REPORT

Shoalhaven Coastal Cliffs and Slopes Risk Management Recommendations Report

Recommendations Report

Client: Shoalhaven City Council

Reference: M&APA1474R001F0.3

Revision: 0.3/Final

Date: 11 May 2018

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Document title:	Shoalhaven Coastal Cliffs and Slopes Risk Management Recommendations Report
Document short title:	
Reference:	M&APA1474R001F0.3
Revision:	0.3/Final
Date:	11 May 2018
Project name:	Shoalhaven Risk Management Programme
Project number:	PA1474
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Date / initials:	11/5/18
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Date / initials:	11/5/18

Classification
Project related

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Foreword

For the purposes of this assessment, the identified areas of potential risk with regards to cliffs and slope instability in the Shoalhaven LGA are limited to those particular areas identified by previous studies (specifically by Douglas Partners in 2011) and assessments, and agreed with Council.

This assessment, carried out by Royal Haskoning DHV with the assistance of JK Geotechnical, is a review of existing work, with an assessment of risk associated with a more recent geotechnical assessment of each of the identified risk areas/sites. The assessment does not attempt to identify any new risk areas. Only those locations previously identified as being at risk were inspected and the recommendations herein are based on those areas.

1 Background

1.1 Historical Hazards and Assessments

Significant wet weather triggered a number of hazardous landslides in parts of the Shoalhaven Local Government Area (LGA) in January and February 2008, and again in August 2015. The landslides occurred in areas previously identified to be at risk of coastal cliff and slope instability. Shoalhaven City Council (SCC) has in the past commissioned a number of expert reports to assess slope instability and the risk of landslide hazards.

A number of previous studies and reports have been reviewed and considered as a part of the risk management program and considered in the context of forward planning for emergency actions in the event of future hazards. These reports are referenced throughout this document, and a list of the same is included within the references in **Section 8** of this report. In summary the reports date back to 1992, with the latest being produced in mid-2016. They cover a range of slope instability assessments, geotechnical investigations, emergency response management plans, hazard and risk assessments, for both public and private property within identified areas of risk in the SCC LGA (between 1992 and 2016).

1.2 Future Action

SCC intends to develop consistent emergency action plans in order to adequately manage emergency incidents in relation to cliffs and slopes in key risk areas. It is intended to provide easily interpreted representation of the key issues highlighted within previous assessments, to enable adequate risk management moving forward. SCC also seeks to clarify discrepancies and complexities in previous assessment findings to enable clear direction for actions to be taken in case of future emergency situations.

As a result of concerns, on 10 November 2015, Council resolved (in part):

That all previous and new expert reports in relation to coastal cliff and slope instability are reviewed in relation to future management, monitoring, owner notification and development controls for areas at risk, with an emphasis on monitoring of stormwater drainage management in high risk areas.

This recommendations report has been developed to address the history of concerns and help define the future actions required. The report sets the basis for the development of an Emergency Action Sub-plan, specific to the coastal cliffs and slopes within Shoalhaven.

1.3 Report Outline

The following sections of this report discuss the general outcomes of the geotechnical and site assessment and risk assessment for the Shoalhaven LGA. **Section 3** discusses the process for analysis of risk and the general outcomes of a risk assessment undertaken for this project. **Section 4** outlines the key aspects relevant to defining a program of works for the Shoalhaven LGA overall, and a suggested program of monitoring is then outlined in **Section 5**. Discussion with regards to planning documentation and relevant required amendments with respect to risk management is given in **Section 6**. **Section 7** discusses requirements and process for owner notification of concerns and management issues relevant to private property, whilst **Section 8** provides discussion and recommendations with regards to education and awareness strategies aimed at property owners and the broader community.

2 Risk Areas

2.1 General

The study area for the project comprises ten sites assessed in the previous expert reports. The sites considered as risk areas requiring management actions are those focused upon within a report developed for SCC by Douglas Partners in 2011, titled Supplementary Geotechnical Observations – Coastal Slope Instability Hazard Study Various Sites Shoalhaven City Council LGA. Within this study, 10 risk areas have been identified as follows:

1) Penguin Head and Culburra Beach;
2) Plantation Point;
3) Hyams Point;
4) Berrara Point;
5) Inyadda Point Headland, Manyana;
6) Narrawallee;
7) Bannisters Point;
8) Collers Beach Headland;
9) Rennies Beach; and
10) Racecourse Beach.

Figure 1 outlines the location of the risk areas within the Shoalhaven Local Government Area. These identified risk areas are reassessed as a part of this investigation and will form the focus of the Emergency Action Sub Plan. **Appendix A** includes maps of the risk areas as outlined within a previous study undertaken by SMEC (2008) and by Douglas Partners (2012) for Narrawallee.

Figure 1: Risk Area Locations - Shoalhaven LGA

A geotechnical and site assessment was undertaken by geotechnical engineers from JK Geotechnics and coastal engineers from Royal HaskoningDHV between the 30th of November and the 2nd of December 2016, at each of the foreshore locations. A summary of the observations for each site is presented in the sub-sections below, along with any site specific potential risk factors. Site observation images are included in **Appendix B**.

In order to outline/discuss any changes in site condition over time, the observations were compared to the site conditions described in the assessments undertaken by SMEC (2008) and Douglas Partners (2011).

2.2 Site Specific Observations and Risk Factors

2.2.1 Penguin Head and Culburra Beach

The 'boulder armour' described by Douglas Partners (DP) to be 5m to 10m wide and covering the base of the cliff around the north-western portion of the Penguin Head site was observed. Over the western end of the northern cliff face the 'boulder armour' was generally missing or a maximum width of about 4 metres in places. Localised erosion of the fill batter slope over this area was evident (see Image 1). Localised, less

than 0.5m^3 soil slumps were noted with 'ag' pipes extending down the cliff face from the yard area above (see Image 2).

The 'armour zone' 5 metres to 8 metres wide described by Douglas Partners over the base of the central eastern portion of the northern cliff face was intermittently present and a maximum width of about 4 metres (see Image 3).

The timber lookout at the crest of the cliff at the eastern end of the headland was set-back between about 1 metre and 1.5 metres from the crest of the cliff. The base of the cliff face below the south-eastern side of the lookout was undercut (maximum height 3.5 metres and 'depth' 1.8 metres). The sub-vertical joints in the sandstone above the undercut were open a maximum width of about 0.1 metre (see Image 4).

The 'dense cover of rock armour' described by DP over the base of the eastern end of the southern cliff face was intermittently present and a maximum width of about 4 metres (see Image 5).

A recent soil slump (about 8 m^3) had impacted the rear yard area at the crest of the cliff. Sections of the damaged brick fence were located on the wave cut platform (see Image 6).

2.2.2 Plantation Point

Over the north-westerly facing cliff face, the isolated 0.2 metre to 0.4 metre blocks on the beach surface were not observed.

Over the western portion of the north facing cliff face, there were signs of run-off erosion impacting the soil profile. Some trees were leaning over or had curved bases, suggesting creep of the soil profile (see Image 7). Over the eastern portion of the north facing cliff face, there were signs of fretting and spalling of the upper residual clay soil profile (see Image 8).

A concrete man hole cover was present at the crest of the north-eastern portion of the cliff and an erosion gully (maximum 2 metres wide and 1.5 metres deep) was present down the cliff face with traces of concrete on the cliff face and at the toe of the cliff (see Images 9 and 10).

2.2.3 Hyams Point

The toe of the vegetated slope at the northern end of the site had been eroded to form a maximum 1 metre high sub-vertical face (see Image 11).

The area described by DP as 'concrete faced slope, cracked and spalling' appears to have been remediated and now comprises a concrete block seawall founded on the bedrock wave cut platform. The terraced rear yard above the seawall has been formed using timber landscape retaining walls (see Image 12).

The discharge area of the stormwater pipe within the east-west orientated easement over a portion of the site was overgrown (see Image 13). At the southern end of the site there appeared to be arcuate area within the overgrown soil slope that probably represents and old landslip, maximum size about 40m^3 (see Image 14).

To the south of the old landslip, two 90mm diameter PVC stormwater pipes discharge at the toe of the soil slope. The ends of the pipe have been orientated to the north and south and the discharge of the pipes appears to have eroded the toe of the soil slope. The sub-vertical erosion face was about 0.5 metres high and the erosion had caused the toe to recede landward about 3 metres (see Image 15).

2.2.4 Berrara Point

A timber deck was located close to the crest of the cliff within the rear yard of 16 Myrniong Grove. The upper section of the cliff comprised an uneven overgrown surface inferred to represent colluvial soils (see Image 16).

The recent landslip area over the upper portion of the cliff face at 20 Myrniong Grove had been remediated with gabion retaining wall supporting a steep (50 degree) slope (3 metres high) which had been provided with erosion control matting that incorporated cells for soil (see Images 15 and 16). A number of the gabion baskets forming the top row of the retaining wall were not full of rock. A PVC stormwater pipe discharged part way down the cliff face (see Images 15 and 16).

The soil slope at the crest of the cliff below 28 Myrniong Grove was concave and sloped down to the south-west at a maximum of about 50 degrees. Patches of residual clay soils and extremely weathered bedrock were evident through the vegetative cover which are assumed to be the result of run-off erosion. This area has been interpreted to represent an old landslip feature (see Image 19).

The gully, orientated approximately north-west to south-east, at the southern end of the site appeared to be at the location of a stormwater easement discharge point. An igneous dyke (orientated approximately north-west to south-east) was exposed in the wave cut platform and cliff face immediately to the south-west of the gully. We have inferred that fractured and altered bedrock at the margin of the dyke has been preferentially eroded by both wave action and run-off from the stormwater easement and/or run-off from the road above. A similarly orientated gully in the wave cut platform seaward of the gully was also noted.

2.2.5 Inyadda Point

At the northern end of the site (below the northern end of Sunset Strip) the cliff face (maximum height about 7 metres) exposed as steep soil slope overlying an intermittent vertical sandstone cliff face. There was evidence of near surface slumping of the soil profile and erosion of the sandstone. Some soil erosion debris was present at the toe of the cliff (see Image 21). The four northernmost properties (1, 3, 5 and 7 Sunset Strip) were identified by DP as ‘most at risk from cliff erosion’.

The east facing vegetated foreshore slope was inferred to comprise colluvial soils and was typically a maximum of about 30 degrees. There was evidence of traces of old landslip features and what appeared to be a more recent landslip below 27 Sunset Strip (see Image 22).

To the west of Inyadda Point, DP previously described a 5 metre to 10 metre wide rock armour covering the wave cut platform. The rock armour lining the south facing foreshore slope was either absent or was a maximum width of about 4m (see Image 23).

The south facing foreshore slope was a maximum of about 35 degrees. A number of erosion gullies were evident and colluvium was exposed in the gully sides. The recent landslip that impacted 65 Sunset Strip in August 2015 was evident (see Image 24).

There appeared to be an erosion gully on the western boundary of 69 Sunset Strip. The section of Sunset Strip above had been provided with a kerb and gutter but the catchment area included the slope above (see Image 25). At the south-western end of the site, ‘erosion/slump chutes’ described by DP were evident but overgrown. The kerb and gutter lining the seaward side of Sunset Strip above (adjacent to 113 Sunset Strip) ended at the property boundary (see Image 26).

2.2.6 Narrawallee

The seaward side of Surfers Avenue was lined by a concave slope with a sub-vertical lower portion (maximum overall height about 2.5 metres high) which generally exposed colluvial clayey soils with gravel and cobbles of sandstone. A localised area of fill appears to have been placed to form the car parking area which was set back 2 metres from the crest of the slope (see Image 27). The seaward side of the road was set-back at least 7 metres from the crest of the slope.

The wave cut platform was generally covered by rounded sandstone gravels, cobbles and boulders and the platform surface either exposed residual clays, extremely weathered claystone or, locally, high strength silcrete overlying the clays and claystone. Boulders of silcrete were 'blocky' and angular in shape and appeared to have been eroded in-situ by wave action. To the south of the car park area, the colluvial soils have been eroded to form sub-vertical faces (maximum 2 metres high) and the tree root systems formed overhangs. Some trees had collapsed onto the wave cut platform. The trees covering the old landslip in the reserve area above were leaning over or had curved bases (see Image 28).

The tree covered slope at the southern end of the site sloped down to the east at a maximum of about 35 degrees. The slope surface was uneven and the trees were leaning over or had curved bases. The slope appears to have been previously impacted by a number of landslips (see Image 29).

To the north-west of the car park area, the colluvial soils have been eroded to form sub-vertical faces (maximum 2 metres high) and the tree root systems formed overhangs. Some trees had collapsed onto the wave cut platform (see Image 30). The roadside stormwater drain inlets were typically infilled with leaf debris (see Image 31).

2.2.7 Bannisters Point

The presence of a deep gully in the wave cut platform over the eastern side of the headland and high tidal levels over the south-eastern portion of the headland prevented access between these locations. However the site was compared to similar nearby sites in order to provide a comparative basis for assessing the risk of further instability affecting the site.

Over the western portion of the south facing cliff face, the toe erosion of the overgrown colluvium soil profile was intermittent. At the crest of the cliff, the rear yard of what was inferred to be 168 Mitchell Parade, there appeared to be a gabion retaining wall at the crest of the cliff face and a newly planted soil slope below (see Image 32).

Some toe erosion of the old rock fall has exposed colluvium over the area of the old rock fall indicated by DP and to the west and east typically forming 1 metre high sub-vertical faces (see Image 33).
At the north-eastern end of Mollymook Beach, at the crest of the slope affected by the 'large ancient slump' identified by DP, a timber lookout was set-back about 2 metres from the crest of the cliff face (see Image 34).

The section of Mitchell Parade above the eroded back scarp described by DP was not provided with kerb and guttering. This supports the DP inference that the erosion was associated with 'uncontrolled discharge' (see Image 35).

