GEOTECHNICAL ASSESSMENT REPORT
FOR
PROPOSED ALTERATIONS AND ADDITIONS
AT
40 LINDLEY AVENUE, NARRABEEN

1. INTRODUCTION.

1.1 This Geotechnical Assessment Report has been prepared to accompany an application for Development Approval with Northern Beaches Council - Warringah.

1.2 The methods used in this Assessment are based on those described in *Landslide Risk Management March 2007*, published by the Australian Geo-mechanics Society.

1.3 The experience of Jack Hodgson Consultants spans some 40 years in Northern Beaches Council area and the Greater Sydney region.

1.4 The site is located in land that is classified as Areas E on the Landslip Risk Map published by Northern Beaches Council - Warringah. The methods used in this Assessment are based on those described in Landslide Risk Management March 2007, published by the Australian Geomechanics Society. Also Council checklist contained within Clause E10 of Warringah DCP and the WLEP Map identifying the Landslip Risk Class as highlighted (red) below:-

	LANDSLIP RISK CLASS *(Highlight indicates Landslip Risk Class of property)*
☐	*A Geotechnical Report not normally required*
☐	*B Geotechnical Engineer (Under Council Guidelines) to decide if Geotechnical Report is required*
☐	*C Geotechnical Report is required*
☐	*D Council officers to decide if Geotechnical Report is required*
☒	*E Geotechnical Report required*

2. PROPOSED DEVELOPMENT.

2.1 Construct new rear lower ground floor level extension.

2.2 Construct new internal stair replacing the existing internal staircase.

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

2. PROPOSED DEVELOPMENT. (Continued)

2.3 Construct new carport roof over existing level area at the front of the property.

2.4 Details of the proposed development are shown on a series of architectural drawings prepared by Bradstreet Building Services, Project No: 1089, Dwg No: A-01 to A-08 Revision A and dated December, 2019.

3. DESCRIPTION OF SITE & SURROUNDING AREA.

3.1 The site was inspected on 30th October, 2019.

3.2 This property is located on the low side of the road and has a northerly aspect. From the road frontage, the slope of the land falls to north at maximum average angles of some 10 to 15 degrees. The topography of the block is controlled by the underlying sandstone bedrock. The property to the north of the subject property sits atop the escarpment above Narrabeen Lake. Above the subject property the slope continues to Edgecliffe Boulevard at an average gradient of approximately 20 degrees.

3.3 Vehicular access to the block is via a concrete vehicle crossing and driveway that provides access to the under house double garage on the north eastern corner of the existing residence, Photo 1. The driveway continues down the eastern boundary right of carriageway to the property located at the rear of the subject property. The road reserve is gravel and garden beds where the bitumen finishes, Photo 2. A level gravel area is at the south western corner of the property supported by timber retaining walls and also terraces the area to the east of the front yard, Photo 3. A pathway steps down from the gravel area and front gate leading to the entry of the existing residence. Access to the rear of the block is via the driveway and a gate near the existing double garage, Photo 4. A level paved and lawn area is at the rear of the existing residence, Photo 5. A swimming pool is at the north eastern corner of the property, Photo 6. A masonry retaining wall is at the northern rear boundary that supports the fill material of the level rear yard of the subject property, Photo 7. This retaining wall was observed to be stable at the time of our inspection.

3.4 The existing part three to two storey brick veneer residence is in good condition for its age. It is supported on brick walls, strip footings and piers that show no signs of cracking or movement due to slope instability.

4. GEOLOGY OF THE SITE.

4.1 The Sydney geological series sheet, at a scale of 1:100,000 indicates the site is underlain by Hawkesbury Sandstones which can be seen outcropping on site. These sandstones are of Middle Triassic age and were probably laid down in braided streams. The sand grains are mainly quartz with some sand grade claystone fragments. There are lenticular deposits of mudstones and laminates which are thought to have been deposited in abandoned channels of the main streams. The sandstones generally have widely spaced sub vertical joints with some current bedding. The joint directions are approximately north/south and east/west. The beds vary in thickness from 0.5 to in excess of 5 metres.

4.2 The slope materials are colluvial at the surface and residual at depth. They consist of sandy loams over sandy clays that merge into the weathered zone of the underlying rocks at depths expected to be in the range of shallow to ~0.5 to 1.5 metres or deeper where filling has be carried out.

