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REPORT ON GEOTECHNICAL INVESTIGATION FOR PROPOSED SUB-DIVISION AT 120 MONA VALE ROAD, WARRIEWOOD

1. INTRODUCTION:

This report details the results of a geotechnical investigation and risk assessment carried out for a proposed sub-division of the existing site at 120 Mona Vale Road, Warriewood. The investigation was undertaken at the request of Mr. Sam Mustaca of Opera Properties Pty Ltd.

It is proposed to sub-divide the existing large site into numerous residential house lots with access roads.

The investigation was carried out to provide information for Development Application purposes. The site has been classified under the Pittwater Council Interim Geotechnical Risk Management Policy 2009 as being within the H1 landslip hazard zone therefore the site requires a Geotechnical Landslip Risk Assessment to be conducted. The investigation comprised:

a) A detailed geological inspection and mapping of the entire site and adjacent land by a Senior Engineering Geologist.
b) Review of Ortho Photomaps and Aerial Photography of the site.
c) Drilling of boreholes to determine subsurface geology and depth to bedrock. The investigation was limited to hand equipment.

Details of the fieldwork are given in the report, together with comments relating to design and construction practice. The following plans and diagrams were supplied for this work;

- Site Survey by Mepstead & Assoc, Reference: 4034, Dated: 19/07/2004
- Concept Plan by Barry Rush and Assoc, Job No.: 0519, Dated: 06/10/2005.

2. SITE FEATURES:

2.1. Location:

The site is located on the low south side of Mona Vale Road, at the intersection with Boundary Road. It is located within moderately to steeply sloping topography at the western end of the Warriewood Valley in Warriewood, Sydney, N.S.W. (see Figure: 1).

2.2. Description:

The site includes Lot 1 DP 383009 and Lots 3, 4 and 5 DP 124602 within the address 120 Mona Vale Road. It is a large (83261m^2) triangular shaped parcel of land formed with Mona Vale Road passing along its northern boundary, Boundary Road along its eastern boundary and Narrabeen Creek along half its southern boundary. The site is currently used in a semi-rural purpose with extensive undeveloped grassy areas used for grazing by various 'farm' animals along with glass houses for cultivation of vegetables. A residential house and numerous shed structures are located in the high north-west corner of the site.

Two separate ridge lines plunge through the site, separated by a small creek that passes through the site draining to the east. The southern two thirds of the site is formed with a steeply to very steeply sided, east plunging ridge with numerous sandstone outcrops and cliffs down its sides. This ridge is bound by Narrabeen Creek to the south and the smaller secondary creek to the north. This large ridge line extends to the east below Boundary Road and into the neighbouring properties. The northern third of the site is formed with a steeply sided, rounded convex ridgeline that plunges to the south-east down to the lower portion of the smaller creek gully. The site is formed with numerous varying slope segments and has been partly modified from its natural state. It has an approximate average slope of -20° towards the east-south-east.

2.3. Geology:

Reference to the Sydney 1:100,000 Geological Series sheet (9130) indicates that the site is located near the boundary between the Hawkesbury (Rh) Sandstone and underlying upper Narrabeen Group (Rnn) rocks. The Hawkesbury Sandstone rock unit typically comprises medium to coarse grained quartz sandstone with minor lenses of shale and laminite. The Newport Formation is the upper unit of the Narrabeen Group, it is of middle Triassic Age and typically comprises interbedded laminite, shale and quartz to lithic quartz sandstones and pink clay pellet sandstones.

The site investigation identified the contact between the weathered Hawkesbury Sandstone and Newport Formation rocks as passing at mid-slope level through the site. The Hawkesbury Sandstone occupies the upper elevations and is outcropping in numerous locations as cliffs, rock ledges and terraces. The upper unit of the Newport Formation is a fine grained sandstone, this unit was identified forming similar rock outcrops directly below the contact.