Where access to the crest of the cliff face was possible between 199 and 215 Mitchell Parade, the profile (in plan) was undulating with steep, uneven, overgrown slopes and a number of trees with curved bases (see Image 36).

The northern end of the headland comprised an uneven vegetated slope and colluvium had been exposed by erosion at the toe of the slope at the interface with the sandstone bedrock wave cut platform. The sub-vertical erosion faces were a maximum height of about 3 metres (see Image 37).

The north-east facing portion of the cliff face (below the car park area to the north of Bannisters) exposed sandstone (maximum height about 6 metres) below the vegetated colluvium slope. Occasional joint controlled wedge failures were evident (see Image 38).

To the south, the cliff face appeared to have a stepped profile comprising a gently dipping stepped wave cut platform, a lower vertical sandstone bedrock face with a limited soil cover, a vegetated bench area, then a further steep colluvial slope above which sloped back up to the rear yards of the property on Mitchell Parade (see Image 39).

The wide gully in the wave cut platform (orientated approximately 100 degrees) was lined by sub-vertical joints and what appeared to be a recent rock fall (approximately 100m^3) had impacted the southern side of the gully (see Image 40).

The cliff face that extended north-west form the northern end of the headland exposed sub-vertical basalt overlying extremely weathered claystone with numerous angular and 'blocky' basalt blocks (maximum 1 metre dimension) and rounded sandstone gravels and cobbles covering the shoreline (see Image 41). The upper steep slope was tree covered with leaning trees and curved tree bases indicating creep was impacting the upper soil profile. The claystone at the base of the cliff was being eroded, resulting in undercutting of the basalt and block collapses (see Image 42).

2.2.8 Collers Beach

At the north-western end of the site, the house identified by DP as being '2 metres to 3 metres above the wave cut platform' corresponded to 17 Shipton Crescent (see Image 43).

Immediately to the south-east of the house and the vegetated slope there was a gully that corresponded to the discharge of a stormwater outlet inferred to be present upslope.

To the south-east of Image 43, there were signs of recent slumping of the lower colluvial soil slopes (maximum about 5m^3) and some sub-vertical toe erosion faces (maximum height about 2 metres). A sandstone cliff face that was unravelling and spalling was evident landward of the lower colluvial soil slope (see Image 44).

A new plastic stormwater pipe extended down the full height of the cliff adjacent to an area of fractured and undercut sandstone (see Image 45). This area was inferred to be below about 61 to 65 Nurrawallee Street.

The cliff face at the south-western end of the site continues to erode and spall along the face and toe with potentially unstable blocks of sandstone evident on the cliff face (see Images 46 and 47).

2.2.9 Rennies Beach

The landslip area adjacent to the eastern boundary of 7 Rennies Beach Close and downslope of the adjacent public car park has been remediated using a gabion retaining wall (maximum 4 metres high) with a maximum 27 degree vegetated sloping backfill surface above. The stormwater pipe discharged onto a concrete base and a reno mattress had been provided over the majority of the base of the remediated area (see Image 48).

A creek line was flowing below the remediated area. Sandstone was exposed in the creek bed and extremely weathered claystone was exposed in the sub-vertical creek bank sides (maximum 3 metres high). Undercut erosion of the claystone was evident (maximum height about 0.5 metres and 'depth' about 1 metre). Small slumps had also occurred (maximum size about 0.5 m^3).

The debris from the rock falls identified by DP was missing. There were overhanging sandstone blocks at this location.

The upper portion of the cliff face over the area was unravelling and spalling with small blocks caught on ledges of the cliff face. The sandstone was fractured and maximum 1m x 1m x 1m, potentially unstable blocks were evident (see Images 49 and 50).

The upper section of the cliff face within the gully to the east had been impacted by a small slump, about 5m^3 (see Image 51). The area of detachment appeared to be controlled by a 45 degree joint sloping down to the south and seepage was evident. There was no kerb and gutter at the eastern end of Rennies Beach Close above and there were signs of run-off erosion (see Image 52).

2.2.10 Racecourse Beach

The cliff face undercut below the south-western side of the car park at Racecourse Beach was estimated to be a maximum height of 4 metres and a 'depth' of 1.5 metres (see Image 53). There were occasional small rocks (less than 0.1m^3) at the base of the cliff. The car park was set-back at least 3 metres from the crest of the cliff face.

At the north of the cliff face a marine sand and colluvial soil area sloped down to the south at a maximum of about 20 degrees. A number of erosion gullies were evident and the slope extended landward up to the rear yards of 43 to 49 South Pacific Crescent (see Image 54).

The uneven surfaced, vegetated colluvial soil slope contained a number of erosion gullies with very little toe erosion evident (see Image 55). Some erosion of the toe of the landslip debris lobe was evident and formed sub-vertical faces (maximum about 0.3 metres high) eroding at the toe (see Image 56).

2.3 Geotechnical Instability Assessment Summary

Following the detailed site assessments at specific properties, a geotechnical assessment was undertaken by JK which addressed the geological setting of each of the sites and the key factors affecting cliff face stability with regards to the bedrock cliff faces and the soil foreshore slopes. Based on this assessment and in combination with site observations and the review of previous reports and documentation, it has been concluded that the majority of instability affecting the foreshore areas at the ten sites has impacted soil slopes. Where the lower portion of the soil profile impacted by landslips represents a residual profile, bedrock has occasionally been impacted.

Whilst the principal trigger for the known landslips was rainfall, there is an increased likelihood of instability associated with a number of the other factors. These are highlighted at the following locations:

- The areas of erosion over the upper portions of soil slopes described at various sites;
- The older instabilities that have impacted the slopes lining the north-eastern side of Mollymook Beach below Mitchell Parade and Cliff Avenue;
- Landslips at a number of private properties in Berrara , Manyana and Mollymook;

- The area of recent and older instability at Surfers Avenue, Tallwood Avenue and Bannister Head Road, Narrawallee. Elevated groundwater levels (possibly artesian) are believed to be the most significant factor impacting stability.

There are some recent areas of instability along Sunset Strip, Manyana, the southern side of Penguin Head and the upper portion of the cliff face at the eastern end of Rennies Beach Close, Ulladulla, which are also likely to have been triggered during rainfall events. Whilst it is evident that erosion of the cliff face is occurring in some locations, the instability appears to be localized and typically of relatively small scale. However, larger scale instabilities of the cliff faces were noted at the Eastern end of Racecourse Beach, Ulladulla (an old landslip), Bannister Head Road Narrawallee and Bannisters Point, Mollymook.

3 Risk Assessment

An assessment and analysis of risk of hazards due to cliff and slope instability was undertaken at each of the sites. This was based on a risk assessment framework provided within the Australian Geomechanics Society (2007a) Practice Note Guidelines for Landslide Risk Management. This section of the report summarises the findings of the risk analysis.

3.1 Potential Geotechnical Hazards

With respect to the cliffs and slopes within the defined risk areas of Shoalhaven LGA, five potential geotechnical hazards were identified. These have been outlined as follows:

1. Instability of overhang/undercut features, blocks and/or wedges of rock over the cliff face;
2. Instability of foreshore colluvial/residual soil slopes, small scale (less than 5m^3) and impacting the full width of a residential lot (at least 200m^3);
3. Large scale cliff face instability;
4. Instability of landslip remediation measures; and
5. Creep of steep soil slopes.

Persons and property identified as being most at risk from geotechnical hazards are:

- Persons on the beach, wave cut platforms, lookouts and in rear yards;
- Site personnel working on landslip remediation measures;
- The lookout structures;
- Landscape structures and houses; and
- Utility infrastructure.

When analysing risk, it must be noted that it is difficult if not impossible to predict when potential geotechnical hazards may occur. It is also not predictable when an extreme or unusual event may occur (such as an earthquake or 1 in 100 year rainfall event etc.), and what impact it might have on the stability of the identified potential hazards.

3.2 Recession Rates and Hazard Lines

Many of the previous studies undertaken considered the causes of cliff and slope instability across the Shoalhaven LGA. When considering risk associated with instability and the likelihood of coastal erosion impacting property, assessment of the rate of recession of the cliff faces must be addressed. The determination of historical rates of recession has been the focus of many previous studies, including complex assessments based on detailed field observations and research.

In their 2008 report titled, A Coastal Slope Instability Study for the Shoalhaven City Council Coastal Zone Management Study and Plan, SMEC discussed calculation of the cliff recession rate based on an assumption that sea levels have remained stable for the last 6500 years (during the Holocene period). However based on the geotechnical assessment and the review of previous studies, it is thought that Douglas Partner's discussion on cliff line erosion rates within their 2011 Report, Peer Review – Coastal Slope Instability Hazard Study Various Sites in Shoalhaven City Council KGA is more accurate. The Douglas Partners Report (2011) outlines that the actual rate of the physical weathering process is more irregular than 10 to18 mm per year previously specified by SMEC. Erosion rates much less than 10 to18 mm per year are thought to be more applicable as sea levels may not have remained stable for the last 6500 years. The location and form of the current cliff faces are likely the result of more reduced rates of erosion.

It should be noted that in order to establish a more accurate erosion rate, very detailed mapping of relic shoreline features developed during the Holocene period (such as older wave cut platforms, semi fossilised shellfish and tube worms and clastic deposits) is required.

In consideration of the above, the erosion rates used by SMEC to establish the 'Recession Risk Lines' presented in the current Shoalhaven Coastal Zone Management Plan (CZMP) may be regarded as resulting in conservative lines. It should be noted that recession does not occur at a uniform rate with time and is more cyclical in behaviour, occurring more infrequently.

It is evident that relatively large scale landslip have impacted sections of the risk areas, however instead of being the result of coastal erosion or shoreline recession, their principal triggers are inferred or assessed to be associated with rainfall, elevated groundwater levels and other exacerbating factors affecting soil foreshore slopes.

In this regard, we note that extensive assessment of the area of recent and older instability at Surfers Avenue and Tallwood Avenue, Narrawallee has been undertaken by DP (DP, 1992 & DP, 2011). DP have recommended installation of instrumentation in order to provide a better understanding of groundwater levels and ground movements.

With inevitable future development along the foreshore areas with Shoalhaven LGA, there will potentially be continued debate over the current hazard lines presented in the CZMP. Based on the assessment of cliff face recession rates and the comments presented by DP in their Peer Review of the Coastal Slope Instability Hazard Study (DP, July 2011) it can be considered likely that future developments will propose building footprints that encroach seaward of the current hazard lines. Development applications will need to be supported by both geotechnical and coastal engineering reports which provide site specific opinion on whether the hazard lines are realistic, and requesting reassessment where deemed necessary or warranted. As this would impose significant cost on both land owners and Council, it is suggested that future reappraisal of the hazard lines and extent of risk areas will be warranted, to be informed by the on-going geotechnical assessment of foreshore sites undertaken to date. A reappraisal within the next ten years should be considered.

Based on RHDHV's knowledge of the NSW coastline, and involvement in similar coastal risk and protection related projects, caution must be exercised and experience applied in the application and interpretation of hazard lines for identifying properties exposed to coastal cliff and slope instability risk.

The following sections summarise the potential risk to property and life which should be considered within the risk areas.

3.3 Risk to Property

A qualitative assessment of risk to property was undertaken in accordance with the guidance provided in Australian Geomechanics Society (2007c) Practice Note Guidelines for Landslide Risk Management (The Guidelines).

The assessment indicates that for hazard related to instability of overhang/undercut features, blocks and/or wedges of rock over the cliff face the assessed risk to property is Low. This would be considered to be 'acceptable', in accordance with the criteria given in the Guidelines.

For hazards related to instability of foreshore colluvial/residual soil slopes, small scale (less than 5m^3) and a larger scale instability impacting the full width of a residential lot (at least 200m^3), the assessed risk to

property is Very Low for small scale instability and Low for larger scale instability. This would be considered to be ‘acceptable’, in accordance with the criteria given in the Guidelines.

For hazards related to large scale cliff face instability, the assessed risk to property is Very Low or Low. The Guidelines consider that this is and ‘acceptable’ level of risk.

For hazards related to instability of landslip remediation measures where previous instability has occurred recently and/or areas where existing structures are located close to the crest of cliff faces and slopes, specific locations were assessed. These are discussed in **Section 4**, relevant to landslip remediation measures identified.

Levels of risk to property at both the Penguin Head Lookout, Culburra Beach and the timber lookout at, Bannisters Point, Mollymook Beach were considered to be ‘acceptable’ in accordance with the criteria given in the Guidelines.

Levels of risk to property were considered to be ‘tolerable’ in accordance with the criteria given in the Guidelines at a number of private properties in Culburra Beach, Berrara, Manyana, Mollymook and Ulladulla (see **Section 4**)

There were 2 properties in Manyana identified as having levels of risk to property considered to be ‘unacceptable’ in accordance with the criteria given in the Guidelines (see **Section 4**).

Whilst creep is occurring, the consequences to property have been assessed as insignificant and so risk levels are at ‘acceptable’ levels, in relation to the criteria given in the Guidelines.

3.4 Risk to Life

On the basis of the identified potential geotechnical hazards and site observations and the qualitative assessment of risk to property, a semi quantitative assessment of risk to life was undertaken. The indicative probabilities associated with the assessed likelihood of instability were used to calculate the risk to life. The assessment has conservatively assumed that the affected person or persons is or are immediately above the specific hazard when it occurs.

The assessed total risk to life for an individual person most at risk, under existing conditions, is considered to be ‘acceptable’, in relation to the criteria given in the Guidelines. However, with regard to site personnel required to complete landslip remediation measures at private property in Manyana (see **Section 4**), an assessed risk to life is considered ‘unacceptable’, in relation to the criteria given in the Guidelines.
With regards to creep of soil slopes, based on an Almost Certain likelihood the assessed risk to life would be considered to be ‘acceptable’, in relation to the criteria given in the Guidelines.

It is recognised that, due to the many complex factors that can affect a site, the subjective nature of a risk analysis, and the imprecise nature of the science of geotechnical engineering, the risk of instability for a site cannot be completely removed. It is however essential that risk be reduced to at least that which could be reasonably anticipated by the community in everyday life and that landowners be made aware of reasonable and practical measures available to reduce risk as far as possible.

