Draft Final Report

Eurobodalla Shire Coastal Hazards Scoping Study

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EUROBODALLA SHIRE COUNCIL

Good Government, better living

Eurobodalla Shire Coastal Hazards Scoping Study

For: Eurobodalla Shire Council

DRAFT OCTOBER 2010

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1 INTRODUCTION

Eurobodalla Shire is located on the NSW South Coast approximately 280 km south of Sydney. The shire coastline stretches approximately 112 km, with major settlements at Batemans Bay, Moruya and Narooma.

Council has initiated the Coastline Management process throughout the shire, with a Coastal Hazards Management Plan completed for Batemans Bay in 2001. However, there is a lack of coastal hazard risk information in other parts of the Shire. Given the length of coastline and vast network of estuaries, beaches and lagoons within the Shire, there is a need to target comprehensive coastal hazard investigations to priority areas. This report identifies the priority areas for targeted assessments, as well as critical data acquisition requirements for the development of a Coastline Management Study and Plan for the entire coastline.

While much of the coastline remains in its natural state, there are areas where development encroaches onto the coastline, raising questions as to the degree of coastal hazard risk. The existing Batemans Bay Coastline Hazard Management Plan identified coastal hazards in the following areas within the Batemans Bay embayment downstream of the Princes Highway Bridge:

- Maloneys Beach,
- Long Beach,
- Cullendulla Beach and Surfside Beach,
- North Batemans Bay (Wharf Road),
- Batemans Bay Central Business District,
- Batemans Bay Beach Road (Boat Harbour West),
- Batemans Bay Hanging Rock (Boat Harbour East),
- Catalina (Corrigans Beach)
- Batehaven (Casey Beach).

Other coastal areas in the Eurobodalla Local Government Area may potentially be at risk of damage to public assets and impacts on recreational amenity caused by coastal hazards. These other coastal areas identified in this report are listed below:

- South Durras
- Sunshine Bay
- Denhams Beach
- Surf Beach
- Lilli Pilli
- Malua Bay and Mc Kenzie Beach
- Rosedale
- Guerilla Bay and Burrewarra Point
- Tomakin and Barlings Beach
- Mossy Point and Tomaga River entrance
- Broulee and Broulee Island
- Moruya (Airport, River and Beach)

- Congo
- Meringo
- Bingie
- Tuross Head (Including Coila Lake and Tuross Lakes Entrances)
- Potato Point
- Dalmeny
- Kianga
- Narooma and Islandview Beach resort
- Mystery Bay
- Akolele and Wallaga Lake.

These locations are illustrated in Figure 1.1.

The coastal hazard is likely to increase with time given current scenarios for climate change and projected sea level rise.

Increasing pressures on the natural resources along the coast are significant, and include population growth, growing residential development needs along the foreshore, coastal development and tourism.

In recognition of the growing pressures and complex interactions between coastal processes that operate within the coastal zone, Council has resolved to review the existing coastal hazard studies, for comprehensiveness and to take account of contemporary scenarios for long term sea level rise and climate change. In addition to this review, a gap analysis of coastal hazard assessment studies was carried out to identify areas requiring detailed assessment. Updated aerial photography, recent information regarding Climate Change and ALS data has allowed much greater accuracy to be obtained in defining coastal hazard risks along Eurobodalla Council's beaches.

The scope and objectives of this study include:

- review existing coastal hazard studies for comprehensiveness, adequacy and currency especially in light of Sea Level Rise and climate change;
- complete a gap analysis of coastal hazard analysis assessment studies and a Shire-wide Coastal Zone Management Plan;
- nominate and prioritise geographic locations for targeted studies and management responses;
- identify and prioritise data acquisition requirements for future studies;
- provide an Action Plan setting out a clear list of priorities, time frames and approximate budgets for the development of a comprehensive Coastal Zone Management Study and Plan;
- identify opportunities and initiatives to progress Eurobodalla's coastal management program; and
- provide a detailed methodology of selection criteria applied to identifying priority sites

2 REVIEW OF EXISTING STUDIES

As part of the scoping study, a review of the previous available reports and data has been undertaken. Details of the previous studies reviewed is provided below.