The lower third of the site is underlain by the Narrabeen Group rocks which are dominated by shales and thin siltstone beds with occasional sandstone units. These rocks tend to weather more deeply and often form rounded convex ridge tops with moderate angle (<20°) side slopes. These side slopes can be either concave or convex depending on local geology. Internally they comprise interbedded shale and siltstone beds with close spaced bedding partings that have either close spaced vertical joints or in extreme cases large space convex joints. The shale often forms deeply weathered silty clay soil profiles (medium to high plasticity) with thin silty colluvial cover.

2.4. Aerial Photogrammetry Assessment:

Air photographs of the site and adjacent land were acquired from the NSW Land and Property Management Authority for assessment of site conditions. Photo sets from 1982 and 2005 were compared along with various photos acquired from public utilities for evidence of changes in land form and indicators of previous instability that could be further investigated during site inspection.

The large scale photo sets acquired (1: 16000 and 1:25000) were enlarged to provide photos at 1:4000 and 1:6250 scale. These were viewed stereographically to identify distinct topographical features and assess changes in site conditions. The northern half of the site was cleared of vegetation between 1982 and 2005 however there were no other signs of significant changes to the site. There were no indicators of large scale instability within the soil slopes or rock outcrops.

3. FIELD WORK:

3.1 Method:

The field investigation comprised a walk over inspection of the site and adjacent properties on the 1st and 8th April 2011 by Senior Engineering Geologists and Geotechnical Engineer. It involved geological and geomorphological mapping of the site and adjacent land with examination of soil slopes, rock outcrops, drainage gullies, trees, and existing built structures for stability. It included the drilling of three hand auger boreholes to verify sub-surface geology.

3.2. Results:

3.2.1. Field Observations:

The results of the field mapping are shown on Figure: 2 with the main observations detailed below, traversing from the northern end of the site to the south.

3.2.1.1. Northern corner:

The northern corner of the site contains dirt access roads passing close to both the eastern and northern boundaries. The upper access road extends across slope along the boundary fence, neat paralleling Mona Vale Road. It is formed via a shallow (<1.0m) cut into the hill slope on its upper side with the spoil fill forming an embankment to support the outer edge. The outer edge of the fill embankment is generally very steep and is up

to 1.5m in height. The lower access road is formed in a similar manner however it is located at the base of the slope within less steeply sloping topography therefore the cut and fill heights are significantly lower.
This northern corner of the site is generally covered in low grasses with small patches of dense fern undergrowth and occasional large eucalypt trees. The slope is formed with small drainage lines and terraces cut across it and occasional partially buried sandstone boulders or outcrops of bedrock.

A very shallow ephemeral drainage line cuts down from the northern boundary to northern side of the small secondary creek that separates the two main ridge lines within the site. An outcrop of the sandstone bedrock was identified within this shallow drainage path forming a 3-4m high cliff line. This outcrop is discontinuous to the north and south and appears exposed only due to erosion within the drainage path.

There were no signs of concentrated stormwater flow other than within existing drainage lines in this portion of the site. There were no signs of recent erosion of surficial soils or landslip instability. The shallow excavation and fill embankment for the upper access road have been in existence for at least 10 years and show only minor creep and erosion. The trunks of all trees showed no signs of significant basal curvature suggesting ongoing soil creep is minimal.

3.2.1.2. Secondary Creek Drainage Path:

A secondary drainage path enters from the adjacent land upslope, passing below Mona Vale Road. This small creek then strikes east through the site before turning north-east and passing below Boundary Road into the neighbouring property. The creek within this drainage path appears to be intermittent and of low flow volume other than what is discharged into it from a small dam at the crest of the site.

The upper portion of the drainage gully is wide and open however it appears modified from its natural condition for the construction of Mona Vale Road. The Mona Vale Road pavement is supported up to 10m above the level of the site via both a steep embankment and a stacked sandstone boulder retaining wall. The embankment contains numerous trees and is densely vegetated, whilst the boulder wall forms a steep embankment extending up from the property boundary fence. The boulder wall is approximately 15m wide at the crest. The majority of the wall and embankment were not visible due to extensive vegetation growth however where inspected they both appeared in a stable condition with no obvious deformation in the wall or erosion and instability in the embankment. A pipe and culvert allow drainage to continue below the road and embankment into the site.

