4 RISK EVALUATION

The earlier sections of this document detail the landslide characterisation process used to undertake the hazard risk assessment process for both property and life for each site in accordance with AGS (2007a). Figure 2.2 shows the general process recommended by the AGS Guidelines in a flow chart form.

The following sections aim to use the understanding of the hazard events occurring along the Shoalhaven coastline to derive the potential fifty year fifty percent risk recession line (i.e. the estimated average cliff recession line after fifty years) and fifty year five percent risk recession line (i.e. the estimated average cliff recession line after 1000 years). This information enables risk evaluation to be undertaken. The risk evaluation compares the assessed risk for each site against an acceptance criterion. On the basis of this risk management and control strategies are recommended where the estimated risk is beyond the acceptable/tolerable limit.

4.1 Coastline Recession Estimation

For future planning consideration, a risk evaluation approach was implemented to assess the significance of the potential hazards to coastal values and derive the fifty year fifty percent risk recession line and fifty year five percent risk recession line.

An estimate of coastline recession provides the basis for determining the ongoing headland recession and estimating the area inland from the crest to be potentially at risk.

The rate of the coastal headlands recession was approximated by dividing the maximum width of rock platform at each site by the 6,500 year “still-stand” period following the Post-Glacial Marine Transgression (the 140 m sea level rise following the peak of the last ice age). The cliff line recession measurements were completed using the digital aerial photographs and Mapinfo (a commercial computerised mapping program) to measure the distance between the cliff line and the edge of the rock platform at the low tide mark.

The sea level has stood still over the past 6,500 years, however it rose over 10,000 years from approximately 17,000 years ago. The understanding for cliff line recession uses the basis that the edge of the rock platform at low tide represents the approximate location of the headland after the gradual sea level rise. For instance, if the rock platform at a site is 65m wide then the rate of recession is equivalent to approximately 0.01m per annum (65m/6,500 years).

On the basis of the rock platform width information provided in Table 4-1 below, under current conditions the cliff lines within the Shoalhaven over the next 50 years may recede between 0.5m to 0.9m, and upwards of 10m over the next 1000 years.

<table>
<thead>
<tr>
<th>Location</th>
<th>Width of Rock Shelf Measurements (m)</th>
<th>Maximum Width of Rock Shelf (m)</th>
<th>Average Recession Rate (mm/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Racecourse Beach</td>
<td>75, 68</td>
<td>75</td>
<td>12</td>
</tr>
<tr>
<td>Rennies Beach</td>
<td>41, 66, 42</td>
<td>66</td>
<td>10</td>
</tr>
<tr>
<td>Collers Beach Headland</td>
<td>79, 55, 42, 65</td>
<td>79</td>
<td>12</td>
</tr>
</tbody>
</table>

Table 4-1: Rate of Coastal Bluff Recession
<table>
<thead>
<tr>
<th>Location</th>
<th>Width of Rock Shelf Measurements (m)</th>
<th>Maximum Width of Rock Shelf (m)</th>
<th>Average Recession Rate (mm/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bannisters Point</td>
<td>70</td>
<td>70</td>
<td>11</td>
</tr>
<tr>
<td>Inyadda Point</td>
<td>81, 51, 66, 48, 87</td>
<td>87</td>
<td>13</td>
</tr>
<tr>
<td>Berrara Bluff</td>
<td>53, 95, 75, 84, 80</td>
<td>95</td>
<td>15</td>
</tr>
<tr>
<td>Hyams Point</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Plantation Point Headland</td>
<td>33, 118</td>
<td>118</td>
<td>18</td>
</tr>
<tr>
<td>Penguin Head</td>
<td>53, 43, 30, 46, 15, 70</td>
<td>70</td>
<td>11</td>
</tr>
<tr>
<td>Culburra Beach</td>
<td>53, 43, 30, 46, 15, 70</td>
<td>70</td>
<td>11</td>
</tr>
</tbody>
</table>

It should be recognised that the rate of recession for each coastal bluff, presented in Table 4-1 above, is an order of magnitude average figure over around 6,500 years. With this understanding, the actual rate of the physical weathering process is more irregular than the 10-18mm per year specified and further relates to the quality of the headland rock type and susceptibility of the rock to weathering and erosion.