2.1 Batemans Bay Drainage Study – Willing and Partners, 1984

This drainage study focused on the commercial/industrial area south of Beach Road at Batemans Bay. This report concludes that retarding basins would be required but the location was to be determined.

Action – This report requires updating of results as it is more than 25 years old.

2.2 Batemans Bay Inundation Study – Willing and Partners, 1988

This report studies different scenarios of Batemans Bay CBD inundation and combination of rainfall and oceanic inundation to obtain a 1:100 AEP flood event. The worst case was determined for a 1:100 AEP oceanic level. The result of this 1:100 AEP flood event was mapped for Batemans Bay Soldiers Club. However, this calculation only takes still water level and not wave action into account.

Action – This report is limited by its age as it is more than 20 years old and additional studies have been undertaken since then.

2.3 Joes Creek Flood Study - Final Report – Willing and Partners, 1989

This report studies the flood behaviour of Joes Creek landward of Corrigans Beach. It provides flood levels for the 5, 20, 50 and 100 year ARI events at various profiles and cross-sections along Joes Creek with a summer solstice high water level of 0.94m AHD and oceanic water levels of 2.25 and 2.55m AHD.

Action – Report is old but water levels provided in this report appear to be reasonable.

2.4 Short Beach Creek Flood Study – Willing and Partners, 1989

This report documents a flood study of Short Beach Creek whose outlet is at the southern end of Casey Beach. Flood levels and peak flow estimates were provided for the 1:5, 1:20, 1:50 and 1:100 AEP flood events at several cross-sections along the creek. Flood levels were calculated using a high tide level of 0.94m AHD and a 100 year ARI still water level of 2.43m AHD. There could be a possible sand bar build up at Casey Beach blocking flow through Beach Road bridge but the risk is low. Mitigation options were assessed and compared. These mitigation options include:

- Construction of a single retarding basin upstream of Batehaven Bypass;
- Construction of two retarding basins including the previously mentioned and an additional one north of Valley Road;
- Bridge modification by increasing the span by 30 to 40m;
- Sunshine Bay Road culverts modification including:
  - Increase of the number of culverts;
  - Replacement of pipe culverts with reinforced concrete box culverts (RCBCs);
  - Provided RCBCs in conjunction with the existing culverts; and
  - Lower roadway level.

- Widening of channel downstream of Sunshine Bay Road (short term mitigation option); and
- Clearing of vegetation upstream of the road (short term mitigation option).

The preferred option consists of a combination of the two short term mitigation options and the replacement of the existing pipes by 3x2700x1200 RCBCs.

Action – Water levels and mitigation options are reasonable.

2.5 Reedy Creek Flood Study and Reedy Creek Flood Study: Additional Options – Willing and Partners, 1989 and 1990

This report documents a flood study of the whole Reedy Creek Catchment and provides flood levels for a 1:5, 1:20, 1:50 and 1:100 rainfall event for various urbanisation scenarios and for a 0.94m AHD high tide level and with a 2.60m AHD and a 2.80m AHD storm surge water levels. Cross-sections were provided at several locations along the creek. Management options, mitigation measures (e.g. culverts) and recommendations were provided. The additional option was the creation of retarding basins and the augmentation of George Bass Drive culverts. The latest option mitigates flooding but dwellings immediately upstream of George Bass Drive were still prone to flooding from floods smaller in magnitude than a 100 year ARI flood.

Action – Report is old but suggested oceanic levels and results appear to be reasonable.

2.6 Review Of Reedy Creek Levee, Malua Bay – Willing And Partners, 1991

This report supplements the previous Reedy Creek Flood Study (1989) and Reedy Creek Flood Study: Additional Options (1990). It studies the influence of the construction of a new levee to protect the houses located directly upstream of George Bass Drive from up to a 100 years ARI flood events. Several options were studied and a preferred option, being the construction of an extended levee, was selected.

Action – Complement results of the two previous studies of Reedy Creek.