Directly down slope from the boundary fence the gully steepens and narrows and is very densely overgrown with weed vegetation. Inspection of the gully sides identified a moderate level of fill soils have been placed around the gully. As the creek passes down slope it begins to flatten out in the centre of the site where a dirt access road passes across it. Below this road the gully is again very densely overgrown until the creek reaches a small deep pond formed close to the eastern property boundary. The creek then passes to the north-east via several shallow channels which appear to contain extensive fill material along with alluvial sediments before it passes into a culvert and below Boundary Road.

Inspection of the creek line was limited due to the very dense weed vegetation which fills the majority of the gully. However there were no signs of recent landslip instability or excess erosion of the gully banks. Inspection of the Mona Vale Road boulder wall and embankment were limited due to vegetation growth however they have been in existence for at least 30 years and show no major signs of instability. Inspection of the road pavement above this location noted that the pavement is relatively uncracked and shows signs of only minor deformation adjacent to the rock wall. The pavement has not been recently renewed or modified.

3.2.1.3. Main Ridge Line:

The ridge line passing through the southern two thirds of the property is the main geomorphological feature of the site. This ridge is extensively modified down its northern face via numerous tracks and fill terraces however only the upper edge of the southern face has been altered from its natural condition. The ridge is separated into three distinct units, an upper ridge crest that is generally gently sloping containing residential structures, a steep sided and east plunging relatively undeveloped portion and then a lower gently sloping unit containing agricultural development.

Upper Unit:

The upper unit contains a single storey brick residential house along with several steel sheds interspersed with lawns and gardens across the ridge crest. Several rock retaining walls up to 2.0m in height are located to the north of the house supporting gently sloping lawn terraces above an access driveway from Mona Vale Road. Another access road also extends from Mona Vale Road heading east through the northern side of this unit. The outer northern side of this access road and also another parking area terrace to the north are formed upon fill soils placed over the natural slope. A small dam is located along slope between the residential area and the northern access road. This dam is formed with a sandstone cliff along its southern face and an embankment up to 3.0m in height along its northern side, adjacent to the access road. It appears that the southern rock face may have been the result of previous quarrying, possibly related to the construction of Mona Vale Road. It exposes high strength Hawkesbury Sandstone bedrock with few bedding or joint defects.

The southern side of this upper unit is formed with a narrow grassed access track and lawn terraces that appear partially formed upon fill soils around their down slope edges. The southern edge of the access track is located directly above a sandstone outcrop and cliff that strikes east along the edge of the residential area. This cliff marks the edge of the developed portion. Another cliff then strikes north at the eastern end of this upper unit.

The entire upper unit is extensively modified from its natural condition with excavation and fill embankments noted throughout. The rock retaining walls are considered in a moderate condition and are showing signs of deformation and cracking. The embankment formed along the northern side of the dam is showing signs of ongoing seepage with a drain at its base collecting approximately 0.25L/s of seepage flow. The outcropping cliff face at the eastern end of this unit shows signs of previous excavation with the embankment directly below appearing to contain fill soils and sandstone boulders.

Central Unit:

The central unit of the main ridge line appears relatively undeveloped other than lawn terraces and access roads with numerous sandstone cliffs mapped terracing down its sides. The majority of the terraces appear formed as a result of excavation into the ridge crest and placement of fill soils over the sandstone cliff top terraces. The unit contains few trees, however the steep slopes are covered in dense fern vegetation. There were several small soggy areas identified suggesting ongoing ground water seepage in these locations.

Lower Unit:

The lower unit, forming the south-east corner of the site, occupies a saddle in the ridge crest between two separate drainage paths. This unit is generally gently sloping and contains large open grassed areas and numerous glass houses for crop cultivation. A large near level terrace is formed in the south-east corner of the site with grass covering. This terrace is filled around its southern and western edges and appears formed across another low south striking secondary ridge crest.

