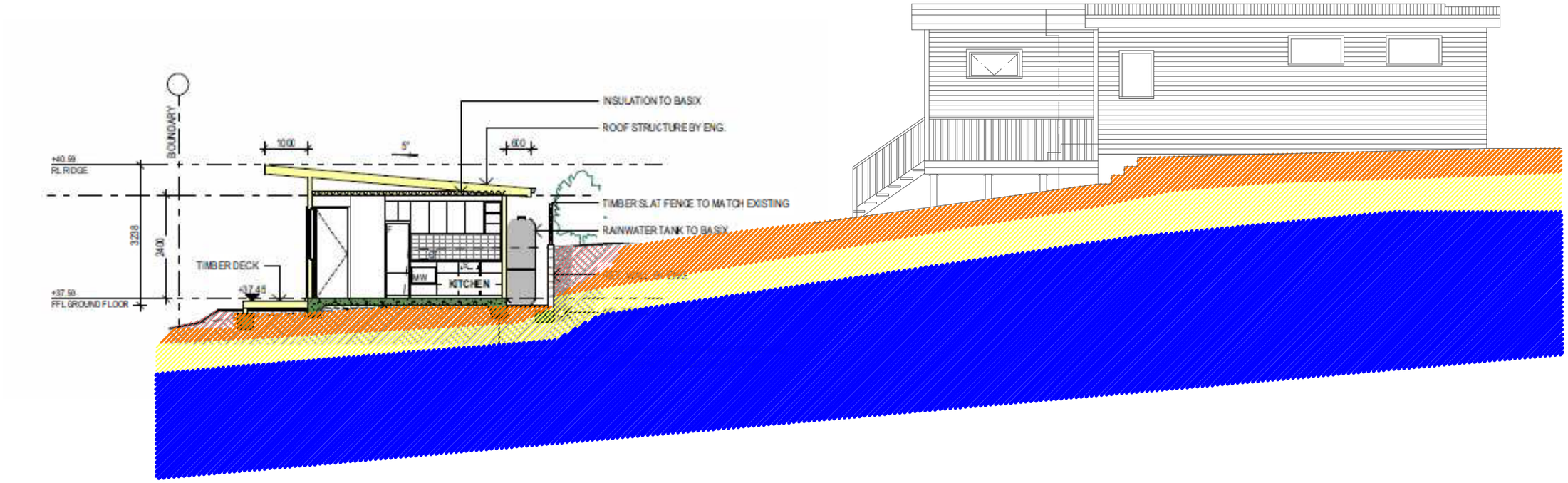
DIRECTOR: G. HODGSON
PO Box 389 Mona Vale NSW 1660
Telephone: 0410 664 359
ABN 92 164 537 973



HODGSON CONSULTING ENGINEERS
GEOTECHNICAL | CIVIL | STRUCTURAL

SITE PLAN - DCP LOCATIONS & HAZARD

Job No	Address
QY 00120	51 PARK AVENUE
Scale	AVALON
NTS	NSW



NOTE
INTERPRETED SUB SURFACE SECTION ONLY.
ACTUAL GROUND CONDITIONS MAY VARY.

HODGSON CONSULTING ENGINEERS
GEOTECHNICAL | CIVIL | STRUCTURAL

TYPE SECTION

Job No	Address
QY 00120	51 PARK AVENUE
Scale	AVALON
NTS	NSW

STRATA PROFILE LEGEND

- Fill
- Sandy Topsoil
- Sandy Loam
- Narrabeen Group Rocks
- Hawkesbury Sandstone

7 RISK ESTIMATION

7.1 QUANTITATIVE RISK ESTIMATION

Quantitative risk estimation involves integration of the frequency analysis and the consequences.
For property, the risk can be calculated from:
$\mathbf{R}_{(Prop)} = \mathbf{P}_{(H)} \times \mathbf{P}_{(S:H)} \times \mathbf{P}_{(T:S)} \times \mathbf{V}_{(Prop:S)} \times \mathbf{E}$ **(1)**

Where
$\mathbf{R}_{(Prop)}$ is the risk (annual loss of property value).

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

$\mathbf{P}_{(S:H)}$ is the probability of spatial impact by the landslide on the property, taking into account the travel distance and travel direction.

$\mathbf{P}_{(T:S)}$ is the temporal spatial probability. For houses and other buildings $\mathbf{P}_{(T:S)}$= 1.0. For Vehicles and other moving elements at risk$1.0 < \mathbf{P}_{(T:S)} > 0$.

$\mathbf{V}_{(Prop:S)}$ is the vulnerability of the property to the spatial impact (proportion of property value lost).

E is the element at risk (e.g. the value or net present value of the property).
For loss of life, the individual risk can be calculated from:

$\mathbf{R}_{(LoL)} = \mathbf{P}_{(H)} \times \mathbf{P}_{(S:H)} \times \mathbf{P}_{(T:S)} \times \mathbf{V}_{(D:T)}$ **(2)**
Where

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

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

$\mathbf{P}_{(S:H)}$ is the probability of spatial impact of the landslide impacting a building (location) taking into account the travel distance and travel direction given the event.

$\mathbf{P}_{(T:S)}$ 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 landslide occurrence.

$\mathbf{V}_{(D:T)}$ is the vulnerability of the individual (probability of loss of life of the individual given the impact).
A full risk analysis involves consideration of all landslide hazards for the site (e.g. large, deep seated landsliding, smaller slides, boulder falls, debris flows) and all the elements at risk.

For comparison with tolerable risk criteria, the individual risk from all the landslide hazards affecting the person most at risk, or the property, should be summed.

The assessment must clearly state whether it pertains to ‘as existing’ conditions or following implementation of recommended risk mitigation measures, thereby giving the ‘residual risk’.