2.7 Reed Swamp - Long Beach Flood Study – Willing and Partners, 1991

This report studies the flooding of Sandy Place due to Reed Swamp outflows at Long Beach for 100 year, 20 year and 5 year ARI flood events. The high water summer solstice level of 0.94m AHD was selected and a 100 year ARI still water level (50^{th} percentile) was estimated to be 2.48m. Flood levels were determined for existing and fully developed catchment conditions at several cross-sections between Reed Swamp and Batemans Bay. Mitigation measures were compared and recommendations were given to limit the flooding in this area.

Action – Results of this report are clear and appear to be reasonable and adequate.

2.8 Batemans Bay Vulnerability Study – Coastal and Riverine Management Directorate, 1996

The storm bite and beach recession due to different sea level rise scenarios (i.e. low, midrange and high) by 2050 were described for the different beaches of the Bay. Wave run-up and still water levels for a 50 year ARI event were given for different sea level rise scenarios (see Table 2.1). Sea level rise values were only given for the 2050 planning period but not for the 2100 planning period. Impacts of climate change on wave climate, wind, temperature and rainfall were described.

Photogrammetric analysis was carried out from aerial pictures dating from 1942 to 1993. Flood history between 1864 and 1995 was provided.

Hazard lines and erosion/accretion areas for different dates were mapped as well as a conceptual model of sand transport pathways.

Risk assessment and management options are given for each beach of Batemans Bay.

Action – Report should be completed with more recent data as the flood history stops in 1995 and the photogrammetry in 1993. In addition, the sea level rise should be studied for the 2100 planning period.

Table 2.1 – Design still water levels and run-up height within Batemans Bay (Coastal and Riverine Management Directorate, 1996)

Location	Survey Cross Section	SWL(m) for RI of 50 yrs	SWL+ SLR(low) (m)	SWL+ SLR(mid) (m)	SWL+ SLR (high) (m)	Wave Run-up (m)
1	Casey 1	2.7	2.8	2.9	3.1	1.8
2	Casey 2	2.6	2.7	2.8	3.0	4.6
3	Casey 3	2.6	2.7	2.8	3.0	2.0
4	Corrigan 2	2.5	2.6	2.7	2.9	4.0
5	Corrigan 3	2.5	2.6	2.7	2.9	0.9
6	Section C	2.3	2.4	2.5	2.7	1.6
7	Section B	2.6	2.7	2.8	3.0	1.1
8	Section A	2.7	2.8	2.9	3.1	1.1
9	Wharf Rd 4	2.6	2.7	2.8	3.0	1.8
10	Surfside 1	2.7	2.8	2.9	3.1	1.4
11	Surfside 2	2.7	2.8	2.9	3.1	1.0
12	Cullendulla 2	1.9	2.0	2.1	3.0	0.8
13	Long Beach 1	2.7	2.8	2.9	3.1	2.0
14	Long Beach 2	2.7	2.8	2.9	3.1	1.5
15	Long Beach 3	2.7	2.8	2.9	3.1	1.2
16	Maloneys Beach 1	2.9	3.0	3.1	3.3	2.0
17	Maloneys Beach 1	2.8	2.9	3.0	3.2	2.0

N.B.: Wave run-up heights are above the appropriate still water level.

2.9 Congo Creek Flood Study – Willing and Partners, 1997

This report studies the inundation of Congo Road. Four improvement options were assessed and compared. The conclusion of this report was to raise Congo Road where it crosses Congo Creek to the level of the existing cattle grid located 20 metres south of the existing bridge (i.e. 1.47m AHD). Cost estimates were also provided.

Action – Bridge at Congo Road described in the report has already been modified since publication of this report.

2.10 Drainage Report Wharf Road-Surfside – Eurobodalla Shire Council, 1997

This report documents the stormwater assets located between Wharf Road and Surfside. Methods to improve them were assessed and a cost estimate was provided. Flood events were modelled for high tide levels of RL1.1m and 100 year ARI ocean inundation of RL 2.7m. Design still water and wave run-up heights used in this study were the same as the ones used by the Coastal and Riverine Management Directorate in 1996 (Table 2.1). The proposed floor levels needed for each area was provided.