There were several areas of seepage noted however there are no signs of excess surface stormwater flow, erosion or landslip instability within this unit. The fill embankments have been in place for at least 30 years and show no sign of landslip instability other than minor creep.

3.2.1.4. Narrabeen Creek:

Narrabeen Creek drains from the land upslope to the south-west of the site and then below Mona Vale Road. The creek base then forms the western half of the southern property boundary. The creek then strikes south-east down through the adjacent land to the south of the site. The creek has formed a steep sided valley which appears relatively unmodified from its natural state. The valley sides form steeply south to south east sloping topography through the southern edge of the site. Both sides of the valley contain extensive outcrops of sandstone bedrock, including cliffs, along with detached sandstone boulders with trees and undergrowth throughout. The majority of the creek base was inaccessible however where it passes the upper corner of the site the valley walls contain numerous high (>3m) vertical cliffs whilst the base contains numerous sandstone boulders. A very large (12m) cliff is located upslope directly to the south-west corner of the site, forming a waterfall with overhang.

The natural Narrabeen Creek Valley faces are steeply sloping however a limited inspection did not reveal any signs of excess surface stormwater flow or erosion other than that related to the creek. There are no signs of landslip instability however there are numerous scattered boulders throughout the gully.

3.2.2. Site Testing:

Hand auger boreholes were used to confirm the geology within key locations across the site. The following summarises the results of site testing, detailed log sheets are included in Appendix: 1 and test locations are shown on Figure: 2.

Borehole 1 was drilled in the lower south-eastern corner of the site, adjacent to the filled embankment terrace. This bore intersected dark grey silty sand topsoil overlying dark brown, slightly clayey sand with sandstone gravel. From 0.35m depth yellow-brown sandy clay was intersected to 0.55m before stiff, light yellow brown

and grey sandy clay was encountered. This horizon was identified as extremely weathered sandstone before refusal occurred at 0.85m depth in very low strength interbedded siltstone and shale.

Borehole 2 was drilled on the low north-east side of the main ridge. This bore was attempted twice with borehole 2A intersecting a thin topsoil horizon overlying dark brown clayey sand with sandstone gravel to 0.50m Below this level dark yellow-brown, moist to wet, clayey sand/sandy clay was intersected which graded to light yellow-brown and grey with depth before hand auger refusal occurred at 0.68m depth on low strength sandstone. It could not be confirmed that this was bedrock.

Borehole 3 was drilled in the lower north-east corner of the site. This bore intersected topsoil and dark grey silty and clayey sand (colluvium) to 0.30m before dark yellow brown, slightly clayey sand with sandstone pebbles was intersected. Hand auger refusal occurred on what was interpreted as a sandstone cobble as it could not be determined if this was bedrock.

4. COMMENTS:

4.1. Geotechnical Assessment.

There were no signs of deep seated or large scale landslip instability identified within the site. Similarly there were no indicators of previous small scale landslip or excess erosion. However the site has been significantly modified from its natural condition and contains numerous filled embankments along with areas of ongoing groundwater seepage. The fill embankments appear to have been in place for at least 30 years and show signs of minor erosion and creep movement only, though these are generally located on the higher portion of the site which is underlain by geology considered naturally more stable.

Mapping of rock outcrops along with the results of the boreholes suggest that the upper portion of the site, above R.L. 64, is underlain by Hawkesbury sandstone bedrock with a thick sandstone unit of the Newport Formation below, extending down to approximate R.L. 58. Below this level the geology consists of interbedded sandstone, siltstone and laminites/shales of the Newport Formation, with at least one medium to high strength sandstone unit at R.L. 50.