5. SUBSURFACE INVESTIGATION AND SITE CLASSIFICATION.

5.1 One Dynamic Cone Penetrometer (DCP) test was conducted in the location shown on the site plan. The test was conducted to the Australian Standard for ground testing: AS 1289.6.3.2 – 1997 (R2013). The result of this test is as follows:

NUMBER OF BLOWS - Conducted using a 9kg hammer, 510mm drop and conical tip -	
DEPTH (m)	**DCP#1**
0.0 to 0.3	6
0.3 to 0.6	12
0.6 to 0.9	14
0.9 to 1.2	**55/0.245**
End of Test	**1.145**
~ RL top of test AHD	**25.67**
~ RL end of test AHD	**24.525**

DCP TESTING NOTES:

DCP#1	55 Blows for 0.245m then 8 blows for 0.006m. Double Bounce. Refusal on rock or floater. Tip – Dry and clean.
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. SUBSURFACE INVESTIGATION AND SITE CLASSIFICATION. (Continued)

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.

6.2 SURROUNDING AREA.

Overland stormwater flow entering the site from the adjoining properties was not evident. Normal surface stormwater runoff will be managed by the street gutter drainage system for the road above though stormwater overflow could enter the site from above during intense or extended rainfall.

7. GEOTECHNICAL HAZARDS.

7.1 ABOVE THE SITE.

No geotechnical hazards likely to affect the subject property were observed above the property.

7. GEOTECHNICAL HAZARDS. (Continued)

7.2 ON THE SITE.

The site is classed slip affected under Council's Policy and an 'E' Hazard area. A failure of the slope across the property is considered to be a potential hazard **(HAZARD ONE)**.

7.3 BELOW THE SITE.

No geotechnical hazards likely to adversely affect the subject property were observed below the site.

7.4 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.

8. RISK ASSESSMENT.

8.1 ABOVE THE SITE.

As no geotechnical hazards likely to adversely impact upon the subject site were observed above the site, no risk analysis is required.

8.2 ON THE SITE.

8.2.1 HAZARD ONE Qualitative Risk Assessment on Property

The block is located near the middle of a slope that rises from the waters Narrabeen Lake to top of the slope approximately at Edgecliff Boulevard. The gradient rises across the site at angles of some 10 to 20 degrees. There was no evidence of slumping or slope instability on the subject property. The likelihood of the slope failing and impacting on the house is assessed as 'Unlikely' (10^{-4}). The consequences to property of such a failure are assessed as 'Minor'(5%). The risk to property is 'Low' (5×10^{-6}).

8. RISK ASSESSMENT. (Continued)

8.2.2 HAZARD ONE Quantitative Risk Assessment on Life

For loss of life, risk can be calculated as follows:
$\mathbf{R_{(LoI)} = P_{(H)} \times P_{(SH)} \times P_{(TS)} \times V_{(DT)}}$ (See Appendix for full explanation of terms)

8.2.2.1 Annual Probability

Competent rock is encountered at relatively shallow depths across the block. No evidence of significant movement was observed on the site.
$\mathbf{P_{(H)}} = 0.0001$/annum

8.2.2.2 Probability of Spatial Impact

The house is located near the middle of the slope.
$\mathbf{P_{(SH)}} = 0.15$

8.2.2.3 Possibility of the Location Being Occupied During Failure

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:
$\frac{20}{24} x \frac{7}{7} = 0.83$
$\mathbf{P_{(TS)}} = 0.83$

8.2.2.4 Probability of Loss of Life on Impact of Failure

Based on the volume of land sliding and its likely velocity when it fails, it is estimated that the vulnerability of a person to being killed in the house when a landslide occurs is 0.2
$\mathbf{V_{(DT)}} = 0.2$

8.2.2.5 Risk Estimation

$\mathbf{R_{(LoI)}} = 0.0001 \times 0.15 \times 0.83 \times 0.2$
$= 0.00000249$
$\mathbf{R_{(LoI)}} = 2.49 \times 10^{-6}$/annum **NOTE:** This level of risk is **'ACCEPTABLE'** provided the recommendations given in **Section 10** are undertaken.

8.3 BELOW THE SITE.

As no geotechnical hazards likely to adversely impact upon the subject site were observed below the site, no risk analysis is required.

8. RISK ASSESSMENT. (Continued)

8.4 BESIDE THE SITE.

As no geotechnical hazards likely to adversely impact upon the subject site were observed beside the site, no risk analysis is required.

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.

9.3 CONCLUSIONS.

The site and the proposed development can achieve the Acceptable Risk Management criteria as published by the Australian Geo-mechanics Society in March 2007, provided the recommendations given in **Section 10** are undertaken.