These levels were calculated with a sea level rise of 0.20m by 2050 which should be replaced by the value of 0.40m from the NSW Sea Level Rise Policy.

Action – Report to be updated to reflect current NSW Sea Level Rise Policy and the 2100 planning period should be developed.

2.11 Batemans Bay Waterway Infrastructure Strategy – WMA, 2002

This report describes the condition of the various waterway infrastructure (e.g. boat ramps, carparks, jetties, toilet blocks, wharves, etc.) along the bay and its estuary up to the town of Nelligen. It details constraints and opportunities and provides cost estimates and priority of possible development options.

Action – Results of this relatively recent report are comprehensively presented and adequate.

2.12 Batemans Bay Wharf Road Development - Soft Option Coastal Engineering Assessment – WMA, 2005

This report describes a sand transport model and the historical foreshore alignment evolution between 1898 and 1999. The high water mark adopted by Council was chosen from the 1964 most eroded shoreline (100% historical data line). It was assumed that buildings are unlikely to be flooded landward of it. Possible mitigation options were provided as well as wave assessment of erosion, coastal inundation (including setup levels and wave run-up) and sea level rise. Sea level rise value of 0.20m by 2050 and 0.50m by 2100 were selected which should be updated to the benchmarks from the NSW Sea Level Rise Policy (2009) being 0.40m by 2050 and 0.90m by 2100. It was found that run-up could approach 5m AHD. In addition, advice on the construction of three buildings on the low-lying beach area of Wharf Road was given.

Action – This relatively recent report is adequate but should be updated to reflect the new sea level rise values.

2.13 Addendum to Batemans Bay Wharf Road Development Soft Option - Coastal Engineering Assessment – WMA, 2005

This report consists of a review of the previous report *Batemans Bay Wharf Road Development - Soft Option Coastal Engineering Assessment (WMA, 2005a)* using a new 100% historical data line more landward than the previous one.

Action – Report complements and updates previous report.

2.14 Reedy Creek, Malua Bay Floodplain Risk Management Study And Plan – Peter Spurway And Associates, 2005

This flood study focuses on houses directly adjacent to and upstream of George Bass Drive along Reedy Creek. A Floodplain risk management study and plan were undertaken

and flood mitigation options were provided with cost estimates and efficiency ratings. An inundation map was created showing that most developments located within the triangle formed by George Bass Drive, Sylvan Street and Reedy Creek are lying on flood prone land. Calculations were carried out for a 1:5, 1:20, 1:50 and 1:100 rainfall events and assuming a 0.94m AHD high tide level.

Action – This relatively recent report is comprehensively presented with inundation mapping.

2.15 Wagonga Inlet Flooding Investigation – Gary Blumberg and Associates/Patterson Britton and Partners, 2005

This report studies the inundation of Wagonga Inlet in Narooma. Bed sediments and salinity data were available within the entrance channel. History of the construction of the breakwater and training wall along the channel was provided. Design flood levels for a 1 in 20, 1 in 50 and 1 in 100 year ARI flood events were identified for the entrance, Narooma Public wharf, the Inlet Basin and Narooma Flat. The estuary was identified as being significantly impacted by oceanic influence in its flood behaviour. The 100 year ARI design flood levels were estimated to be 1.9m AHD at Wagonga Inlet entrance and Narooma Public Wharf and 2.2m AHD in the Inlet Basin, at McMillan/Brice Street Depression and the Oval.

Results are limited by limited available flood and tidal gauging data for Wagonga Inlet and the adjacent areas of Narooma Flat. The study highlighted a need for further peak water level gradients and channel scour data as well as flood records and topographic information.

Action – Additional flood, peak water level gradients, channel scour, topographic and tidal gauging measurement to be undertaken for Wagonga Inlet and Narooma Flat.

2.16 Flood Risk Assessment – URS, 2006

This report documents a flood analysis for the entire Council area of Eurobodalla Shire. It lists the floodprone areas within the Council boundaries. It reviews the past flood studies. Sea level rise recession of the sandy beaches was found to be ranging between 4.5 and 88 m by 2100. The impact of climate change on sea level rise, wind and rainfall was described. Floodplain risk management options were prioritised and preliminary cost estimates were provided. The report also provides a proposed program of flood studies, risk management studies and risk management plans over the eight years following the report.