The Hawkesbury and upper Newport Formation sandstone units are relatively massive and resistant to erosion with weathering producing shallow sandy soil profiles that are susceptible to erosion. As such landslip instability within these horizons will be very limited to shallow earth slides within the thin soils and rock topples/slides from exposed cliff lines. The Newport Formations interbedded siltstones, sandstones and laminites/shales identified below R.L. 58 are more susceptible to weathering and can form deeper clayey soil deposits. These clayey soils are more prone to landslip instability (earth slide/flow), especially on the southern faces of ridge lines, and when slopes are steepened above their natural angles through construction activities, as often seen throughout the Pittwater Council area.

The majority of the site is underlain by geology which generally has a low susceptibility to landslip instability (i.e. sandstone bedrock). Whilst the lower portion is considered more susceptible similar developments have occurred across the region successfully whilst maintaining the risk from landslip instability within 'Acceptable' levels. The site is therefore considered suitable for the proposed sub-division and subsequent residential development provided all works are undertaken with the implementation of proper engineering design and construction practices, especially those which are developed for use in landslip prone areas.

4.2. Slope Stability:

The contact between the upper sandstones and the lower interbedded units is known to result in significant levels of ongoing groundwater seepage. This is due to the groundwater flow along defects within the resistant sandstone being forced to surface by the low permeability of the more clay rich interbedded units below. This results in an increased risk of instability around this contact (approximate R.L. 58) due to saturation of the clayey soils below and undermining of the overlying rock horizons. A large volume of the seepage on the site is occurring near this contact however there were also numerous seepage points noted upslope on the main southern ridge line which appear related to the small dam constructed near the crest of the site.

The existing dam contains extensive leaks and is expected to be the cause of numerous groundwater seepage points down slope. This is due to the ongoing flow from leaks and pressure head of water it will be providing in both bedrock defects and at soil contacts. The embankment is relatively old and was likely poorly constructed resulting in its deterioration and significant leaking. The removal of this dam or its proper reconstruction would reduce the risk of instability within that area of the site and down slope.

The fill embankments provide a risk of small scale earth/debris slide landslip instability, though many of these existing embankments may be removed as part of the sub-division development. The seepage points noted on the lower slopes, especially on the southern side of the main ridge, also have the potential to result in small scale earth/debris slides or flows within both the fill and natural soil slopes. The risk of landslip in these locations will be relatively low however it may be increased through poor design and construction. The rock outcrops around the main southern ridge, also have the potential to provide rock topple/falls to lower portions of the site for the long term.

The proposed sub-division will result in extensive modifications to the existing site conditions therefore it is expected that the majority of the existing fill embankments will be removed or re-formed and contoured. However development works across these areas have the potential to result in the formation of new landslip hazards through poor excavation or earthworks practice. Excavations of cuts in the lower interbedded units (below R.L. 58) have the potential to result in shallow landslip instability whilst fill embankments will require proper preparation of foundations and control of both compaction and ongoing surface stormwater control.

Pittwater Councils Geotechnical Hazard Zone Map identifies the entire site as being subject to the H1 classification for landslip instability. Therefore development works on individual lots will be controlled by this zoning. Each building lot and the proposed development for that lot will require separate geotechnical

investigation and reporting to be submitted with Development Applications as per the Council Policy due to the potential for an increase in risk of instability through poor design and construction.

4.3. Landslip Hazards:

Based on our site mapping we have identified the following geological/geotechnical landslip hazards which need to be considered in relation to the existing site and the proposed development, these hazards are:

A. Earth/debris flow (<20m³) from fill embankments in upper portion of site related to existing dam and soil saturation.
B. Earth slide (<20m³) from fill embankments in upper portion of site
C. Rock topple/slide from cliff lines around southern ridge line.
D. Earth slide/flow from natural soil slopes in lower south-east corner of site.
E. Earth slide from fill embankments across lower portion of site.
F. Earth slide from natural slopes in northern half of site.