10. RISK MANAGEMENT.

10.1. TYPE OF STRUCTURE.

The proposed structures are considered suitable for the 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 March, 2015.

10.2.2 The proposed alterations and additions will require minimal excavation for any new footings that are required. The depth to the underlying bedrock is approximately 1.0 to 1.5 metres. We recommend that any new foundations required are to be taken to the underlying bedrock.

10. RISK MANAGEMENT. (Continued)

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

10.3. FILLS.

No fill materials required as shown on the prepared drawings.

10.4. FOUNDATION MATERIALS AND FOOTINGS.

It is recommended that all footings be supported on the underlying sandstone bedrock. The design allowable bearing pressures are 1.0 MPa for spread footings or shallow piers. All footings are to be founded on material of equal consistency to prevent differential settlement.

All footings are to comply with minimum setbacks from existing sewer or any other infrastructure. Infrastructure owners are to be contacted regarding all requirements and standards in relation to works in proximity to their property.

10.5. STORM WATER DRAINAGE.

Any stormwater generated from any new works is to be piped to the existing stormwater system passing through any On-Site Detention and any discharge systems that may be required by the regulating authorities. All works to be in accordance with AS 3500.

10.6. SUBSURFACE DRAINAGE.

No subsurface drainage required as shown on the prepared drawings.

10.7. INSPECTIONS.

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

11. GEOTECHNICAL CONDITIONS FOR ISSUE OF CONSTRUCTION CERTIFICATE.

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

The work to be completed is to be carried out in accordance with the Risk Management Report PX 00055 dated 5th November, 2019.

The Geotechnical Engineer is to inspect and approve the foundation materials of all 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 to be completed was carried out in accordance with the Geotechnical Assessment Report PX 00055 dated 5th November, 2019.

The Geotechnical Engineer has inspected and approved the foundation materials of all footing excavations before concrete was placed.

REPORT CONTINUES ON NEXT PAGE

13. RISK ANALYSIS SUMMARY.

HAZARDS	Hazard One
TYPE	The site is classed slip affected under Council's Policy. 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	2.49 x 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

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Photo 5

Photo 6

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Photo 7

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PO Box 389 Mona Vale NSW 1660
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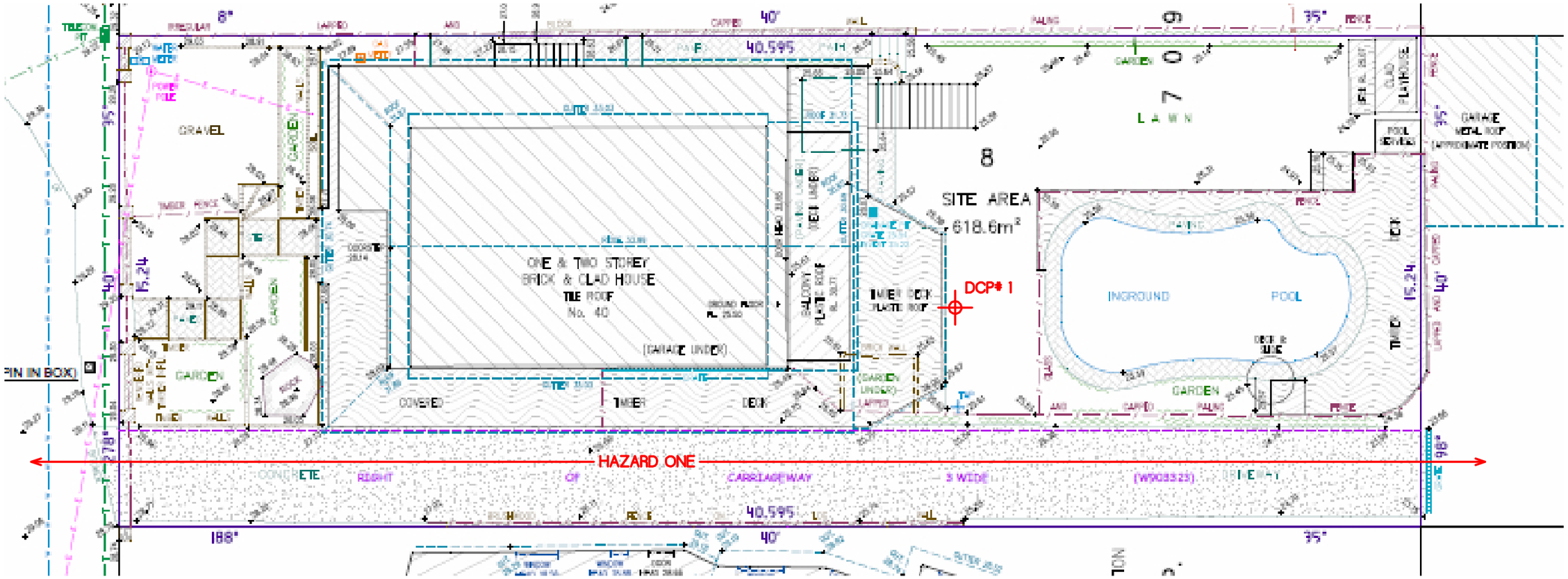
ABN 92 164 537 973