In addition to the approximate cliff recession over the next 50 years and 1000 years, an allowance has been made for the possible occurrence of the failure mechanisms described for each site visited. The site specific failure allowances have been determined by site inspection and by identifying past occurrences of block falls, debris slides and landslide events, as well as identifying specific areas of instability. These failure allowances have been derived from the risk assessments for each location as detailed in Section 3 of this report. Depending on the potential hazards observed at each site, 1m to 5m has been added to the cliff recession estimate to allow for the possible occurrence of block falls, debris slides and larger landslide events. The failure allowances and cliff recession estimates over the next 50 years and 1000 years are provided in Table 4-2 below. As indicated earlier, this information is very general and should be used with more site specific geological and geomorphological information to determine actual rates of recession for planning consideration.

**Table 4-2: 50 Year and 1000 Year Cliff Recession Estimates**

<table>
<thead>
<tr>
<th>Location</th>
<th>Average Recession Rate (mm/yr)</th>
<th>Site Specific Failure Allowance (m)</th>
<th>50 Year Rate of Recession Plus Allowance (m)</th>
<th>1000 Year Rate of Recession Plus Allowance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Racecourse Beach</td>
<td>12</td>
<td>1</td>
<td>1.5</td>
<td>13</td>
</tr>
<tr>
<td>Rennies Beach</td>
<td>10</td>
<td>2</td>
<td>2.5</td>
<td>12</td>
</tr>
<tr>
<td>Collers Beach Headland</td>
<td>12</td>
<td>3</td>
<td>3.5</td>
<td>15</td>
</tr>
<tr>
<td>Bannisters Point</td>
<td>11</td>
<td>3</td>
<td>3.5</td>
<td>14</td>
</tr>
<tr>
<td>Inyadda Point</td>
<td>13</td>
<td>5</td>
<td>5.5</td>
<td>18</td>
</tr>
<tr>
<td>Berrara Bluff</td>
<td>15</td>
<td>2</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td>Hyams Point</td>
<td>-</td>
<td>2</td>
<td>3²</td>
<td>3²</td>
</tr>
<tr>
<td>Plantation Point</td>
<td>18</td>
<td>2</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>Penguin Head</td>
<td>11</td>
<td>3</td>
<td>3.5</td>
<td>14</td>
</tr>
<tr>
<td>Culburra Beach</td>
<td>11</td>
<td>6</td>
<td>6.5</td>
<td>17</td>
</tr>
</tbody>
</table>

Notes: 1. Recession estimates rounded to the nearest 0.5m.
2. Rate of Recession approximated for Hyams Point.
The aerial photographs provided in Figures 4.1 to 4.9 show the estimated cliff line and the estimated 50 year and 1000 year bluff recession lines for the significant Shoalhaven headlands and bluffs. It should be recognised that the location of the cliff lines are approximate only due to the difficulty in determining the actual crest from the aerial photographs.

4.2 Potential Impact of 50 and 1000 Year Cliff Recession

The average rate of cliff recession (50 and 1000 Year) within the Shoalhaven area is intended to show the potential impact of the slope failure hazards on properties and dwellings at each of the study sites. The failure hazards are typically expected to occur during, or shortly after, extreme weather events or earthquakes. Depending on the different factors associated with each failure mechanism, the majority of cliff recession is expected to occur at the one time for the vulnerable part of a headland, rather than the gradual cliff recession per year as implied in Section 4.1 above.

The cliff recession lines on the aerial photographs in Figures 4.1 to 4.9 show the areas of headland that fall within the estimated 50 year and 1000 year recession zones. Table 4-3 describes the approximate number of properties, structures and dwellings that fall within the areas of potential recession.

Some areas that could not be accessed for inspection were identified as being at the crest of a slope from the contour information provided by Shoalhaven City Council. Lots in these areas have been annotated on the aerial photographs in Figures 4.1 to 4.9, where assets may be at risk but cliff recession estimates could not be made. It is recommended that any development recommendations within these lots be certified by an experienced geotechnical engineer or engineering geologist as safe and supported by a Landslip Assessment Report prepared in accordance with the Australian Geomechanics Society Guidelines.