4.4. Risk Assessment:

There were no indicators of deep seated or large scale landslip instability within this site. The site has been assessed in accordance with the methods of the Australian Geomechanics Society (Landslide Risk Management, AGS Subcommittee, May 2002 and March 2007) and Pittwater Council's Interim Geotechnical Risk Management Policy for Pittwater – July 2009. The Australian Geomechanics Society Qualitative Risk Analysis Matrix is enclosed in Appendix 2 along with relevant AGS notes and figures.

The relatively small scale identified landslip hazards on the existing site each provided a Risk to Life of $\leq 10^{-6}$ and a Risk to Property of Low in their current condition and without remedial/stabilisation works being implemented. The risk associated with these existing landslip hazards is therefore considered 'Acceptable' against the Pittwater Council Risk Management Policy. However this risk level is based on the very low occupancy of the existing site. The risk associated with landslip hazards created by the proposed works is difficult to assess until final design and mark out have been completed, however based on our geotechnical assessment and experience, provided the proposed works are undertaken with engineering design and construction practices including geotechnical input as required by Pittwater Councils Policy then the risk of instability should remain within the 'Acceptable' level across this site.

4.5. Geological Model.

In an effort to understand the likely impact that the proposed changes may have on the site it is necessary to develop a Geological/Geotechnical Model for the site. This model is developed using a combination of architectural drawings, land survey, geological mapping and test bore data. The results are presented as several sections through the site within Figure: 3, enclosed in Appendix: 1.

4.6. Design & Construction Requirements:

The proposed design will require the construction of extensive pavements for access road construction as well as a stormwater drainage system prior to sub-division and development of the individual building lots. These preliminary works will involve extensive clearing of existing structures and the re-modification of the existing ground surface levels to achieve the design grades. A brief of recommendations for this work is outlined below.

4.6.1. Excavation:

The geotechnical engineer should be consulted regarding the suitability of any proposed excavation works on this site. Excavation to ≥1.0m depth in the upper portion of the site, above R.L. 58, is expected to encounter medium to high strength sandstone bedrock unless natural soils are overlain by fill material. The weathered profile in the lower portion of the site will be deeper therefore low strength interbedded sandstone/siltstone and laminite/shale bedrock may be located up to 3m depth below existing ground surface levels. However bedrock is outcropping at surface in numerous locations across the upper portion of the site and also in isolated locations across the lower half.

The excavation of medium to high strength sandstone bedrock will require the use of rock excavation equipment. Rock face instability is also possible in this material as is shallow soil instability in the weathered horizon. Any excavation through the interbedded sandstone, siltstone and laminite/shale units on the lower portion of the site will require low angle batters to reduce the potential for instability on the upslope side.

The excavation of soil and extremely weathered bedrock may be readily achieved using conventional earth moving equipment or hydraulic excavators with the assistance of ripping for the very low strength bedrock and thin ironstone bands. The geotechnical engineer should be consulted in regards to the suitability of any rock excavation equipment proposed for this site.

4.6.2. Earthworks:

Prior to placement of any new fill all surficial topsoil, organic material and any loose or saturated ground should be removed. Following removal of all unsuitable surficial material the exposed ground surface (sub-grade) should be proof rolled using a minimum 8 tonne roller during inspection by a geotechnical professional to identify areas of low strength or instability.

For filling purposes a granular material, such as crushed sandstone, may be placed in layers of ≤300mm loose thickness prior to compaction of each individual layer to achieve a density of ≥ 97 % standard compaction or to the engineers design requirements. Testing to confirm that the level of compaction is achieved should be undertaken as per the requirements of AS3798 to a minimum of Level 2 control.

4.6.3. New Footings:

The geology is variable across the site with levels modified from their existing conditions. Based on the identified geology the site classification for the upper portion of the site will generally either be Class 'A' or 'S' unless significant levels of fill soil are placed over the natural ground surface. The lower portion of the site is expected to vary between Class 'S' and 'M' however this will also be impacted by site variations. As such it is recommended that each individual building lot be re-classified as per AS2870 – 2011, 'Residential Slabs and Footings' as part of individual development applications.