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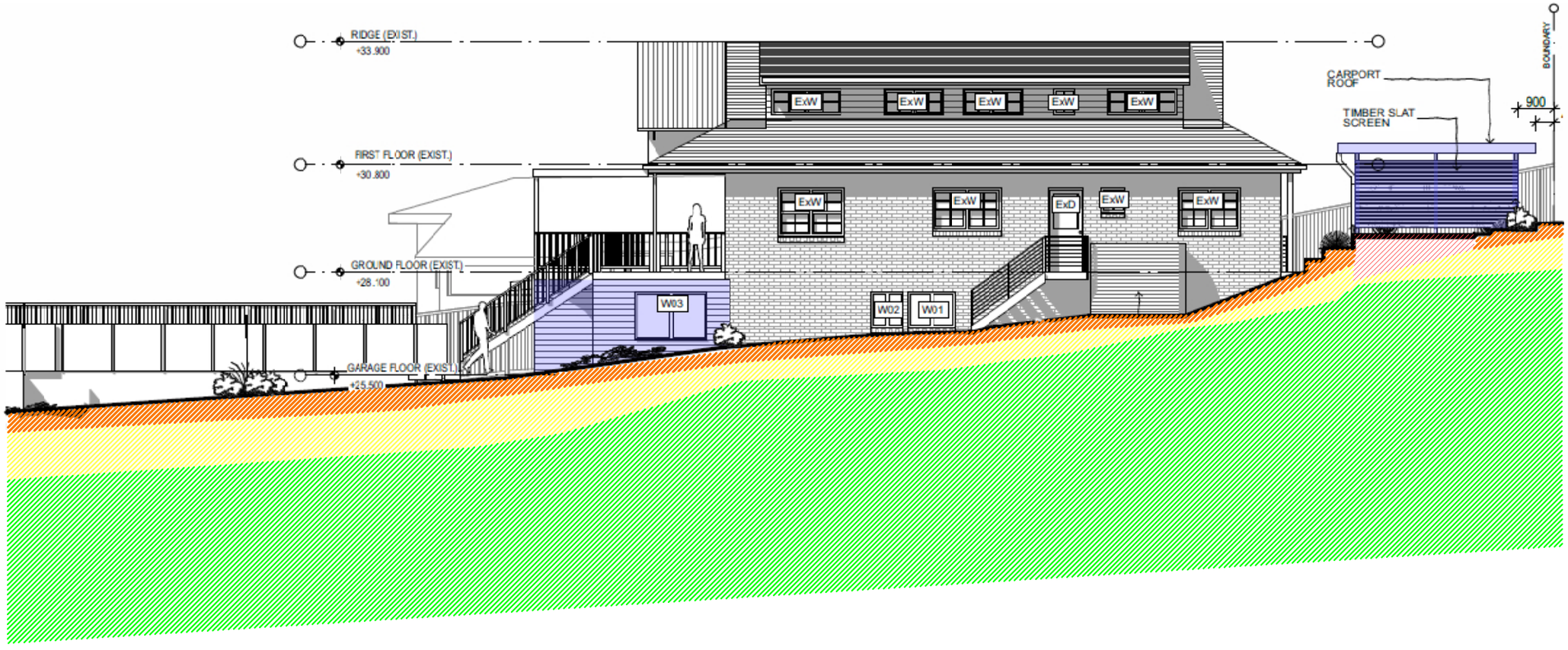
SITE PLAN - DCP LOCATIONS & HAZARD

Job No	Address
PX 00055	40 LINDLEY AVENUE
Scale	NARRABEEN
NTS	NSW



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

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TYPE SECTION

Job No	Address
PX 00055	40 LINDLEY AVENUE
Scale	NARRABEEN
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’.