4 Program of Works

This section of the report outlines a program of works and recommendations specifically regarding landslide risk management measures relevant to each of the risk areas.

The recommendations outlined here form an integral part of the Landslide Risk Management (LRM) Process. The measures are outlined where applicable to Council, private property owners and utility owners. Apart from assisting with risk management, the purpose of the measures is also to provide a sense that the LRM process is a matter for all of the community to participate in and to share in the responsibility for its implementation.

Recommendations have assumed that no activities would be carried out on surrounding land which may affect the risk on the subject sites. It is also assumed that all buried Council and other services within and adjacent to the site are regularly maintained and in good condition.

With the recommendations outlined in the sections below implemented, the assessed risk to life and property would remain at or be reduced to 'acceptable' levels, in accordance with the criteria given in the Guidelines.

The general LRMs recommended across the sites are outlined in **Sections 4.1**, **4.2** and **4.3**.

4.1 Council

1. Council should assess current public stormwater drainage in identified risk areas (see maps in **Appendix A**). Investigate the development and implemention, of a regular monitoring program taking into account Council's resourcing capacity to respond, integrated with existing stormwater monitoring and maintenance program (suggest annually) to check for leaks and carry out repairs/upgrades as required. The monitoring program would also include inspections in risk areas after significant storm events (ARI 100), and as a part of emergency response preparedness.

2. Vegetation management programmes to include assessment of identified risk areas and incorporation of required landscaping and/or revegetation to stabilise exposed areas if required.

3. Landslips to be remediated in accordance with geotechnical advice.

4. Council to require geotechnical assessments to support development applications for landslip remediation works on private property, including confirmation that risk will be reduced to 'acceptable' levels (geotechnical engineer to approve the design of the remediation measures/works).

5. Council to provide information to private property owners on potential hazards within each risk area and guidance on specific actions and or measures that can be taken to minimise risk (See **Section 7**.

4.2 Property Owners

1. Monitoring of private properties within risk areas should be undertaken regularly (suggested 12 monthly) by property owners (See **Section 5** and monitoring template provided in **Appendix C**).

2. Property owners to check drainage, water mains, sewer system, pool backwash systems and any other water carrying services for leaks/damage and repair as necessary. Frequency of monitoring to coincide with significant storm events or weather conditions (after periods of prolonged rainfall and/or predicted high tidal levels) or 12 monthly. Refer to Program of Monitoring in **Section 5.**
3. Vegetation management should be used to assist in stabilising slopes and areas above cliff faces.
4. Existing landslips on private properties to be remediated in accordance with geotechnical advice.
5. Specific private properties with identified risks should be assessed by a Coastal Engineer and/or Geotechnical Engineer and monitored in accordance with the monitoring program in **Section 5**.

4.3 Shoalhaven Water (Council's water and sewer Group)

1. Utility infrastructure within risk areas to be checked to ascertain any leaks or requirements for repair of water carrying pipelines.
2. Where requirements for repair are noted to be within private property, Shoalhaven Water to notify property owners.

The sections below provide a summary of the general risk profile at each risk area, a discussion on the proposed LRM measures and the residual risk levels should the LRMs be implemented at each general risk area overall. LRMs specific to individual private properties have not been included here, however landowners will be provided with information relevant to their properties.

Table 1: Current risk levels and impact of landslide risk management (LRM) measures on risk levels specific to overall risk areas

LOCATION	CURRENT RISK LEVEL*	GENERAL LRM MEASURES							RISK LEVEL FOLLOWING LRM MEASURES**
		Monitoring of public land and facilities within key risk areas undertaken by Council as a part of routine maintenance inspections, taking into account Council's resourcing capacity to respond. Monitoring of private properties within risk areas should be undertaken regularly (suggested 12 monthly) by property owners.	Council should assess current public stormwater drainage in identified risk areas Investigate the development and implementation of regular monitoring program taking into account Council's resourcing capacity to respond, integrated with existing stormwater monitoring and maintenance program (annually) to check for leaks and carry out repairs / upgrades as required. The monitoring program would also include inspections in risk areas after significant storm events (ARI 100), and as a part of emergency response preparedness.	Property owners to check drainage, water mains, sewer system, pool backwash systems and any other water carrying services for leaks/damage and repair as necessary. Frequency of monitoring to coincide with significant storm events or weather conditions (after periods of prolonged rainfall and/or predicted high tidal levels) or 12 monthly.	Council to require geotechnical assessments to support development applications for landslip remediation works on private property, including confirmation that risk will be reduced to 'acceptable' levels (geotechnical engineer to approve the design of the remediation measures/works)	Shoalhaven Water to check water and sewer infrastructure within risk areas to ascertain any leaks or requirements for repair.	Landslips to be remediated in accordance with geotechnical advice.	Specific private properties with identified risks should be assessed by a Coastal Engineer and/or Geotechnical Engineer and monitored in accordance with a monitoring program.	
Penguin Head and Culburra Beach	LOW & VERY LOW (moderate)	✓	✓	✓		✓		✓	LOW & VERY LOW
Penguin Head Lookout	LOW & VERY LOW	✓							LOW & VERY LOW
Plantation Point	LOW & VERY LOW	✓	✓	✓		✓			LOW & VERY LOW
Hyams Point	LOW & VERY LOW	✓	✓	✓		✓			LOW & VERY LOW
Berrara Point	LOW & VERY LOW (moderate)	✓	✓	✓	✓	✓	✓	✓	LOW & VERY LOW
Inyadda Point	LOW & VERY LOW (moderate – very high)	✓	✓	✓		✓	✓		LOW & VERY LOW
Narrawallee	LOW & VERY LOW	✓	✓	✓		✓			LOW & VERY LOW
Bannisters Point	LOW & VERY LOW (moderate)	✓	✓	✓	✓	✓	✓		LOW & VERY LOW
Timber Lookout, Mollymook Beach, Bannisters Point	VERY LOW	✓	✓	✓		✓			VERY LOW
Collers Beach	LOW & VERY LOW (moderate)	✓	✓	✓		✓			LOW & VERY LOW
Rennies Beach	LOW & VERY LOW	✓	✓	✓	✓	✓			LOW & VERY LOW
Racecourse Beach and Carpark	LOW & VERY LOW	✓	✓	✓		✓			LOW & VERY LOW

*The risk levels for specific properties (i.e. private properties, specific locations) are in some places moderate to high, however this table considers generic areas only. Risk to some specific areas is included in brackets were relevant.
**The risk level assumes that all of the LRM measures and the necessary actions are implemented.

4.4 Water Carrying Services and Stormwater Drainage

It is recommended based on the geotechnical assessment of the risk areas that all water carrying pipelines discharging on to slopes and cliff faces should be piped to the base of the slope/cliff and discharged such that flow is directed away from the slope. All existing surface (including roof) and subsurface drains, pool backwash systems, septic tanks, water tanks etc, should be subject to ongoing and regular maintenance by property owners. It is recommended that within the a 12 month period following the issue of this report that property owners (private property, Council and utility owners) within the identified risk areas check all water carry pipelines/water storing systems for leaks and/or other damage and repair as necessary. These checks should be undertaken by a licensed plumber or other similarly experienced professional.

Property owners should require a written report confirming the scope of work completed including any repairs undertaken. This may assist property owners should there be future slope instability within or adjacent to their property and where poorly maintained water carrying pipelines are suspected as a trigger for the instability. Following this initial maintenance, it is recommended that similar checks be carried out no less than every ten years, with a similar report being prepared for property owners.

The presence of abandoned absorption trenches (soakaway drains) and disused service trenches located close to the crests of foreshore slopes and cliffs can potentially increase localised instabilities. These areas should be excavated and backfilled with cement stabilised sand to prevent these areas introducing additional run-off into the slopes and possibly increasing the likelihood of instability.

It is recommended that Council implement additional requirements for any new developments in the identified risk areas, ensuring that all proposed surface (including roof) and subsurface drains are subject to ongoing and regular maintenance by property owners. Newly proposed pool backwash systems should also be required to be piped and discharged to the main sewer to avoid any additional overland flows.

A catchment wide hydraulic assessment is required to assess the existing Council stormwater drainage adjacent or within identified risk areas. A hydraulic engineer should assess the design of the system and its capacity and where necessary, improvements should be made to prevent uncontrolled discharge of stormwater through properties and over slopes, which has the potential to cause instability. This work should be considered as a priority within the risk areas identified and discussed in this report.

4.5 Existing Landslip Remediation Measures

Landslip remediation measures are required or underway at Sunset Strip, Inyadda Point, Manyana. Coffey and DP have investigated this location with recommendations developed for the remedial activities to a number of private properties.

Similarly, landslip remediation measures were recommended by Coffey (2016) for public reserve land adjacent to private property at Mitchell Parade, Mollymook. Council has indicated that the area of public and private land adjacent to Council's sewer has been remediated.

4.6 Additional Geotechnical

For the site at Surfers Avenue and Tallwood Avenue, Narawallee, it is recommended that further monitoring of groundwater be undertaken. Recent and older instability at this location warrants a better understanding of groundwater levels and ground movements, and DP's advice to install instrumentation to obtain further data should be implemented.

Although levels of risk at certain properties were assessed as being 'tolerable', it is recommended that Council advise the relevant property owners at Penguins Head Road, Culburra Beach; and Myrniong Grove, Berrara;, that they should seek further geotechnical advice to determine if any actions require implementation to manage the coastal portions of their sites.

4.7 Additional Recommendations for Public Areas

The lookouts at Penguin Head and Bannisters Point, as well as the car park at Racecourse Beach, are subject to impact from potential cliff/slope instability. The following specific actions should be considered for implementation by Council in the event of instability occurring due to extreme weather events:

- Immediate closure of the lookouts.
- Immediate prevention of access to the car parking bays at the crest of the cliff.
- Commissioning of a geotechnical assessment to provide suitable and site specific LRM recommendations for immediate implementation. Potential LRMs for the lookouts could require re-location. For the car park, LRMs could include re-location of the fence line landward of its current location.

5 Program of Monitoring

Suitable monitoring programmes are required for both Council and private property owners, to ensure constant consideration and understanding of conditions within risk areas. In all 'risk' areas, private property owners and Council should monitor their individual properties or general site area on an annual basis and after periods of prolonged or heavy rainfall and/or predicted high tidal levels (particularly where they coincide with storm events).

Based on previous studies of available rainfall data in relation to landslide events, in particular a study carried out for the Pittwater area (Walker 2007, Reference 2), the following tentative definition of heavy rainfall and prolonged rainfall is suggested for the purposes of monitoring identified risk areas:

- Heavy Rainfall: at least 100mm of rainfall in one day; and
- Prolonged Rainfall: at least 150mm of rainfall over a 5 day period.

These amounts of rainfall represent 2 year ARI occurrences for the Pittwater area and are considered reasonable for the Shoalhaven City Council area. However as the Pittwater catchment area is heavily urbanised and receives a greater runoff than Shoalhaven, SCC Council officers have provided more localised advice on monitoring triggers for the Shoalhaven area. This advice is based on localised experience of Council officers and the impacts of heavy and prolonged rain events, and includes consideration of the amount of rain which usually triggers potential lake opening and localised flooding:

- Heavy Rainfall: suggest 150mm of rainfall in one day; and
- Prolonged Rainfall: at least >250mm of rainfall over a 5 day period.

Based on the geotechnical assessment undertaken, and the above definition of relevant weather indicators, the following sections of the report provides specific suggested monitoring requirements for both public and private land custodians.

5.1 Council Monitoring Requirements

Council may include regular monitoring of public risk areas within existing monitoring and maintenance programs relevant to public areas and infrastructure. Where monitoring is triggered by certain levels of rainfall, Council should identify an approach that focuses on specific sites within risk areas, as the capacity to inspect overall risk areas each time the catchment receives 150mm of rain or more is unrealistic. Nearby rainfall gauges within Shoalhaven LGA include:

- Greenwell Point, approximately 5km from Penguin Head and Culburra Beach;
- Currarong, directly on the Coastline at the north of the bulk of the risk sites;
- Vincentia, approximately 2km to the west of Plantation Point;
- Lake Conjola, approximately 4km to the west of Inyadda Point Headland;
- Ulladulla, approximately 2km from Rennies Beach.

Where possible, rainfall at the above gauges should be monitored to determine when identified risk areas should be monitored and assessed for hazards as a result of heavy rainfall (triggered by 150mm over 24 hours or 250mm over 5 days), particularly when in combination with high tide levels taking into account Council's resourcing capacity.

The purpose of monitoring identified risk areas is primarily to continually assess existing conditions of cliffs and slopes and note any indications of deterioration such as:

- cracking along or immediately behind the crest areas of slopes and cliff faces;
- deformed fence posts or deteriorating fencing;
- deteriorating lookout structures;
- evidence of rock falls and/or soil slumps at the base of the slopes;
- cracked, leaning or deformed retaining walls;
- cracked, leaning or deformed lookout structures.

A procedure for capturing, collating and analysing monitoring data should be developed, which aims at continual improvement of the monitoring program and ultimately reduction in risk associated with hazards on public property. The monitoring program should enable more applicable and cost effective maintenance and management of infrastructure within Council's area of responsibility.

It is recommended that Council include maintenance requirements as a part of conditions of consent for new developments on sloping blocks within risk areas.

5.2 Private Landowner Monitoring Requirements

Sections 7 provides discussion around owner notification.

The purpose of implementing a monitoring program for private properties within risk areas is primarily to ensure continual assessment of existing conditions and any indications of deterioration which may increase the risk of hazards. This might include:

- cracked, leaning or deformed retaining walls;
- evidence of rock falls and/or soil slumps at the base of the slopes;
- cracking along or immediately behind the crest areas of slopes and cliff faces;
- deformed fence posts or failing fencing.