Action – Report is recent and gives limited details but flood action plan is adequate.

2.17 Batemans Bay Coastline Hazard Management Plan – Webb, McKeown & Associates, 2006

This report documents management options for the whole Batemans Bay coastline from Maloneys Beach in the north to Casey Beach in the south. The conclusions were that the main issues are:

- coastal inundation in the inner bay (Batemans Bay CBD and Wharf Road);
- coastal inundation, beach recession and erosion at Surfside, Cullendulla and Long Beach;
- storm bite at Maloneys Beach; and
- wave overtopping inundation along the southern zone (i.e. Hanging Rock to Casey Beach) with additional erosion and recession issues at Corrigans Beach due to climate change.

Runup levels, erosion rates, beach recession rates, inundation level, wave setup, wave height and dune height were provided for the different beaches as shown in Table 2.2.

Detailed management options with cost estimates and impacts on various criteria (land ownership, aesthetics, ecology, recreational amenity, social issues, economic issues and climate change) were studied as well as the present value of likely future damage over the next 50 years.

A preferred option was selected for each beach.

This report is well detailed and precise. However, it has been realised using previous sea level rise benchmarks and should be updated using the new sea level rise value from the NSW Sea Level Rise Policy (2009).

The beach erosion rates quoted in this report are probably too low given the existence of refracted swell waves impacting the beach. These refracted swell waves are contributing to the erosion of Cullendulla Beach by generating an eastward longshore drift all along the beach, transporting the sand in front of the entrance of Cullendulla Creek where the sand moves offshore at the edge of the shallows visible on the aerial photographs. The 50 year beach recession rates are also relatively low except at Cullendulla where the rate is significant. However, the inundation levels appear to be reasonable.

Action – Report is recent. Inundation levels appear adequate but erosion rates should be confirmed as most values are relatively low.

2.18 Wharf Road Coastal Hazard Assessment And Hazard Management Plan – BMT WBM, 2009

This report provides an oceanic inundation level at Wharf Road. The risk of overtopping was detailed and the sedimentation processes assessed. It was found that 80% of the sand supplied from the river to the bay was accreting on Corrigans Beach at the expense of the beaches along the northern side. The historic shoreline behaviour analysis at Wharf Road was analysed and the estuarine processes within Batemans Bay were described. Percentage exceedance lines for the historical shoreline alignment were identified and storm tide levels including sea level rise were calculated. It was found that the Wharf Road East precinct will be impacted by non-storm tidal inundation by 2100. Short, medium and long term erosion was assessed. A recession of around 18m is expected with a sea level rise of 0.91m by 2100. The existing seawall at the corner of Wharf Road was found to be at high risk of failure due to erosion, overtopping and undersize armour. Some sewer and water supply pipes might also be at possible risk.

Coastal values and significance of the Clyde River estuary and Batemans Bay were described. Management options were assessed and ranked. Voluntary resumption was selected as the preferred option.

Action – Report is recent and comprehensively presented; its results appear to be adequate.

Table 2.2 – Summary of 1% AEP Coastal Hazard for Batemans Bay (WMA, 2006)