Table 4-3: Potential Impact on Properties and Dwellings at Study Sites within the 50 and 1000 Year Recession Limits

<table>
<thead>
<tr>
<th>Location</th>
<th>Potential 50 Year Cliff Recession Limit$^1$</th>
<th>Potential 1000 Year Cliff Recession Limit$^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Properties Boundaries Dwellings</td>
<td>Properties Boundaries Dwellings</td>
</tr>
<tr>
<td>Racecourse Beach</td>
<td>&lt;20% (5)$^2$ Dwellings</td>
<td>100% (30)$^2$ Dwellings</td>
</tr>
<tr>
<td>Rennies Beach</td>
<td>100% (1) Dwellings</td>
<td>100% (1)$^3$ Dwellings</td>
</tr>
<tr>
<td>Collers Beach Headland</td>
<td>100% (7) Dwellings</td>
<td>100% (7) Dwellings</td>
</tr>
<tr>
<td>Bannisters Point</td>
<td>-</td>
<td>&lt;15% (1)</td>
</tr>
<tr>
<td>Inyadda Point</td>
<td>&lt;90% (~30) Dwellings</td>
<td>100% (~33) Dwellings</td>
</tr>
<tr>
<td>Berrara Bluff</td>
<td>100% (8) Dwellings</td>
<td>100% (8)</td>
</tr>
<tr>
<td>Hyams Point</td>
<td>100% (9) Dwellings</td>
<td>100% (9)</td>
</tr>
<tr>
<td>Plantation Point</td>
<td>100% (1)$^4$ Dwellings</td>
<td>100% (1)$^4$ Dwellings</td>
</tr>
<tr>
<td>Penguin Head</td>
<td>100% (43) Dwellings</td>
<td>100% (43) Dwellings</td>
</tr>
<tr>
<td>Culburra Beach</td>
<td>100% (6)$^5$ Dwellings</td>
<td>100% (6)$^5$ Dwellings</td>
</tr>
</tbody>
</table>

$^1$ Percentage impacted (number impacted)$^2$ $^3$ $^4$ $^5$
Notes:
1. Figures provided are based on the approximate location of the 50 year and 1000 year recession lines from the Aerial photographs provided in Figures 4.1 to 4.9.
2. Includes Racecourse Beach car park at southern end of South Pacific Crescent.
3. Includes Rennies Beach car park adjacent to Rennies Beach Close.
4. Includes boat ramp and picnic area at Plantation Point.
5. Includes car park overlooking Tilbury Cove, Culburra Beach

### 4.3 Risk Acceptance Criteria

The risk acceptance criteria considers the occurrence of the potential hazards identified for each Shoalhaven location, discussed in detail in Section 3, and evaluates the risks against a Tolerable Risk Criteria for property loss and loss of life. In this instance, the individual or property risks are accepted due to being tolerable or risk mitigation measures are undertaken to reduce the risk to more tolerable levels.

The AGS 2007 guidelines indicate that the regulator, with assistance from the practitioner where required, is the appropriate authority to set the standards for tolerable risks relating to perceived safety in relation to other risks and government policy. The importance of the implementation of levels of the tolerable risk should not be understated due to the wide ranging implications, both in terms of the relative risks or safety to the community and the potential economic impact to the community. The AGS provide recommendations in relation to tolerable risk for loss of life as shown below in Table 4-4.

<table>
<thead>
<tr>
<th>Situation</th>
<th>Suggested Tolerable Loss of Life Risk for the person most at risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing Slope (1) / Existing Development (2)</td>
<td>$10^{-4}$/annum</td>
</tr>
<tr>
<td>New Constructed Slope (3) / New Development (4) / Existing Landslide (5)</td>
<td>$10^{-5}$/annum</td>
</tr>
</tbody>
</table>