Monitoring for the above will enable proactive management measures to be implemented in a timely manner. The frequency of monitoring should be 12 monthly, and/or coincide with significant storm events or weather conditions (after periods of heavy or prolonged rainfall and/or predicted high tidal levels).

It is imperative that such monitoring be formally documented and that the required frequency of reporting (and to whom) is clearly defined. Australian Geomechanics Society (AGS), Geoguides for Slope Management and Maintenance outlines recommended requirements for record keeping relevant to monitoring and maintenance of risk sites. Where incidents of instability have occurred within the monitoring period then, where possible, it is suggested that private property owners include relevant details within the monitoring reports. These details would include the date of the incident, the weather conditions on the day and leading up to the incident, a location plan/sketch, photographs and dimensions of the specific features (block sizes, crack widths etc. would also need to be recorded). Where new incidents have occurred, the monitoring reports should be provided to the geotechnical engineer so that if there are any causes for concern, further advice can be provided. The need for site specific stabilisation measures can then be better assessed. An example site inspection/maintenance record sheet template, adapted from AGS Geoguide LR11, is included in **Appendix C.**

5.3 General Risk Area Assessment

In addition, on a 10 yearly basis, a detailed assessment of all the site areas in this report should be undertaken by experienced geotechnical and coastal engineers to assess current conditions with regard to the contents of this report and the on-going inspection monitoring reports.

6 Modifications to LEP and DCP

In order to undertake the necessary programme of works, and to enable implementation of the developed Emergency Action Sub-plan, it may be necessary to make amendments/modifications to relevant planning legislation. This section provides a review of relevant planning legislation, and summarises key aspects and/or appropriate amendments for consideration with regards to future risk planning and management relevant to slopes and cliffs within Shoalhaven.

6.1 Coastal Management Act 2016

The new *Coastal Management Act 2016* replaces the *Coastal Protection Act 1979* and aims to provide for more robust strategic management of NSW coastal areas into the future. The new act retains the current requirements with respect to emergency action sub-plans and emergency coastal works, but focuses more on the roles and responsibilities of public authorities. Provisions for private landholders to erect temporary coastal protection works without consent has been repealed within the new Act, however private landowners can continue to seek consent for temporary and longer term coastal protection works.

6.2 Other Relevant Planning Legislation and Guidance

The Shoalhaven Local Environmental Plan (LEP) and Development Control Plan (DCP) may need to consider amendments/modifications based on the new *Coastal Protection Act 2016,* along with relevant requirements of the Draft Coastal Management Manual (2015) and NSW Coastal Planning Guideline: Adapting to Sea Level Rise (2010).

The Draft Coastal Management Manual (2015) discusses that provisions within the LEP should prohibit specific types of development within vulnerable coastal areas, aimed at controlling increases in unacceptable risk associated with coastal cliff and slope instability.

Further, based on the recommendations in this report for risk related remediation and landslide risk management measures, relevant aspects of the Shoalhaven LEP and DCP may need to be modified to enable approval of required works, however it is understood that the DCP no longer uses the current cliff hazard lines as building lines. Development applications must be supported by geotechnical and coastal engineering reports, which may provide expert opinion on why the hazard lines should be reassessed and adjusted. Development consent conditions should also include maintenance requirements for new developments on sloping blocks within risk areas.

6.3 Shoalhaven LEP 2014

The Shoalhaven Local Environmental Plan 2014 outlines local environmental planning provisions for land within Shoalhaven under State legislation. Relevant clauses for coastal hazard risks, planning and management are:

- Clause 7.4 Coastal risk planning
- Clause 7.7 Landslide risk and other land degradation

6.3.1 Clause 7.4 Coastal risk planning

This clause applies to land identified as Coastal Risk Planning Area, and requires development consent to be granted for any development within these areas.

The objectives of this clause are focused around avoidance of impacts from coastal hazards, land use incorporating risks from coastal hazards, emergency evacuation due to coastal risk, and avoidance of development that increases severity of hazards.

Any development or works within a Coastal Risk Planning Area must meet the following specific requirements:

a) will avoid, minimise or mitigate exposure to coastal processes, and
b) is not likely to cause detrimental increases in coastal risks to other development or properties, and
c) is not likely to alter coastal processes and the impacts of coastal hazards to the detriment of the environment, and
d) incorporates appropriate measures to manage risk to life from coastal risks, and
e) is likely to avoid or minimise adverse effects from the impact of coastal processes and the exposure to coastal hazards, and
f) provides for the relocation, modification or removal of the development to adapt to the impact of coastal processes and coastal hazards, and
g) has regard to the impacts of sea level rise.

All properties discussed within this assessment should be considered to be within Coastal Risk Planning Areas and subject to the above requirements in terms of development works and approvals. The Coastal Risk Planning Areas Maps should be revised where necessary to ensure all of the assessed properties are included within identified coastal risk areas.

6.3.2 Clause 7.7 Landslide risk and other land degradation

The objective of this clause is to maintain soil resources and the diversity and stability of landscapes, including protecting land comprising steep slopes, and susceptible to other forms of land degradation.

This clause applies to the following land:

(a) Land with a slope in excess of 20% (1v:5h), as measured from the contours of a 1:25,000 topographical map; and
(b) Land identified as “Sensitive Area” on the Natural Resource Sensitivity—Land Map.

All properties discussed within this assessment should be considered for applicability under the above clauses and mapping amended where relevant to ensure development criteria are met for all future development in the assessed areas/sites.

6.4 Shoalhaven Development Control Plan 2014

The Shaolhaven DCP includes a specific chapter relevant to management of development within coastal areas. Chapter G6 of the DCP entitled “Coastal Management Areas” discusses the 9 areas of cliff/slope instability. Council should amend clause 5.1 and Chapter G6 to include Penguin Head, Culburra Beach and Narawallee in the list of areas affected by cliff/slope instability to ensure all risk areas are considered under Clause 5.1.2 Areas of cliff/slope instability in Chapter G6 of the DCP.

Clause 5.1.2 outlines the requirement for geotechnical reports prepared by professional geotechnical engineers to assess the site stability and suitability for the proposed development, and provide recommendations for engineering design. It is recommended that reference is also made to this report (RHDHV 2017) within Clause 5.1.2.

The DCP Chapter G2 Sustainable Stormwater Management & Erosion/Sediment Control provides guidelines relevant to stormwater management within developments. Section 5.4.2 of this chapter applies to development discharging stormwater to coastal cliffs and dunes and outlines performance criteria and acceptable solutions that developments must meet.
Council should assess potential amendments which consider kerb and guttering on roads and driveway design to limit runoff from public land onto private property and avoid creating water paths down driveways within and adjacent to slopes and cliffs. Standard curb and guttering and driveway design has already been amended to address this issue.

In this regard, Council has amended its Natural Areas Generic Plan of Management to allow for disposal of stormwater on its land to manage risk.

7 Education and Awareness

Council has previously prepared community education material relevant to coastal cliff and slope instability to provide the community and specifically potentially effected landowners with important information on management and planning for hazards. This has predominantly been in the form of mail outs to property owners and information brochures for residents. Recommendations for inclusion in or expansion of Council's program on education and awareness are provided here.

Section 5 of this report outlines proposed monitoring requirements for both Council and landowners to ensure relevant knowledge and increased understanding of hazards and associated risks is captured and used for future planning and emergency management on cliffs and slopes.

Council encourages private property owners in identified risk areas to undertake their own monitoring on their properties as a way of proactively managing risk and identifying potential risks early so that expert geotechnical and coastal engineering advice can be obtained by owners to inform any works that may be required. A guideline and template for monitoring and collecting this data are contained in **Appendix B**.

Based on the recommendations in this report, it is expected that Council would assess the identified public areas to define priorities for required works. As their planning of works is developed, keeping the community informed will be key to promoting a unified approach to managing and planning for future hazards. It is common that community sessions are held to discuss public programs of works and involve community stakeholders where necessary to adopt the best approach and provide for more robust outcomes. Provision of standard designs for a variety of remediation works may also be included in sessions or community awareness materials.

The Emergency Action Sub-plan will form the basis of identifying actions and roles and responsibilities for the protection of public property in emergency event situations. Training may be required for Council ground staff with regards to the emergency actions and to ensure complete understanding of roles and responsibilities with regards to emergency situations. According to NSW EMPLAN, at the local level, the Local Emergency Management Committee (LEMC) is responsible for making recommendations and assisting in the coordination of emergency management training relevant to local government areas.

The Emergency Action Sub-plan will be made publically available.

7.1 Owner Notification

Further to the proposed notification to owners outlined in the Program of Works in **Section 4** above, this part of the report outlines recommendations in regards to the frequency and means of owner notification and the content of that notification.

It is assumed that all property owners of properties identified to be at risk of coastal cliff and slope instability based on previous reports have been consulted and are aware of the risks in relation to their properties. It is important that the recommendations of this report relating to the notification of private property owners is implemented so that they have the information

Based on the outcomes of the geotechnical assessment on existing foreshore cliffs and slopes and the recommendations in this report, it is expected that Council will provide relevant information directly to landowners. Whilst it is suggested that this should be done via letter to the landowner, it is also understood that documentation, inclusive of this document and the Emergency Action Sub-plan, will be publicly available.

A general proforma for advice to property owners, aimed at providing key information relevant to risk areas and recommendations related to management of risk on their properties, has been included **Appendix D**.

8 References

1. Australian Geomechanics Society (2007c) 'Practice Note Guidelines for Landslide Risk Management', Australian Geomechanics, Vol 42, No 1, March 2007.
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3. Coffey (2015), Geotechnical assessment of Impact of landslide event at 65 Sunset Strip, Manyana, (Ref. GEOTWOLL038866AA-AArev3, dated 10 December 2015) prepared on behalf of Ms E Orr by Coffey Geotechnics Pty Ltd (Coffey).
4. Coffey (2016), Landslide risk assessment, Public Reserve Areas below 27 Sunset Strip, Manyana and 231 Mitchell Parade, Mollymook Beach (Ref. GEOTWOLL03799AD-AB (Rev.1), dated 4 August 2016) prepared by Coffey.
5. Coffey (2016), Geotechnical assessment at 'No. 20 Myrniong Grove, Berrara' (Ref. GEOTWOLL03902AB-AA, dated 14 March 2016) prepared on behalf of John Drew by Coffey.
6. Douglas Partners (1992), Geotechnical Assessment of stability of Cliffs Line, Bannister Point (Project 12436B, 10 June 1992) prepared on behalf of SCC by DP.
7. Douglas Partners (2011), Supplementary Geotechnical Observations - Coastal Slope Instability Hazard Study Various Sites Shoalhaven City Council LGA (Project 72051-1, dated 12 July 2011) prepared on behalf of SCC by Douglas Partners (DP)
8. Douglas Partners (2011), Peer Review - Coastal Slope Instability Hazard Study Various Sites in Shoalhaven City Council LGA (Project 72051-1, dated 12 July 2011) prepared on behalf of SCC by DP.
9. Douglas Partners (2011), Scoping Study and Stability Assessment on Various Lots Surfers Ave, Tallwood Ave and Bannister Head Rd Narrawallee (Project 78319, dated December 2011) prepared on behalf of SCC by DP.
10. Douglas Partners (2015), Geotechnical report on 'Slope Failures Two Sites within the Shoalhaven City Council LGA' at 65 Sunset Strip, Manyana, and 168 Mitchell Parade, Mollymook (Project 78771.00, dated 8 September 2015) prepared on behalf of Mills Oakley Lawyers by DP.
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13. Geomechanics, Vol 42, No 1, March 2007, pp197-212.
14. SMEC (2008), A Coastal Slope Instability Study for the Shoalhaven City Council Coastal Zone Management Study and Plan (Ref. 3001209-020, dated August 2008, prepared on behalf of Shoalhaven City Council (SCC) by SMEC Australia (SMEC).
15. SMEC (2009), A Shoalhaven Coastal Hazard Study Summary Report for the Shoalhaven Coastal Zone Management Plan (Ref. 3001209-019 Rev. 3, dated 20 July 2009) prepared on behalf of SCC by SMEC.
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18. Umwelt (2012), Coastal Zone Management Plan (Ref. 2239/RO4_V3, dated October 2012) prepared on behalf of SCC by Umwelt.
19. Shoalhaven City Council (2015), Shoalhaven Development Control Plan 2014, Chapter G6: Coastal Management Areas (Version 2, dated 1 July 2015) prepared by SCC.
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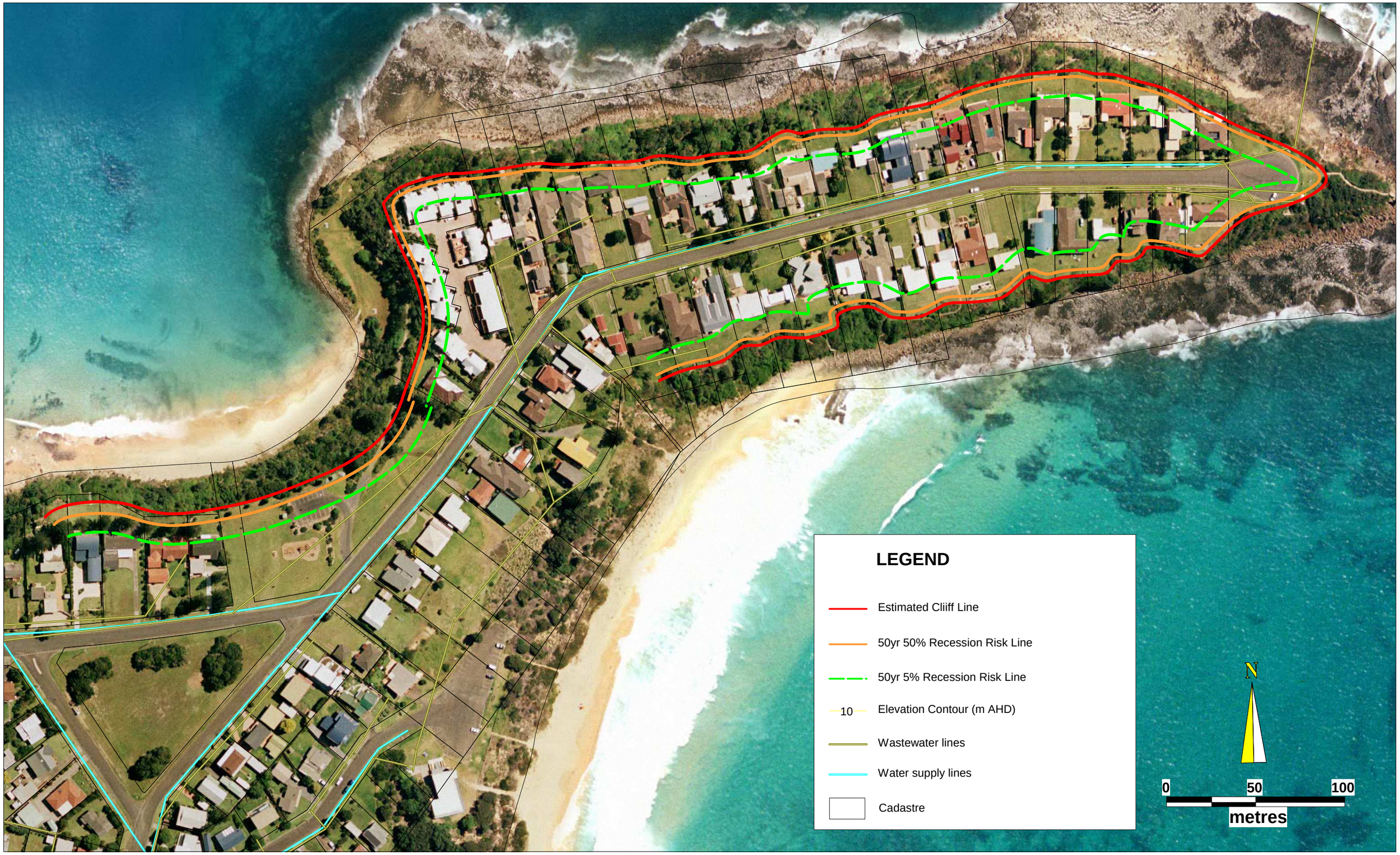
21. Walker B.F (2007), 'Rainfall Data Analysis and relation to the landsliding at Newport', Australian