Area	Average Dune/Wall Height (mAHD)	Assessed 1% AEP Foreshore Setup (mAHD)	Theoretical Nearshore Wave Height (m)	Theoretical Wave Runup (m)	Estimated Overtopping Rate (m^3/s)	Adopted Beach Erosion Rate ($m^3/m/event$)	Adopted Beach Recession Rate (m/50 years)	Adopted Foreshore Inundation Level (mAHD)	Adopted Backshore Inundation Level (mAHD)
CBD	1.7 to 2.2	2.0	1.0	1.1	360	-	-	2.4	2.2
Beach Road (BH West)	1.8 to 2.2	2.0	1.5	1.6	450	-	-	2.4	2.2
Wharf Road West	1.5 to 2.0	1.8	1.4	1.4	160	-	-	2.4	2.0
East	1.5	1.8	1.4	1.8	160			2.5	2.0
Surfside Beach West	2.5	2.8	1.5	1.4	100	25	5	<3.8	2.3
East	3.0	2.8	1.5	1.0	-	40	5	<3.8	2.3
Cullendulla Beach West	1.5 to 2.0	2.0	1.5	0.8	250	20	70	>2.2	2.2
Middle	1.5 to 2.0	2.0	-	-	-	8	28	>2.2	2.2
Creek	-	2.0	-	-	-	-	90	-	2.2
Long Beach West	5.0	2.7	1.5	2.0	zero	20	8	-	-
Middle	5.0	2.7	1.5	1.5	5	35	8	-	3.5
East	3.0 to 3.5	2.7	1.5	1.2	15	10	8	>2.7	3.5
Maloneys Beach Middle	6.0	2.9	1.6	2.1	-	9	12	<3.6	3.5
Hanging Rock (BH East)	1.8 to 2.2	2.0	1.4	2.1	810	-	-	2.5	2.0
Corrigans Beach North	3.5	2.5	1.5	0.9	zero	-	6	-	-
South	2.5	2.5	1.5	0.9 to 4.0	400	40	6	2.6	2.5
Caseys Beach North	4.0	2.6	2.5	4.6	-	-	-	<5.0	>2.5
South	3.0	2.6	2.5	4.6	140	-	-	<5.0	>2.5

3 SITE OBSERVATIONS

3.1 Introduction

In addition to the assessment of coastal hazards by analysis of the available data and previous reports, site observations were made about the different beaches and characteristic places along Eurobodalla Shire Coastline. A site visit was conducted by SMEC's project team between 15 and 18 March 2010. Notes from that site visit are provided below.

3.2 South Durras

3.2.1 Durras Lake Entrance and Caravan Park (Northern Beach)

The dune of South Durras Beach near the lake entrance is healthy with a full dune and foredune and a good succession of vegetation (Figure 3.1). The access road is located behind the dune and is not at immediate risk. The beach is fully exposed to an open ocean wave climate. Offshore reef and Wasp Island provide some sheltering. There is no development present on the dune. Some evidence of an old scarp is noticeable within the dune area. The beach is composed of fine grained sand and has a relatively flat gradient. The beach accessways are uncontrolled and fencing should be considered to prevent damage to the dune from foot traffic. The southern end of the beach is very narrow and a creek outlet creates a gully. However nothing is at risk except a boat ramp covered with sand (Figure 3.2). There is some evidence of tyre tracks and the sandy part of the beach is used as a turning area. The flooding of the creek due to elevated tailwater level may impact a couple of low-lying houses.

The caravan park is located behind the dune and is at least three metres above the lake level. The flooding risk is therefore very low. Saltmarshes were observed between the low-lying houses located along Lakeside Drive and the lake entrance channel (Figure 3.3). This shows that this area is flooded regularly and the low-lying dwellings might become at risk from inundation in the future due to sea level rise.

3.2.2 Murramarang Resort (Southern Beach)

Some stormwater erosion was noticeable at the southern end of the beach north of the resort (Figure 3.4). The small ICOLL located behind this beach is currently closed and does not appear to generate a major immediate hazard but may generate some flooding issues for a couple of lots (but no dwellings) in case of breakthrough. In the long term, the hazards may be more significant due to an increased risk of breakthrough of the beach berm and an elevated tailwater level.

Some cabins of the resort are close to the edge of the beach and there is some evidence of minor erosion along beach (Figure 3.5). Another gully is visible at the southern end of the beach. There are only a few facilities for day visitors outside the caravan park. The beach is well-protected by reefs and Wasp Island and appears to be underlain by bedrock.

3.3 Maloneys Beach

The dune has been mown over and some trees appear to be poisoned and cut (Figure 3.6). The dune seems artificial given the very steep dune face. The wave climate is low and the beach well-protected. The reef at the eastern end is very exposed at low tide. Some housing and Northcove Beach Road/Maloneys Drive are located behind the dune. A toilet block and a small car park are located further back from the beach. It is

suggested that the dune be replanted, fenced off and some formal access should be provided.