Notes:
1. “Existing Slopes” in this context are slopes that are not part of a recognizable landslide and have demonstrated nonfailure performance over at least several seasons or events of extended adverse weather, usually being a period of at least 10 to 20 years.
2. “Existing Development” includes existing structures, and slopes that have been modified by cut and fill, that are not located on or part of a recognizable landslide and have demonstrated non-failure performance over at least several seasons or events of extended adverse weather, usually being a period of at least 10 to 20 years.
3. “New Constructed Slope” includes any change to existing slopes by cut or fill or changes to existing slopes by new stabilisation works (including replacement of existing retaining walls or replacement of existing stabilisation measures, such as rock bolts or catch fences).
4. “New Development” includes any new structure or change to an existing slope or structure. Where changes to an existing structure or slope result in any cut or fill of less than 1.0m vertical height from the toe to the crest and this change does not increase the risk, then the Existing Slope / Existing Structure criterion may be adopted. Where changes to an existing structure do not increase the building footprint or do not result in an overall change in footing loads, then the Existing Development criterion may be adopted.
5. “Existing Landslides” have been considered likely to require remedial works and hence would become a New Constructed Slope and require the lower risk. Even where remedial works are not required per se, it would be reasonable expectation of the public for a known landslide to be assessed to the lower risk category as a matter of “public safety”.

For property loss, the Tolerable Risk Criterion may be determined by the Importance Level of the building or structure. The Importance Level is directly related to societal requirements during or immediately after extreme events (Appendix A). In addition to the AGS recommendations in relation to tolerable risk, further support for determining the tolerable risk for loss of life and property may be sought from the appropriate Dams specification.
The AGS risk threshold provided in Table 4-4 for existing developments on slopes suggests the ‘Tolerable Loss of Life for the person most at risk’ is $10^{-4}$ per annum. Table 4-5 below summarises those existing sites where the hazards identified are deemed intolerable in accordance with this AGS risk threshold:

Table 4-5: Intolerable risk to life (individual risk) at Shoalhaven Locations

<table>
<thead>
<tr>
<th>Location</th>
<th>Potential Hazard Identified</th>
<th>Annual Probability for Loss of Life (AGS, 2007)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Racecourse Beach</td>
<td>Rock fall (&lt;1m)</td>
<td>$4 \times 10^{-4}$</td>
</tr>
<tr>
<td>Rennies Beach</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Collers Beach Headland</td>
<td>Rock fall (1.5-2m)</td>
<td>$2.5 \times 10^{-5}$</td>
</tr>
<tr>
<td>Bannisters Point</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Inyadda Point</td>
<td>Large Slump (200m$^3$)</td>
<td>$4 \times 10^{-3}$</td>
</tr>
<tr>
<td>Berrara Bluff</td>
<td>Rock fall (&lt;1.5m)</td>
<td>$1 \times 10^{-4}$</td>
</tr>
<tr>
<td>Hyams Point</td>
<td>Rock fall (&lt;1.5m)</td>
<td>$1 \times 10^{-4}$</td>
</tr>
<tr>
<td>Plantation Point</td>
<td>Debris slide (&lt;5m$^3$)</td>
<td>$4 \times 10^{-5}$</td>
</tr>
<tr>
<td>Penguin Head</td>
<td>Rock fall (&lt;1.5m)</td>
<td>$5 \times 10^{-4}$</td>
</tr>
<tr>
<td>Culburra Beach</td>
<td>Rock fall (&lt;1.5m) Debris slide (200m$^3$)</td>
<td>$5 \times 10^{-4}$ $6 \times 10^{-4}$</td>
</tr>
</tbody>
</table>

5 RISK TREATMENT

5.1 Background
Coastal areas of the Shoalhaven Shire, as any other foreshores along the NSW east coast, have been continuously experiencing rapid population growth due to various factors such as more favourable climate, natural environment, lifestyle and employment opportunities. These factors in conjunction with soaring values of real estate assets have added pressures for increased usage of the existing land by renovation/improvement of the existing property or replacement of the existing dwelling with a new, often larger and denser residential development. Because of ocean view and proximity to beach amenities, this trend of coastal re-urbanisation has affected, to a greater extent, the residential lots which are closest to the crest of bluffs and headlands and are therefore exposed to threats from coastal slope hazards compared with the lots inland. It is also possible that engineering development activities close to the edge of bluffs and headlands could themselves cause/trigger slope hazards and hence, elevate risks to property and loss of life if undertaken without an adequate engineering design input and geotechnical advice.

This chapter describes mitigation measures available to Shoalhaven Council to manage the threats imposed by the slope hazards on the coastal community, values and assets with regard to residential development along the bluffs and headlands.