Appendix A – Risk Area Maps (SMEC 2008)



SMEC

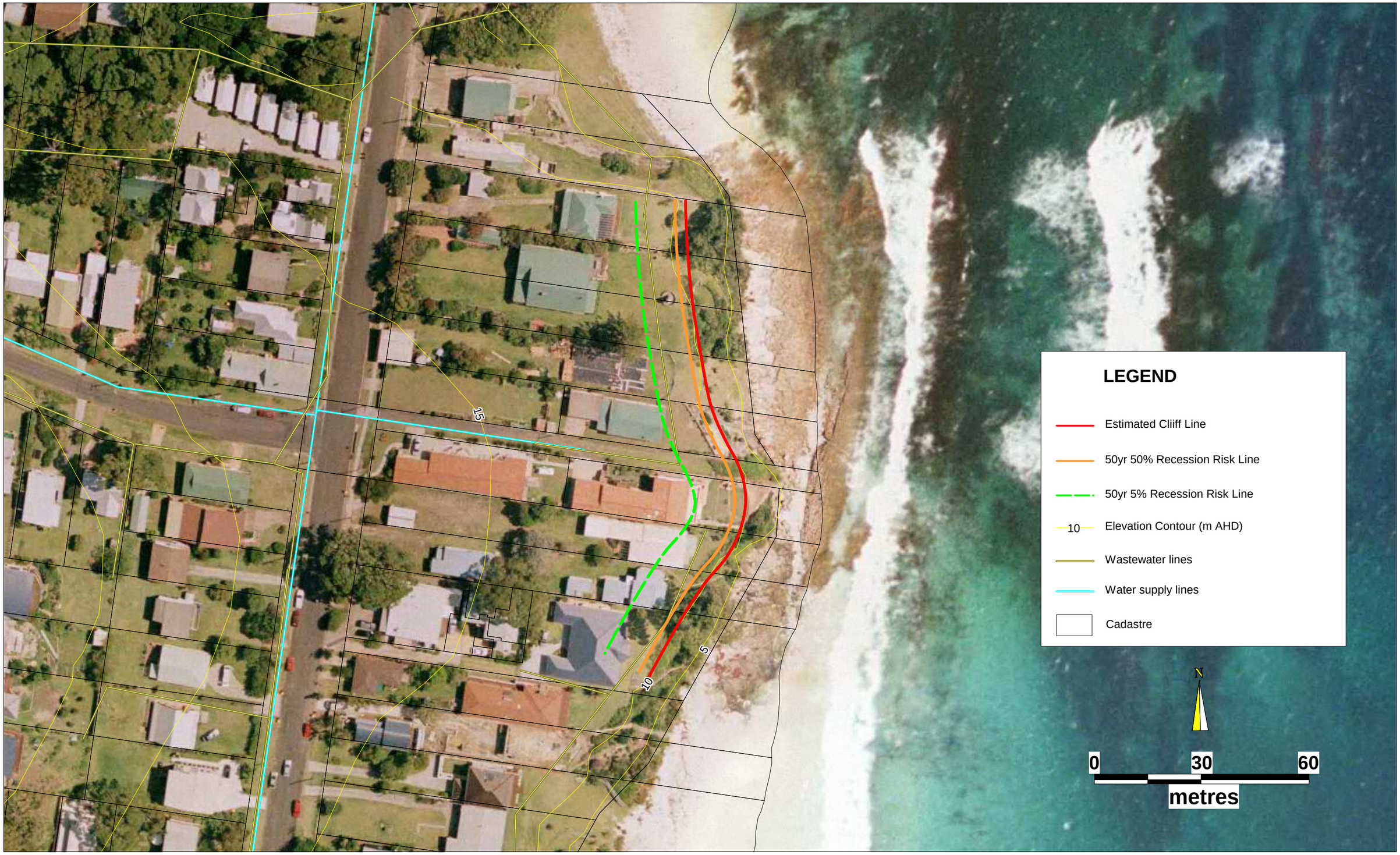
COASTAL SLOPE INSTABILITY HAZARD STUDY

FIGURE 4.9 CLIFF RECESSION HAZARD LINES PENGUIN HEAD AND CULBURRA BEACH

SMEC

COASTAL SLOPE INSTABILITY HAZARD STUDY

FIGURE 4.8 CLIFF RECESSION HAZARD LINES PLANTATION POINT



SMEC

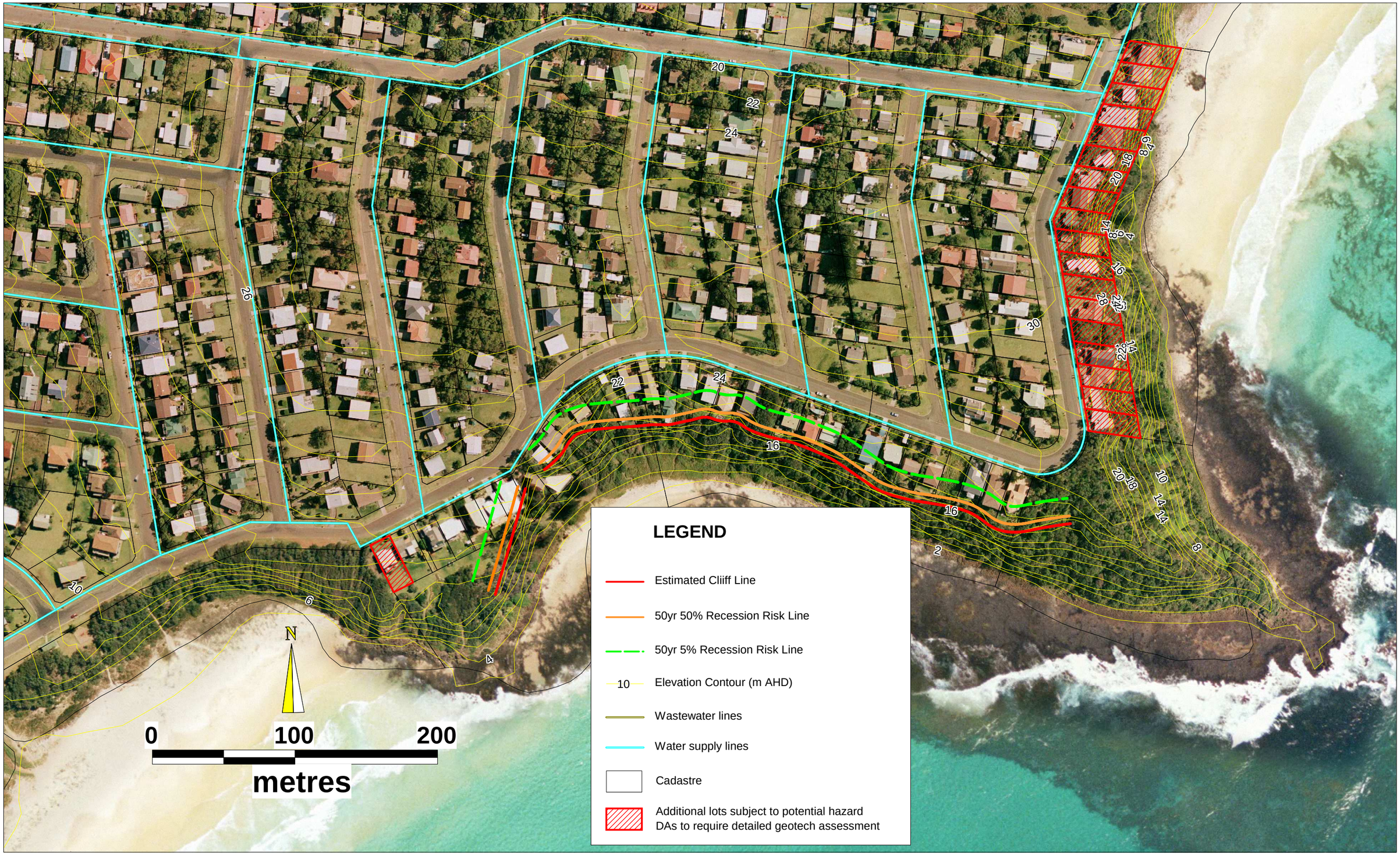
COASTAL SLOPE INSTABILITY HAZARD STUDY

FIGURE 4.7 CLIFF RECESSION HAZARD LINES HYAMS POINT

SMEC

COASTAL SLOPE INSTABILITY
HAZARD STUDY

FIGURE 4.6 CLIFF RECESSION HAZARD LINES BERRARA BLUFF



SMEC

COASTAL SLOPE INSTABILITY HAZARD STUDY

FIGURE 4.5 CLIFF RECESSION HAZARD LINES INYADDA POINT

LEGEND

- Estimated Cliff Line
- 50yr 50% Recession Risk Line
- 50yr 5% Recession Risk Line
- 10 — Elevation Contour (m AHD)
- Wastewater lines
- Water supply lines
- Cadastre
- Additional lots subject to potential hazard
  DAs to require detailed geotech assessment

N

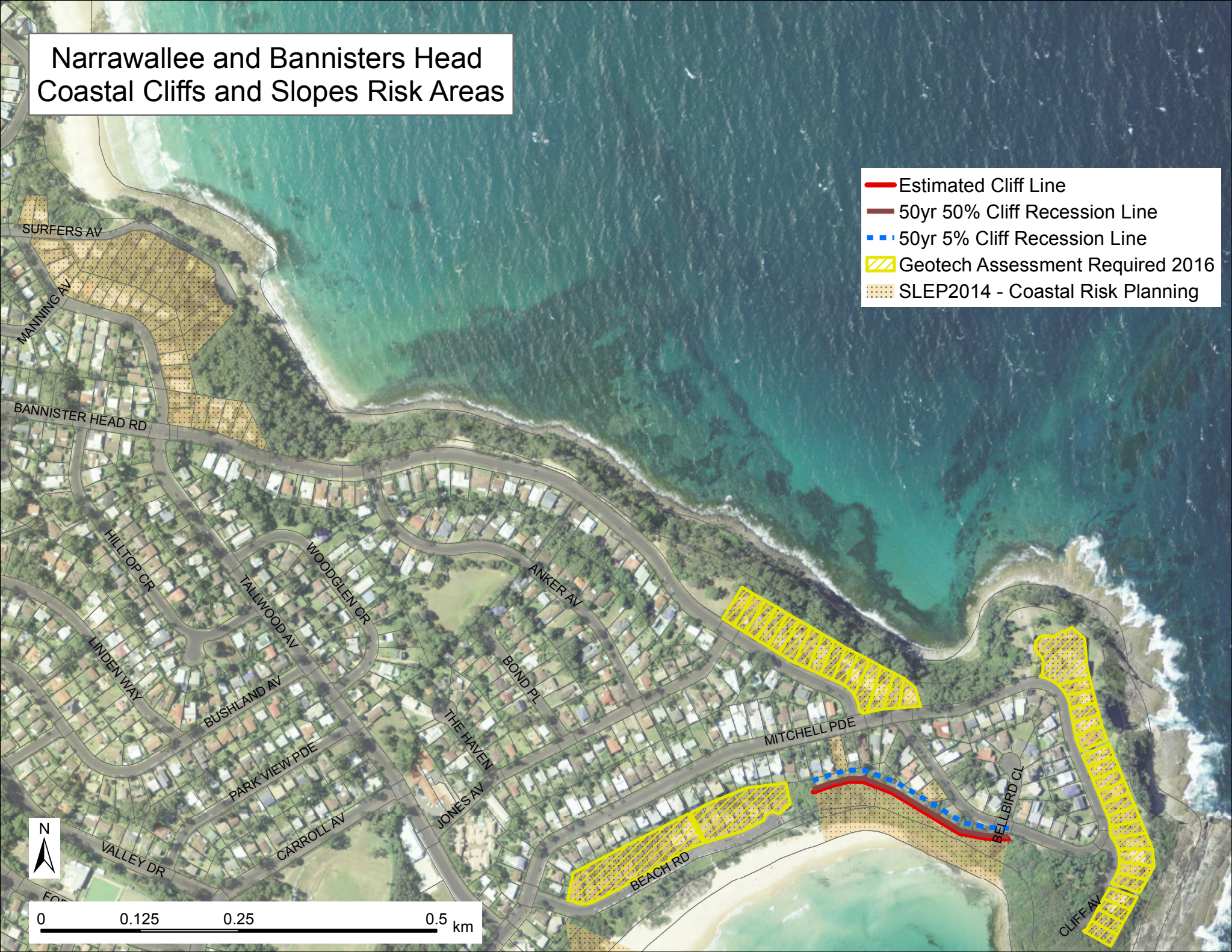
0 50 100

metres

SMEC

COASTAL SLOPE INSTABILITY HAZARD STUDY

FIGURE 4.4 CLIFF RECESSION HAZARD LINES BANNISTERS POINT


Narrawallee and Bannisters Head
Coastal Cliffs and Slopes Risk Areas
Estimated Cliff Line
50yr 50% Cliff Recession Line
50yr 5% Cliff Recession Line
Geotech Assessment Required 2016
SLEP2014 - Coastal Risk Planning
SURFERS AV
MANNING AV
BANNISTER HEAD RD
HILLTOP CR
TALLWOOD AV
WOODGLEN CR
ANKER AV
LINDEN WAY
BUSHLAND AV
BOND PL
THE HAVEN
PARK VIEW PDE
JONES AV
MITCHELL PDE
BELLBIRD CL
CARROLL AV
VALLEY DR
BEACH RD
CLIFF AV
N
0
0.125
0.25
0.5 km