There generally is a low immediate risk for the properties at Maloneys Beach. However, the road and around five dwellings located around 30-40m away from the dune might be subject to future risk at the western end of the beach as a consequence of beach recession due to sea level rise (Figure 3.7). The loss of the road may cut the access to the town. This part of the beach is a little more exposed to waves than the eastern half but a reef protects the bay from the largest swell.

There is a small creek entrance at the western end of the beach that may generate flooding issues for one house located along the creek near the entrance. Some houses may be subject to geotechnical (slope stability) hazard along the headland west of the beach as the rock is very erodible (soft siltstone).

3.4 Long Beach

The dune is very low at the eastern end of the beach with the road and housing behind it (Figure 3.8). The beach is very narrow at high tide. The embankment on the eastern side is very steep and some erosion is undercutting the slope (Figure 3.9). There is a stormwater outlet at the end of Fauna Avenue with buried rock seawall along either end but the full extent of the seawall – possibly all along Fauna Avenue – is unknown (Figure 3.10). An erosion scarp was observed at the western end of Bay Road.

The dune increases in height at the western end as does the wave climate (perhaps 50% of the full ocean wave energy). The new estate located behind the main dune heavily invaded by lawn grass is not at immediate risk (Figure 3.11). Rabbits were observed during the site visit which may be damaging the dune vegetation.

Between Long Beach and Maloneys Beach, the rock is composed of soft siltstone and several houses are located directly on the edge of the cliff (Figure 3.12). The wave climate there is low. Some malodorous sludge was seen to be leaking through the groundwater onto a small beach below the cliff (Figure 3.13).

Breaching of the lagoon located behind the centre section of the beach does not appear to be an immediate issue or an issue by 2100.

3.5 Cullendulla Beach

Cullendulla Beach is actively eroding with some trees falling due to undercutting by waves (Figure 3.14). However, there is no development behind this beach and no infrastructure is at risk. A future development is at the planning stage between Cullendulla and Surfside Beach.

3.6 Surfside

3.6.1 Eastern End (Surfside Beach)

Houses at the eastern end of the beach are low-lying and very close to the dune and a scarp is visible on the dune (Figure 3.15). The beach is exposed to some swell energy and a storm water pipe has already been lost (Figure 3.16).

3.6.2 Western End (McLeod Street and Timbara Crescent)

Wave energy at this location is relatively high. Most houses at the western end of Surfside are low-lying (Figure 3.17). An active erosion scarp of 50-60cm is visible in front of some beach houses of Timbara Crescent and along McLeod Street. The latter is very close to

the beach. Both houses and road are at threat of inundation and erosion. The pipes under McLeod Street bridge are covered with sand (Figure 3.18). The creek on the landward side of the bridge appears to suffer from poor water quality.

3.7 North Batemans Bay (Wharf Road)

The beach is actively eroding with a visible scarp and exposed vegetation (Figure 3.19). There is a seawall protecting the road and Easts Riverside Holiday Park (Figure 3.20) and a small groyne has been illegally built at the eastern end. Some properties are very low lying. Wave exposure through Batemans Bay is high and there is a direct impact of offshore swell, particularly at high tide.

3.8 Batemans Bay CBD and Boat Harbour

The seawall all along the harbour (from Batemans Bay CBD to Hanging Rock) is in fairly good condition (Figure 3.21). CBD shops located along the water have elevated floor levels. Houses inside the marina near Hanging Rock are very low and protected by different types of seawalls in varying condition. Some housing has no protection (Figure 3.22). A lot of sand is present within the marina. Hanging Rock boat ramp is in good condition (Figure 3.23). The area is protected from waves with waves breaking on offshore shoals (Figure 3.24).

3.9 Corrigans Beach

The northern end is more exposed to wave climate than the southern end which is protected by reefs. The dune is steeper and in poor condition at the northern end. There are many weeds and no formal access (Figure 3.25). However, there is a significant buffer to development. Joes Creek coming out within the northern half of the beach is relatively high and may create inundation issues in the future.