5.2 General Recommendations
The measures that could be implemented to control risks from coastal slope hazards in all coastal urban areas are described below.

1. Slope hazard zoning for land use planning
This would involve division of existing urban areas and virgin lands proposed for development in the bluffs and headlands into homogeneous sections based on degrees of risks associated with coastal slope processes. This approach is expected to provide a great benefit to Council in its planning for future urban development and effective land management in these areas in such a way that the geotechnical risks to the coastal community, assets and values are maintained at an acceptable level. Reference to (AGS 2007a & 2007b) is recommended for further relevant details on slope hazard zoning. It is suggested that the slope hazard zoning be carried out in accordance with the above referenced AGS document.

2. Inspection, monitoring and maintenance
Inspection, monitoring and maintenance is a key activity required for maintaining expected short and long term performance of any existing structure including slope structures in bluffs and headlands. In the context of slope instability in the coastal foreshore areas, inspection and monitoring is suggested to be undertaken at the individual as well as local governmental level.
Contribution to the inspection regime from an individual is expected in the areas where existing residential houses occupy the crest of the slope. The owner of each property should be responsible for:

- Maintaining adequate surface drainage path in and out of the property and piping the drainage outlet away from the immediate slope to avoid potential scouring on the slope surface.
- Fixing/repairing the leaking or broken underground drainage/sewer pipes as soon as the fault has been identified.
- Undertaking periodic visual inspection of the property and surrounds for any cracking, ground movement etc (say every 6 months to annually or after large storm periods).
- Where the risk levels are determined to be higher then an inspection by qualified and suitably experienced personnel is required.
- Maintaining vegetation cover or other means of surface protection (as applicable) inside the property boundary to minimise surface infiltration into underlying foundation materials.
- Where practical, encouraging/facilitating vegetation growth on the crest and slope below the house.
- Seeking appropriate geotechnical and design advice if any construction activities including renovation/addition or replacement are planned within the extent of the property.
- Following Council’s relevant regulatory requirements for new construction inside the property.

From the local governmental level, it is recommended that periodic inspections be undertaken of all the slopes, which are subjected to impact from coastal processes, by a suitably qualified geotechnical practitioner at a frequency of, say, every 5 years. Information collected from such inspection would be valuable for Council in:

- Determining degree and extent of slope deterioration.
- Identifying potential slope hazards, such as unstable blocks, which pose risks to the area above/below the slope.
- Timely implementation of remedial actions.
- Managing risks more efficiently.
- Adjusting Council’s regulatory requirements for future planning and development of the area.

3. Quality engineering design and practice

Good engineering design of foundations and earthworks not only reduces maintenance costs of the structure throughout its design life, it also minimises uncertainties associated with foundation-structure interaction and hence the risks. Some notes on good and poor engineering practice for hillside construction are presented in Appendix C (reproduced from AGS 2007c, Appendix G). It is suggested that the guidelines on good engineering practice provided in Appendix C be used when a development is proposed on or close to the coastal fringe areas.
6 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary and Conclusion

Slope risk assessments at ten sites have defined existing and potential slope failure mechanisms presenting cliff instability to property and/or individual susceptibility arising from landslides at these sites. Qualitative assessments have been used to define the risk to property at each of the sites visited. Quantitative assessments have been used to define the risk to life at each of the sites visited.

The failure mechanism identified as most commonly occurring at these sites were block (<1.5m in diameter) falls/topples relating to the undercutting erosive effects of tidal wave action and the jointed nature of the rock. To a lesser extent, but no less significant, debris topples/slides and slumping of loosened rock debris and soil typically less than 200m$^3$ were a feature of some of the sites visited. Risk assessments were undertaken on those potential failures deemed significant in terms of potential to cause property damage or risk to life.

The qualitative risk assessments undertaken for properties, including both private residences and public infrastructure such as car parks, at each of the sites typically showed that property damage from rock falls and toppling blocks (<1.5m) was low to very low. Apart from high risk of rotational failures assessed at Culburra Beach and Inyadda Point, slumping and debris flows <200m$^3$ were generally low risk failure events.