SMEC

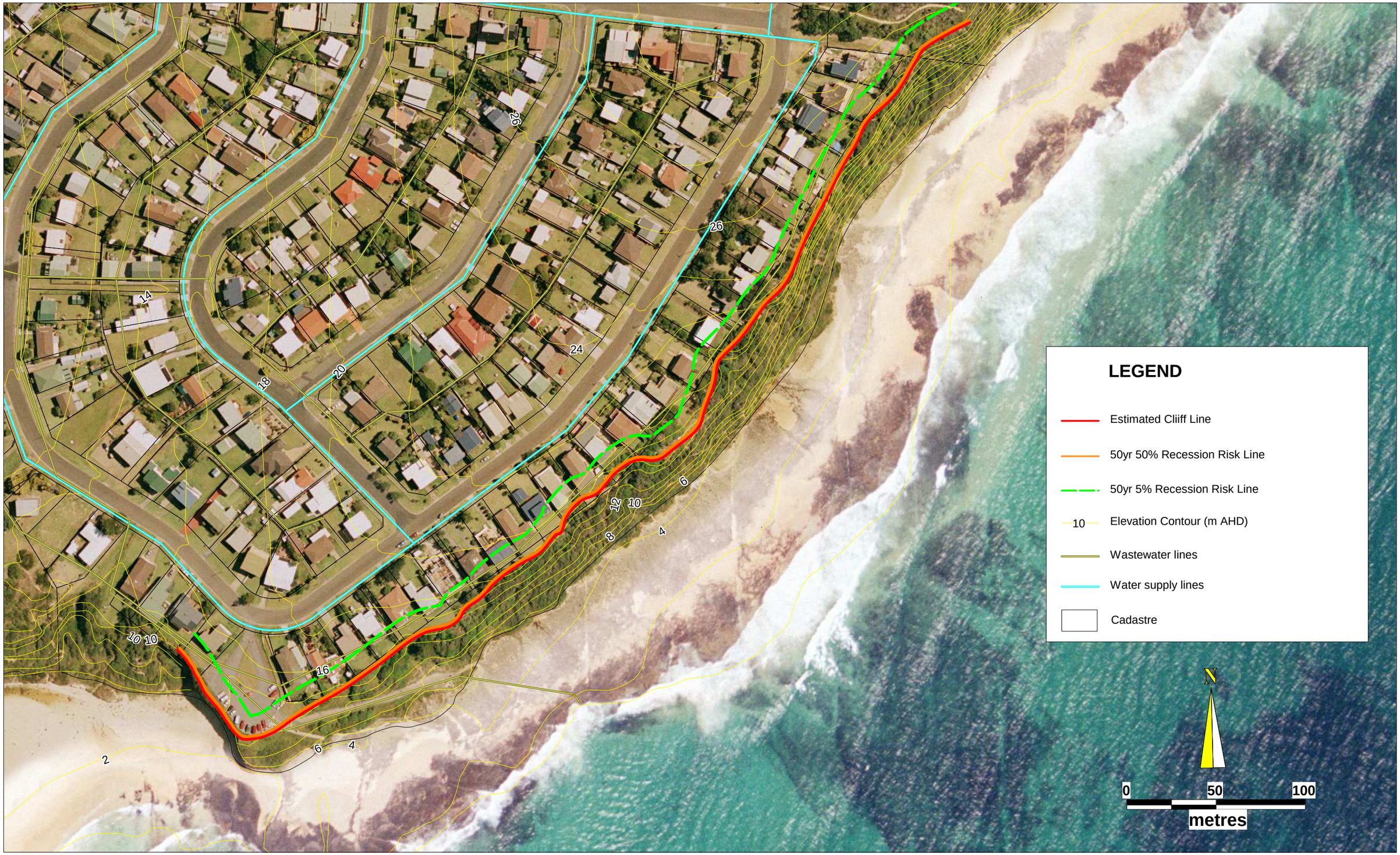
COASTAL SLOPE INSTABILITY
HAZARD STUDY

FIGURE 4.3 CLIFF RECESSION HAZARD LINES COLLERS BEACH HEADLAND

SMEC

COASTAL SLOPE INSTABILITY HAZARD STUDY

FIGURE 4.2 CLIFF RECESSION HAZARD LINES RENNIES BEACH



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COASTAL SLOPE INSTABILITY HAZARD STUDY

FIGURE 4.1 CLIFF RECESSION HAZARD LINES RACECOURSE BEACH

Appendix B - Site Observation Images

Image 1

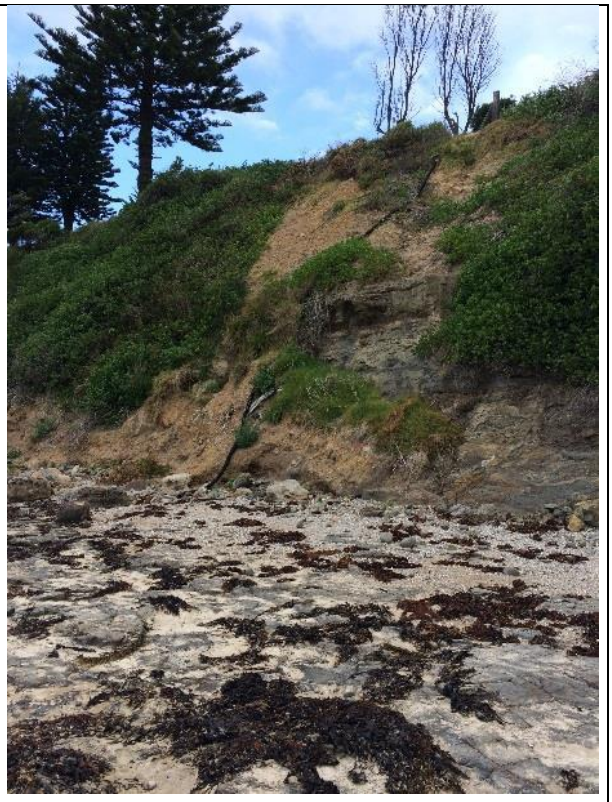


Image 2

Image 3

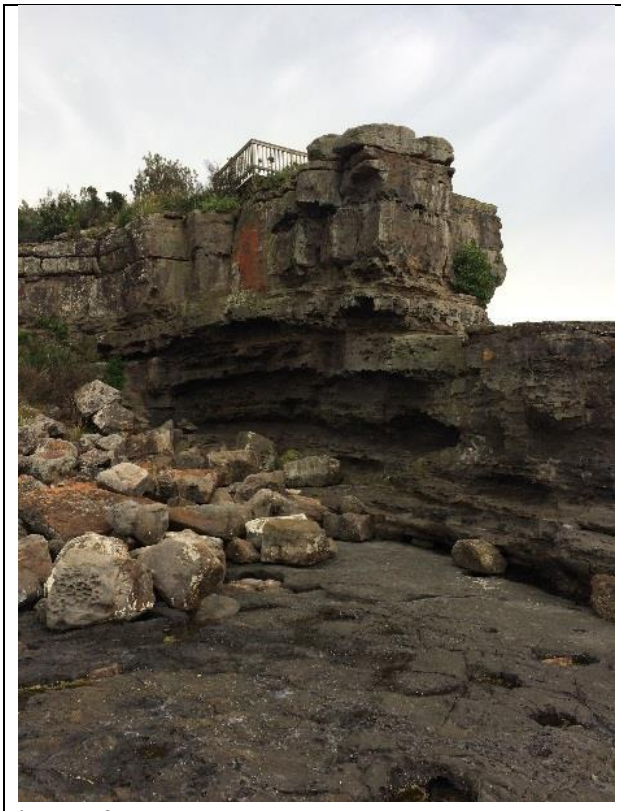


Image 4

Image 5

Image 6

Image 7

Image 8

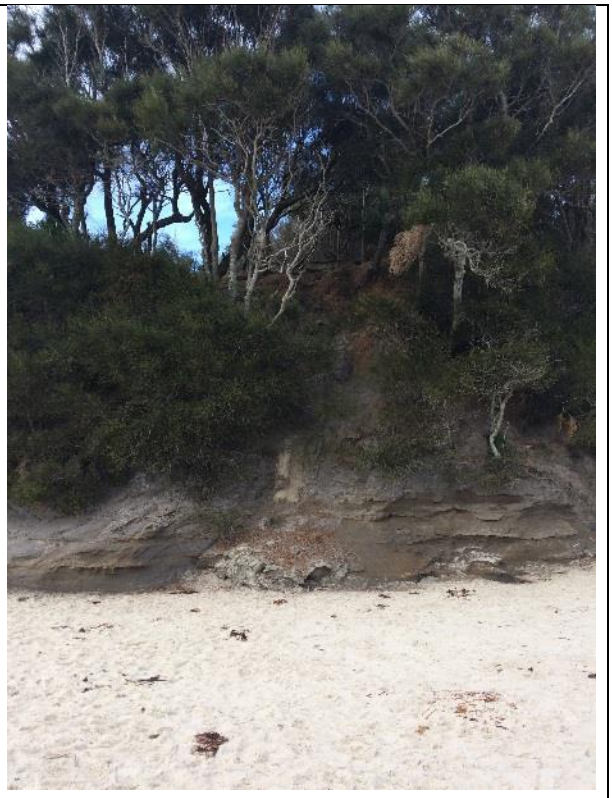


Image 9

Image 10

Image 11

Image 12

Image 13

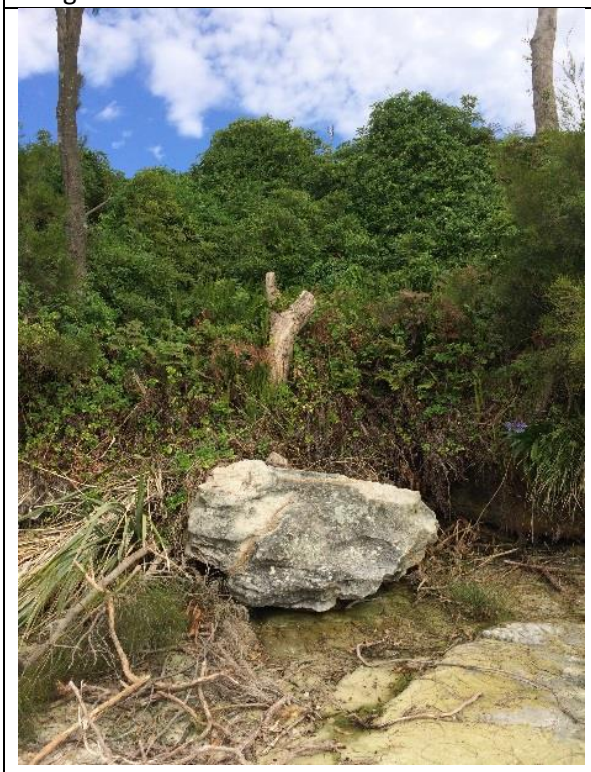


Image 14

Image 15

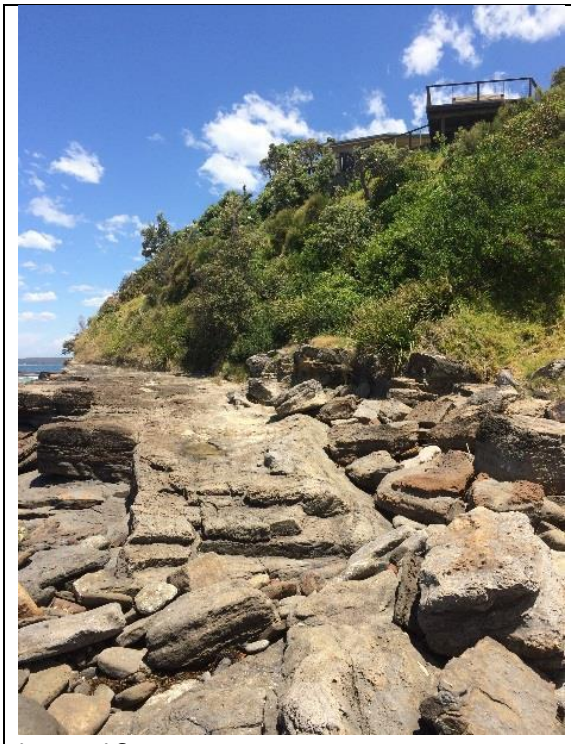
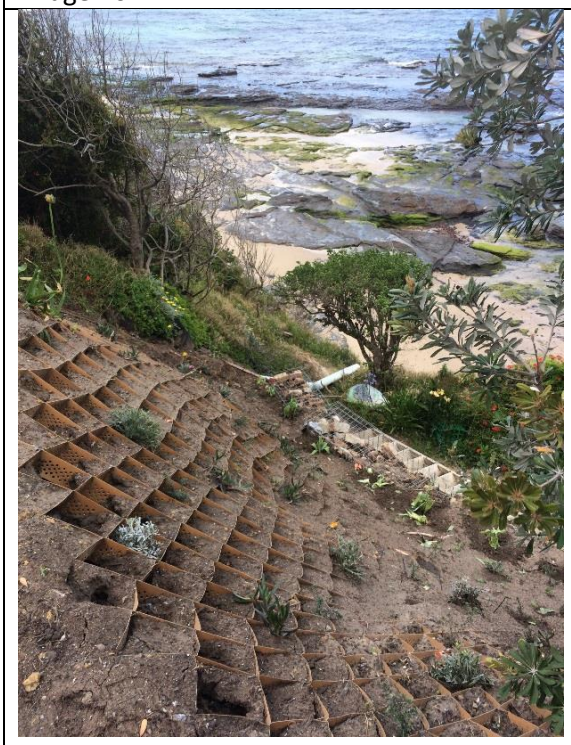