Due to the underlying site conditions and steepness of the slope it is recommended that any new dwelling or retaining structures proposed for the site/s be founded off insitu bedrock of at least very low strength. The results of the site investigation suggest that extremely weathered bedrock is expected at ≤1.0m depth through the unmodified portions of the site and may be located at up to 3.0m depth where fill embankments have been previously constructed. Localised variations in these depths can be expected due to variability within natural geological processes and modifications to the land surface.

4.6.4. Drainage:

The existing site stormwater drainage system is primitive however this will be upgraded as part of the sub-division. The existence of the secondary drainage path and creek through the site will assist with stormwater design and control however to prevent an increase in risk of instability across the site once development has begun drainage easements should be provided for all building lots to allow for drainage of collected stormwater from hard surface areas.

4.7. Conditions Relating to Design and Construction Monitoring:

To comply with Councils conditions and to enable the completion of Form: 2 and 3 required as part of construction, building and post-construction certificate requirements of the Councils Interim Geotechnical Risk Management Policy 2009, it will be necessary for Geotechnical Consultants to;

1. review the structural design drawings for compliance with the recommendations of this and subsequent geotechnical reports,
2. confirm that adequate stormwater management systems are put in place,
3. inspect all new footings and excavations to confirm compliance to design assumptions with respect to allowable bearing pressure, basal cleanness and the stability of footings and excavation faces prior to the placement of steel or concrete.

This review and inspection procedure will be necessary for both the development of the sub-division and its infrastructure and within individual building lots as part of individual development applications.

4.8. Design Life of Structure:

We have interpreted the design life requirements specified within Councils Risk Management Policy to refer to structural elements designed to support the proposed developments, the adjacent slope, control stormwater and maintain the risk of instability within acceptable limits. Specific structures and features that may affect the maintenance and stability of the site in relation to the proposed and existing development are considered to comprise:

- stormwater and subsoil drainage systems,
- retaining walls and soil slope erosion and instability,
- maintenance of trees/vegetation on this and adjacent properties,

Man-made features should be designed and maintained for a design life consistent with surrounding structures (as per AS2870 – 1996 (50 years)). In order to attain a design life of 100 years as required by the Councils Risk Management Policy, it will be necessary for the structural and geotechnical engineers to incorporate appropriate design and inspection procedures during the construction period. Additionally the property owners and Council should adopt and implement a maintenance and inspection program.

If this maintenance and inspection schedule are not maintained the design life of the property cannot be attained. A recommended program is given in Table: 2 and should also include the following guidelines.

- The site is inspected 12 months after the works have been completed to verify that there have been no changes to site stability (during construction) by both the Structural Engineer and Geotechnical Consultant (at the same time, same day).
- The conditions on the block don't change from those present at the time this report was prepared, except for the changes due to this development.
- There is no change to the property due to an extraordinary event external to this site, and the property is maintained in good order and in accordance with the guidelines set out in;
    a) CSIRO sheet No. 10-91 1988
    b) The Australian Geomechanics "Landslide Risk Management" Volume 42, March 2007.
    c) AS 2870 – 2011, Australian Standard for Residential Slabs and Footings

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

It is assumed that Pittwater Council will carry out regular inspections and maintenance of road verges, stormwater systems and large trees on public land throughout the site so as to ensure that stability conditions do not deteriorate with potential increase in risk level to the site/s. Also individual Government Departments and service providers will maintain public utilities in the form of power lines, water and sewer mains to ensure they don't leak and increase either the local groundwater level or landslide potential.

5. CONCLUSIONS:

The existing site has been assessed as per the Pittwater Council Interim Geotechnical Risk Management Policy 2009 and achieves the 'Acceptable' risk criteria. The site is considered suitable for sub-division and can achieve the 'Acceptable' risk criteria provided any recommendations outlined in this report are followed and any future development works are undertaken as per the recommendations of this and any future geotechnical reports.

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Reviewed by
Peter Crozier
Principal

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