Quantitative risk to life assessments of individual susceptibility during the occurrence of failure events also showed that block falls/topples resulting in loss of life were generally possible to unlikely. It is anticipated that where these events occur that failure of smaller blocks from lower levels of the cliffs would result in the injury rather than death to the person attempting to evade the debris. Risk to life from slumping and debris slides/falls <200m$^3$ were also assessed to be possible to unlikely risks. At Culburra Beach the large areas of slumping appeared to be mainly contained within the slope, therefore limiting the risk to life, with debris protruding several metres from the toe of the slope. At Inyadda Point in Manyana tension cracks were observed in the slope but there was little evidence that the cracks would develop into a large landslide causing risk to the existing houses and their occupants.

The AGS guidelines show an example of evaluating the risks in terms of a tolerable acceptance criteria property loss and loss of life. In this instance, the individual or property risks are accepted due to being tolerable or risk mitigation measures are undertaken to reduce the risk to more tolerable levels.

The AGS 2007 guidelines indicate that the regulator is the appropriate authority to set the standards for tolerable risks relating to perceived safety in relation to other risks and government policy. However, the AGS recommendation of tolerable risk to life on existing developed slopes is $10^{-4}$, and $10^{-5}$ on newly developed slopes. In terms of property, the AGS recommends the importance level of the property or structure be rated in terms the societal requirements particularly during or after extreme events.
In conclusion, the importance of the implementation of levels of the tolerable risk should not be understated due to the wide ranging implications, both in terms of the relative risks or safety to the community and the potential economic impact to the community.

6.2 Site Specific Development Recommendations

The site observations and assessments made at each Shoalhaven location have been discussed in Section 3. The risk evaluation and recommended treatments have been discussed in Sections 4 and 5. These assessments have concluded that geotechnical risks identified at a number of the study areas are intolerable or marginally tolerable and as such management and remediation of the sites should be implemented. Such measures, as a minimum should include the provision of geotechnical reports accompanying any development application in the areas identified below should include a risk assessment in accordance with AGS 2007c. In addition, specific sites should adopt additional mitigation measures to alleviate the assessed risks including those defined below:

1. Racecourse Headland
   - Further inspections are required in future years regarding the stability of the rock wall above the Northern part of Racecourse Beach, adjacent to the car park and beach access steps.

2. Rennies Beach Bluff
   - Vegetate the southern slope below the private property and monitor for undercutting after heavy prolonged rain events.

3. Collers Beach Headland
   Mitigation and management of the geotechnical risks are required. The options include signage of the rock fall danger and/or exclusion zones or slope remediation works.
   - Signage of rock fall danger required.
   - Development applications are to be certified by an experienced geotechnical engineer or engineering geologist as safe and supported by a Land Slip Assessment report prepared in accordance with Australian Geomechanics Society Guideline for landslide susceptibility, hazard and risk zoning for land use planning (2007), accompanying Commentaries and Practice Notes.

4. Bannisters Point, Mollymook
   - It is recommended that the area of crest open to pedestrian access along Mitchell Parade be fenced off as a general precaution.
   - Development applications are to be certified by an experienced geotechnical engineer or engineering geologist as safe and supported by a Land Slip Assessment report prepared in accordance with Australian Geomechanics Society Guideline for landslide susceptibility, hazard and risk zoning for land use planning (2007), accompanying Commentaries and Practice Notes.
5. **Inyadda Point, Manyana**

Mitigation and management of the geotechnical risks are required. The options include signage of the rock fall danger and/or exclusion zones or slope remediation works.

- Monitor changes in the slope over time, particularly the growth of the tension cracks after prolonged rain events.
- Signage of rock fall danger required.
- Development applications are to be certified by an experienced geotechnical engineer or engineering geologist as safe and supported by a Land Slip Assessment report prepared in accordance with Australian Geomechanics Society *Guideline for landslide susceptibility, hazard and risk zoning for land use planning* (2007), accompanying *Commentaries and Practice Notes*.

6. **Berrara Headland**

Mitigation and management of the geotechnical risks are required. The options include signage of the rock fall danger and/or exclusion zones or slope remediation works.