Image 16

Image 17



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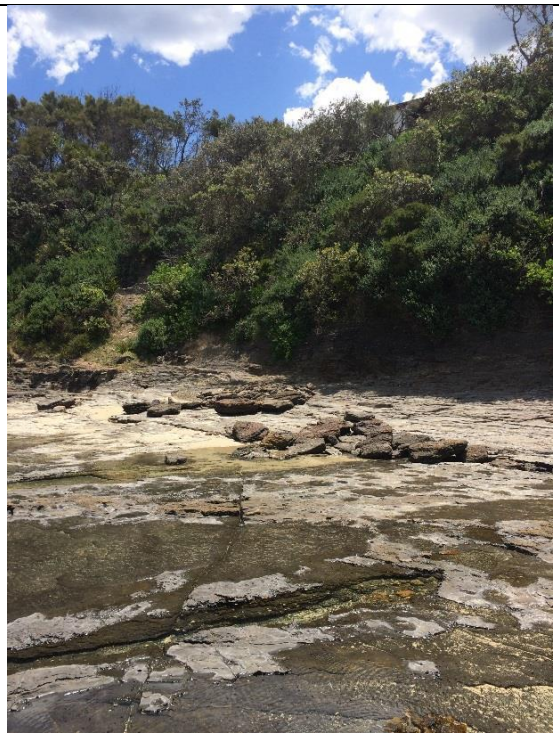

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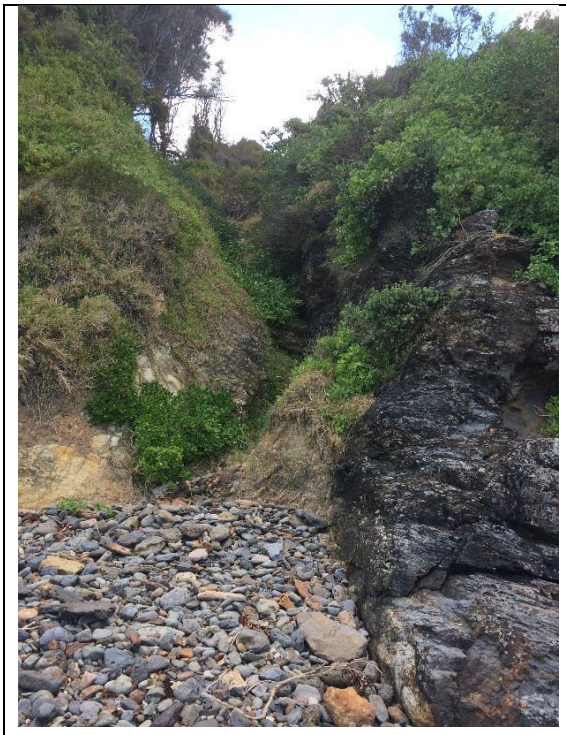


Image 20

Image 21

Image 22

Image 23

Image 24

Image 25

Image 26

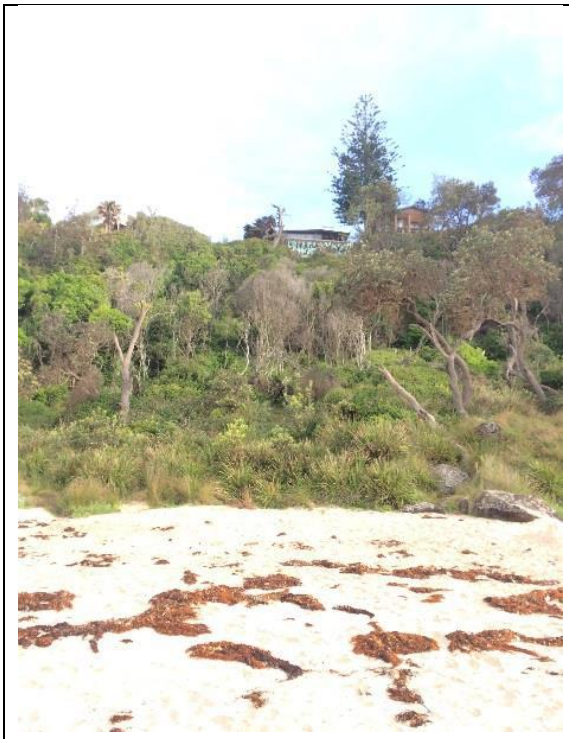
Image 27

Image 28

Image 29

Image 30

Imgae 31



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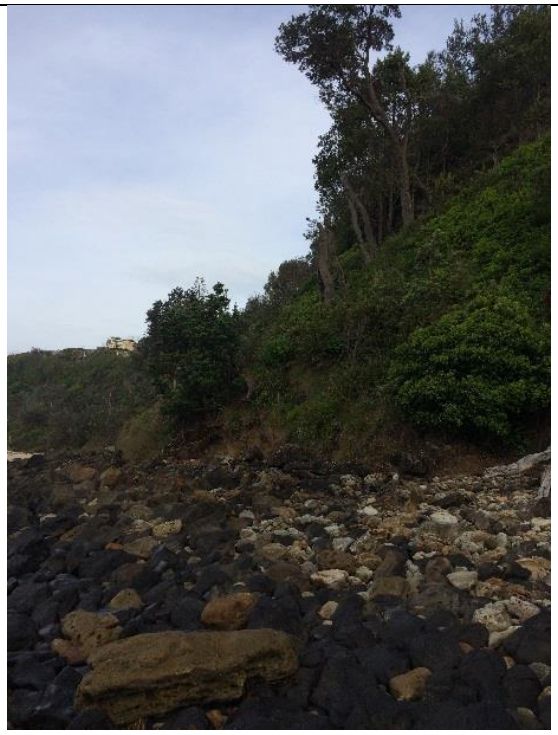

Image 33

Image 34

Image 35

Image 36

Image 37

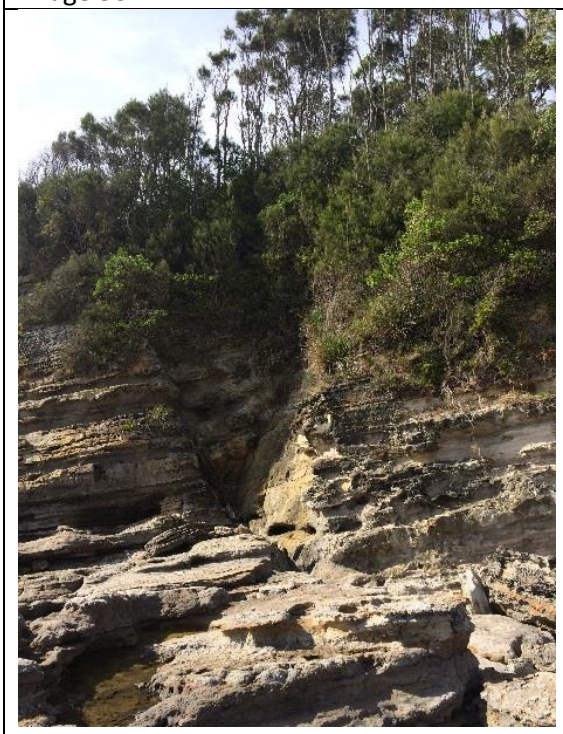

Image 38

Image 39

Image 40

Image 41

Image 42

Image 43

Image 44

Image 45

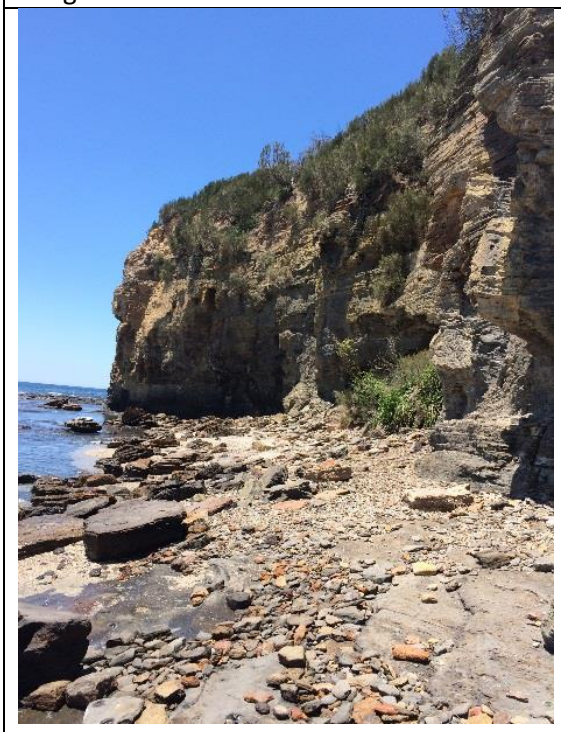

Image 46

Image 47

Image 48

Image 49

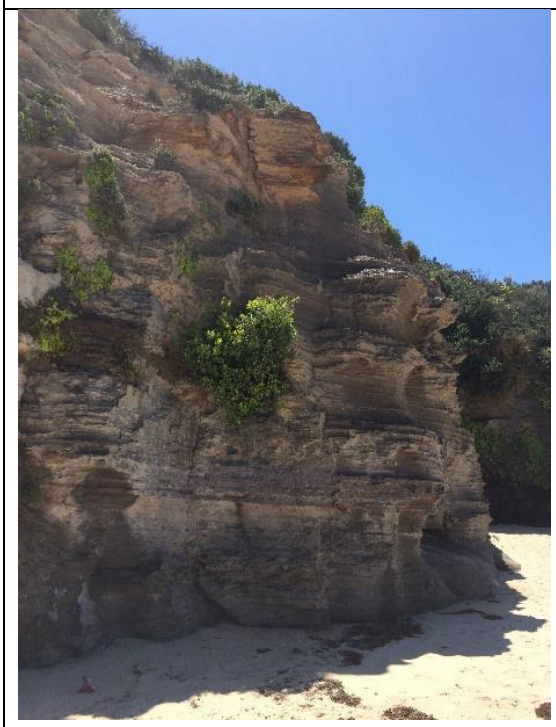

Image 50

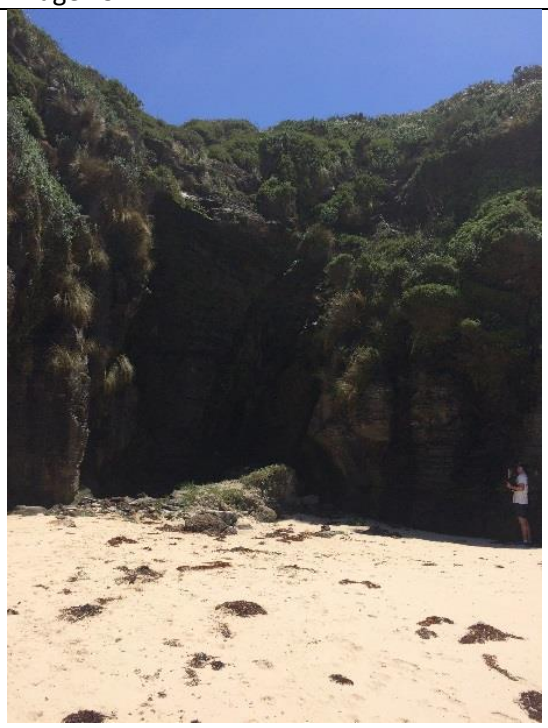

Image 51

Image 52

Image 53

Image 54

Image 55

Image 56

Appendix C – Australian Geoguides for Slope Management and Maintenance

INSPECTION/MAINTENANCE RECORD

(Tick boxes as appropriate and add information as required/relevant) Date: _____

Site location (street address / lot & DP numbers / map reference / latitude and longitude):

_____

FEATURE	NOTES	Inspected	Photos attached	Tested	Maintained	By owner	By professional	Notes added
Slopes & surface protection:								
☐ Natural slope/cliff								
☐ Surface water drains								
☐ Shotcrete								
☐ Cut/fill slope								
☐ Stone pitching								
☐ Other								
Retaining walls:								
☐ Cast in situ concrete								
☐ Masonry (natural stone)								
☐ Cribwall (concrete)								
☐ Anchored wall								
☐ Sub-soil drains								
☐ Concrete block								
☐ Masonry (brick, block)								
☐ Cribwall (timber)								
☐ Reinforced soil wall								
☐ Weep holes								
Ground improvement:								
☐ Rock bolts								
☐ Ground anchors								
☐ Deep subsoil drains								
☐ Soil nails								
Effluent and storm water disposal systems:								
☐ Effluent treatment system								
☐ Effluent disposal field								
☐ Storm water disposal field								
Other:								
☐ Netting								
☐ Catch fence								
☐ Catch pit								

Observations/Notes (add pages/details as appropriate) _____

_____

_____

Attachments: ☐ Sketch(es) ☐ Photograph(s) ☐ Other (eg measurements, test results)

Record prepared by: _____ (name) _____ (signature)

Contact details: Phone: _____ E-mail: _____

Professional Status (in relation to landslide risk assessment): _____

Appendix D –Proforma for Owner Notification

Owner Notification Proforma

To:	Property owner XX
Subject:	Shoalhaven Coastal Cliffs and Slopes Risk Management Program
From:	Shoalhaven City Council
Date:	December 2017
Reference:	
Contacts:	

Background:

Due to concerns over the impacts of wet weather coastal cliff and slope stability in a number of coastal areas across the Shoalhaven LGA, Shoalhaven City Council (Council) is implementing a Cliffs and Slopes Risk Management Program. The program has reviewed previous and current assessments with regards to identified risk areas, instigated further geotechnical assessment of risk areas and specific sites, and has included development of a recommendations report for guiding future requirements for management of risk areas. The program has also resulted in a specific Emergency Action Sub-Plan for coastal cliffs and slopes within Shoalhaven LGA.

Part of this program is to provide private landowners with specific information relevant to their properties. This letter provides information and recommendations in relation to management of risk on your property.

A general information leaflet is also attached, which has been distributed to all property owners in identified risk areas.

Site Specific Details: [Include here details captured in the Geotechnical assessment relevant to individual private properties and the general risk area in which their property is situated. Include images where relevant]

The details provide here are based on the findings of the geotechnical assessment of the risk area in which your property is situated.

Inyadda Point, Manyana was identified as a key risk area for coastal hazards relevant to cliffs and slopes. At the northern end of the site (below the northern end of Sunset Strip) the cliff face shows evidence near surface slumping of the soil profile and erosion of the sandstone. Some soil erosion debris was present at the toe of the cliff. The four northernmost properties (1, 3, 5 and 7 Sunset Strip) were identified by DP as 'most at risk from cliff erosion'.

There was evidence of traces of old landslip features and what appeared to be a more recent landslip below 27 Sunset Strip.

A number of erosion gullies were evident on the south facing foreshore slope and colluvium was exposed in the gully sides. The recent landslip that impacted 65 Sunset Strip in August 2015 was evident.

Recommendations:

Immediate: [Include here recommendations for any immediate works as a result of the geotechnical investigation at this site]

Site monitoring/inspection:

Property owners are being encouraged to implement regular monitoring and inspection as a part of ongoing proactive management of sloped sites. The purpose is to ensure continual assessment of existing conditions and identify any indications of deterioration which may increase the risk of hazards. This might include:

- cracked, leaning or deformed retaining walls;
- evidence of rock falls and/or soil slumps at the base of the slopes;
- cracking of the crest areas of slopes and cliff faces;
- deformed fence posts or failing fencing.

Monitoring for the above will enable proactive management measures to be implemented in a timely manner. The frequency of monitoring should be 12 monthly, and/or coincide with significant storm events or weather conditions (after periods of heavy or prolonged rainfall and/or predicted high tidal levels).

It is imperative that such monitoring be formally documented and that the required frequency of reporting (and to whom) is clearly defined. Australian Geomechanics Society, Geoguides for Slope Management and Maintenance outlines recommended requirements for record keeping relevant to monitoring and maintenance of risk sites (see reference for Further Information). Where incidents of instability have occurred within the monitoring period then, where possible, it is recommended that private property owners record relevant details within the monitoring reports. These details would include the date of the incident, the weather conditions on the day and leading up to the incident, a location plan/sketch, photographs and dimensions of the specific features (block sizes, crack widths etc would also need to be recorded). Where new incidents have occurred, the monitoring reports should be provided to the geotechnical engineer so that if there are any causes for concern, you can obtain further advice. The need for site specific stabilisation measures can then be better assessed. An example site inspection/maintenance record sheet template is included as an attachment to this memo.

Owner Notification Proforma

Emergency Action Sub-Plan: [Include details here that are specific to the implementation of the EASP]

Include here specific information from the EASP relevant to property owner responsibilities and actions in the event of an emergency situation.

Further Information:

Further information on the risk management program can be found on Council's website:

https://www.shoalhaven.nsw.gov.au/Environment/Cliffs and slopes risk

https://www.shoalhaven.nsw.gov.au/Environment/Coastal-Landscape/Coastal-Hazards

https://www.shoalhaven.nsw.gov.au/Planning-amp-Building/Development/Development-in-areas-of-coastal-instability

https://www.shoalhaven.nsw.gov.au/Emergency

For further information and guidelines on slope management and maintenance refer to the Australian Geoguides for Slope Management and Maintenance. The latest versions of the GeoGuides are downloadable from the AGS website**:** www.australiangemechanics.org**.**

GeoGuide LR10 is specifically aimed at those who have property on the coast and could be susceptible to coastal erosion processes.

Appendix E - Risk Assessment Tables

TABLE A1
SUMMARY OF RISK ASSESSMENT TO PROPERTY

General Location	Penguin Head and Culburra Beach	Plantation Point	Hyams Point	Berrara Point	Inyadda Point, Manyana	Narrawallee	Bannisters Point, Mollymook	Collers Beach, Ulladulla	Rennies Beach, Ulladulla	Racecourse Beach, Ulladulla
POTENTIAL GEOTECHNICAL HAZARD 1	**Instability of overhang/undercut features, blocks and/or wedges of rock over the cliff face**									
Assessed Likelihood	Almost Certain									
Assessed Consequences	Insignificant									
Risk	Low									
Comments	Localised failure, does not impact structures at the crest of the cliff face. Larger scale cliff face failures addressed in Table A3. Specific site locations addressed in Tables A4 to A6.									

TABLE A2
SUMMARY OF RISK ASSESSMENT TO PROPERTY

General Location	Penguin Head and Culburra Beach	Plantation Point	Hyams Point	Berrara Point	Inyadda Point, Manyana	Narrawallee	Bannisters Point, Mollymook	Collers Beach, Ulladulla	Rennies Beach, Ulladulla	Racecourse Beach, Ulladulla
POTENTIAL GEOTECHNICAL HAZARD 2	**Instability of foreshore colluvial/residual soil slopes, small scale (less than 5m^3) and large scale (impacting the full width of a residential lot [at least 200m^3]).**									
	Small					Large				
Assessed Likelihood	Likely					Possible				
Assessed Consequences	Insignificant					Insignificant (Assumes only landscape structures impacted, houses set well back from edge of cliff)				
Risk	Low					Very Low				
Comments	Specific site locations addressed in Tables A4 to A6.									

TABLE A3
SUMMARY OF RISK ASSESSMENT TO PROPERTY

General Location	Penguin Head and Culburra Beach	Plantation Point	Hyams Point	Berrara Point	Inyadda Point, Manyana	Narrawallee	Bannisters Point, Mollymook	Collers Beach, Ulladulla	Rennies Beach, Ulladulla	Racecourse Beach, Ulladulla
POTENTIAL GEOTECHNICALHAZARD 3	**Large scale cliff face instability.**									
Assessed Likelihood	Rare	Rare	Rare	Rare	Rare	Rare	Rare	Rare	Rare	Rare
Assessed Consequences	Major	Minor	Major	Major	Major	Major	Major	Major	Major	Major
Risk	Low	Very Low	Low	Low	Low	Low	Low	Low	Low	Low
Comments	Failure impacts seaward portion of house	Failure impacts utility infrastructure	Failure impacts seaward portion of house	Failure impacts seaward portion of house	Failure impacts seaward portion of house	Failure impacts seaward portion of house	Failure impacts seaward portion of house	Failure impacts seaward portion of house	Failure impacts seaward portion of house	Failure impacts seaward portion of house

TABLE B1
SUMMARY OF RISK ASSESSMENT TO LIFE UNDER EXISTING CONDITIONS

General Location	Penguin Head and Culburra Beach	Plantation Point	Hyams Point	Berrara Point	Inyadda Point, Manyana	Narrawallee	Bannisters Point, Mollymook	Collers Beach, Ulladulla	Rennies Beach, Ulladulla	Racecourse Beach, Ulladulla
POTENTIAL GEOTECHNICAL HAZARD 1	**Instability of overhang/undercut features, blocks and/or wedges of rock over the cliff face**									
Assessed Likelihood	Almost Certain									
Indicative Annual Probability	$1x10^{-1}$									
Persons at Risk	In rear yard On beach or platform at the toe of the slope/cliff face In reserve area at the crest of the slope									
Number of Persons Considered	2									
Duration of Use of Area Affected (Temporal Probability)	Person in rear yard; 0.02 Person on beach, platform at the base of the cliff, or in reserve (Plantation Point); 4×10^{-5}									
Probability of Not Evacuating Area Affected	0.01									
Spatial Probability	1									
Vulnerability to Life if Failure Occurs Whilst Person Present	0.01 (rear yard) 0.5 (beach, platform at the base of the cliff and reserve at the crest of the slope)									
Risk for Person Most at Risk	2×10^{-7} (rear yard) 2×10^{-8} (beach, platform at the base of the cliff and reserve at the crest of the slope)									
Total Risk	4×10^{-7} (rear yard) 4×10^{-8} (beach, platform at the base of the cliff and reserve at the crest of the slope)									

Notes
Person in rear yard, occupancy based on 0.5hrs per day: about 0.02.
Person walking on track or access path; occupancy based on average walking rate of 4 seconds per 5m length per day for 9 months of year: about 4×10^{-5}.
Specific site locations addressed in Tables B4 to B6.

TABLE B2
SUMMARY OF RISK ASSESSMENT TO LIFE UNDER EXISTING CONDITIONS

General Location	Penguin Head and Culburra Beach	Plantation Point	Hyams Point	Berrara Point	Inyadda Point, Manyana	Narrawallee	Bannisters Point, Mollymook	Collers Beach, Ulladulla	Rennies Beach, Ulladulla	Racecourse Beach, Ulladulla
POTENTIAL GEOTECHNICAL HAZARD 2	**Instability of foreshore colluvial/residual soil slopes, small scale (less than 5m^3) and large scale (impacting the full width of a residential lot [at least 200m^3]).**									
	Small Scale					Large Scale				
Assessed Likelihood	Likely					Possible				
Indicative Annual Probability	$1x10^{-2}$					$1x10^{-3}$				
Persons at Risk	In rear yard On beach or platform at the toe of the slope/cliff face In reserve area at the crest of the slope									
Number of Persons Considered	2									
Duration of Use of Area Affected (Temporal Probability)	Person in rear yard; 0.02 Person on beach, platform at the base of the cliff, or in reserve (Plantation Point); 4×10^{-5}									
Probability of Not Evacuating Area Affected	0.01					0.1				
Spatial Probability	1									
Vulnerability to Life if Failure Occurs Whilst Person Present	0.1					0.5				
Risk for Person Most at Risk	2×10^{-7} (rear yard) 4×10^{-10} (beach, platform at the base of the cliff and reserve at the crest of the slope)					1×10^{-6} (rear yard) 2×10^{-9} (beach, platform at the base of the cliff and reserve at the crest of the slope)				
Total Risk	4×10^{-7} (rear yard) 8×10^{-10} (beach, platform at the base of the cliff and reserve at the crest of the slope)					2×10^{-6} (rear yard) 4×10^{-9} (beach, platform at the base of the cliff and reserve at the crest of the slope)				

Notes
Person in rear yard, occupancy based on 0.5hrs per day: about 0.02.
Person walking on track or access path; occupancy based on average walking rate of 4 seconds per 5m length per day for 9 months of year: about 4×10^{-5}.
Large scale instability assumes only landscape structures impacted, houses set well back from edge of cliff.
Specific site locations addressed in Tables B4 to B6.

TABLE B3
SUMMARY OF RISK ASSESSMENT TO PROPERTY

General Location	Penguin Head and Culburra Beach	Plantation Point	Hyams Point	Berrara Point	Inyadda Point, Manyana	Narrawallee	Bannisters Point, Mollymook	Collers Beach, Ulladulla	Rennies Beach, Ulladulla	Racecourse Beach, Ulladulla
POTENTIAL GEOTECHNICALHAZARD 3	**Large scale cliff face instability.**									
Assessed Likelihood	Rare									
Indicative Annual Probability	$1x10^{-5}$									
Persons at Risk	In rear yard On beach or platform at the toe of the slope/cliff face In reserve area at the crest of the slope In the house									
Number of Persons Considered	2									
Duration of Use of Area Affected (Temporal Probability)	Person in rear yard; 0.02 Person on beach, platform at the base of the cliff, or in reserve (Plantation Point); 4×10^{-5} Person in house; 0.3									
Probability of Not Evacuating Area Affected	0.5									
Spatial Probability	1									
Vulnerability to Life if Failure Occurs Whilst Person Present	1									
Risk for Person Most at Risk	1×10^{-7} (rear yard and reserve) 2×10^{-8} (beach, platform at the base of the cliff and reserve at the crest of the slope) 1.5×10^{-6} (in house)									
Total Risk	2×10^{-7} (rear yard and reserve) 4×10^{-8} (beach, platform at the base of the cliff and reserve at the crest of the slope) 3×10^{-6} (in house)									

Notes
Person in rear yard, occupancy based on 0.5hrs per day: about 0.02.
Person walking on track or access path; occupancy based on average walking rate of 4 seconds per 5m length per day for 9 months of year: about 4×10^{-5}.
Person in house, occupancy based on 8hrs per day: about 0.3.
Specific site locations addressed in Tables B4 to B6.