- Signage of rock fall danger required.
- Development applications are to be certified by an experienced geotechnical engineer or engineering geologist as safe and supported by a Land Slip Assessment report prepared in accordance with Australian Geomechanics Society *Guideline for landslide susceptibility, hazard and risk zoning for land use planning* (2007), accompanying *Commentaries and Practice Notes*.

7. **Hyams Point**

Mitigation and management of the geotechnical risks are required. The options include signage of the rock fall danger and/or exclusion zones or slope remediation works.

- Signage of rock fall danger required.
- Development applications are to be certified by an experienced geotechnical engineer or engineering geologist as safe and supported by a Land Slip Assessment report prepared in accordance with Australian Geomechanics Society *Guideline for landslide susceptibility, hazard and risk zoning for land use planning* (2007), accompanying *Commentaries and Practice Notes*.

8. **Plantation Point**

Mitigation and management of the geotechnical risks are required. The options include signage of the slumping and tree fall danger and/or exclusion zones or slope remediation works.

- Signage of rock fall and tree fall danger required.
- Trees/vegetation currently being undercut near the crest should be removed prior to failure.

9. **Culburra Beach Headland**

Mitigation and management of the geotechnical risks are required. The options include signage of the rock fall and tree fall danger and/or exclusion zones or slope remediation works.
• Signage of rock fall and tree fall danger required.
• Stabilise slope from rotational failures by planting deep rooting vegetation.
• Development applications are to be certified by an experienced geotechnical engineer or engineering geologist as safe and supported by a Land Slip Assessment report prepared in accordance with Australian Geomechanics Society Guideline for landslide susceptibility, hazard and risk zoning for land use planning (2007), accompanying Commentaries and Practice Notes.

10. Penguin Head

Mitigation and management of the geotechnical risks are required. The options include signage of the slumping and tree fall danger and/or exclusion zones or slope remediation works.

• Signage of rock fall danger required.
• Development applications are to be certified by an experienced geotechnical engineer or engineering geologist as safe and supported by a Land Slip Assessment report prepared in accordance with Australian Geomechanics Society Guideline for landslide susceptibility, hazard and risk zoning for land use planning (2007), accompanying Commentaries and Practice Notes.
7 REFERENCES AND BIBLIOGRAPHY

7.1 References


7.2 Bibliography


Figures
FIGURE 1.1 SITE LOCATION PLAN
FIGURE 2.1 MAJOR TYPES OF LANDSLIDES
FIGURE 2.2 FRAMEWORK FOR LANDSLIDE RISK MANAGEMENT

* Framework for Landslide Risk Management (reproduced from AGS 2007c Figure 1, page 66).
FIGURE 3.1 REGIONAL GEOLOGY

* Extract derived from Wollongong 1:250,000 Geological Series Sheet S1 56-9
FIGURE 3.2 REGIONAL GEOLOGY
* Extract derived from Ulladulla 1:250,000 Geological Series Sheet S1 56-13

LEGEND FOR REGIONAL GEOLOGY MAP SHEETS (FIGURES 3.1&3.2)
FIGURE 4.1 CLIFF RECESSION HAZARD LINES RACECOURSE BEACH

LEGEND
- Estimated Cliff Line
- 50yr 50% Recession Risk Line
- 50yr 5% Recession Risk Line
- Elevation Contour (m AHD)
- Wastewater lines
- Water supply lines
- Cadastre
FIGURE 4.2

COASTAL SLOPE INSTABILITY
HAZARD STUDY

RENNIES BEACH

LEGEND

- Estimated Cliff Line
- 50yr 50% Recession Risk Line
- 50yr 5% Recession Risk line
- Elevation Contour (m AHD)
- Wastewater lines
- Water supply lines
- Cadastre
COASTAL SLOPE INSTABILITY
HAZARD STUDY

FIGURE 4.3 CLIFF RECESSION HAZARD LINES COLLERS BEACH HEADLAND

LEGEND
- Estimated Cliff Line
- 50yr 50% Recession Risk Line
- 50yr 5% Recession Risk Line
- Elevation Contour (m AHD)
- Wastewater lines
- Water supply lines
- Cadastre
COASTAL SLOPE INSTABILITY
HAZARD STUDY

LEGEND

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

FIGURE 4.4 CLIFF RECESSION HAZARD LINES BANNISTERS POINT