At the southern end, it was observed that only around 20% of the swell wave energy is reaching the beach. The creek leading to the beach is polluted with an incised morphology (Figure 3.26). A Gross Pollutant Trap within the creek (GPT) is blocked by sediments and rubbish (Figure 3.27). The caravan park is very close to both the beach and the creek. Hence it may be at risk from inundation. The beach has a flat gradient. However there would be enough buffer to build a new vegetated dune to protect the caravan park currently at immediate inundation risk.

Around 3-4 houses are on a bluff facing Corrigans Beach which is possibly unstable (Figure 3.28).

3.10 Casey Beach

There is an unstable cliff at the lookout facing Casey Beach with some trees close to fallling (Figure 3.29 and 3.30). There could be possible housing at risk from slope stability hazards at the top of the headland. The northern half of Casey Beach is influenced by strong wave climate while the southern end is more protected by Tollgate Islands and offshore reefs – around 30% of ocean wave climate.

The beach is protected by a seawall which appeas to not be underlain by geotextile. This seawall protects the road and housing located along the beach. The northern end of the seawall is very steep and both the northern and southern ends are subject to erosion at the top of the seawall (Figure 3.31). The seawall has already been severely damaged during storm events and fixed in the past. The beach has been lost at high tide in front of the seawall.

The bridge over Short Beach Creek is protected by rocks around its abutments (Figure 3.32). This rock protection is in fair condition. The access onto the beach is limited over the seawall. Some trees are undermined where there is a gap in seawall protection directly south of Short Beach Creek mouth, probably due to edge effects of the seawall (Figure 3.33). The sewage pumping station is at risk of damage due to wave attack.

At the southern end of the beach, several houses are at the top of the obviously eroding bluff with large areas of erosion at the base of the cliff (Figure 3.34).

3.11 Sunshine Bay

There is a low wave climate due to the presence of extensive rock reef all along the bay. Housing is on the edge of the bluff at the northern end of the beach. There is no natural dune and some noticeable erosion was observed along the beachfront and the car park (Figure 3.35). Beach sand is coarse with grain size larger than 1mm. The dune has a very steep gradient and is backed by housing close to the beach but these buildings seem founded on hard clay (Figure 3.36). A low-lying timber shack protected by a poor quality timber wall is located at the southern end of the beach and is at immediate risk (Figure 3.37).

3.12 Denhams Beach

Around 40% of the open wave climate reaches the beach due to the presence of offshore reefs and islands. The only potential issue is housing on the southern headland being at long term risk of bluff erosion (Figure 3.38). There is no natural dune and nothing is at risk on the beach.

3.13 Surf Beach

3.13.1 Surf Beach

This pocket beach is subject to moderate wave climate (around 50% of open wave climate). There is some housing on eroding bluffs on both ends. Housing at the top of the bluff is at a certain distance from the edge and might only be subject to long term risk due to bluff erosion. The dune is in good condition, fenced and has formal accessways (Figure 3.39). Two buildings (possible pumping station and toilet amenities) on the beachfront at the northern end of the beach would be at possible long term risk. There is a small creek entrance at the southern end of the beach. Sewer lines are located very close to the beach and may eventually be at risk.

3.13.2 Wimbie Beach

This small pocket beach directly south of Surf Beach is well-protected (around 20% of open wave climate). One house near the creek entrance located behind the beach might be subject to future inundation issues. As along Surf Beach, some sewer lines are located very close to the beachfront and may be at risk.

3.14 Lilli Pilli

3.14.1 Circuit Beach (Northern Beach)

This pocket beach is subject to a low-moderate wave climate. The only developments are located a substantial distance from the shoreline. A small creek comes out within the bay and creates a gully. The road is close to the cliff edge but nothing is at immediate risk.

3.14.2 Lilli Pilli Beach (Southern Beach)

This small pocket beach is surrounded by bluffs and subject to low wave climate due to the presence of rock reefs. Some developments exist but are a long way back from the beach.

3.15 Malua Bay and McKenzie Beach

3.15.1 Mosquito Bay

This narrow bay is subject to slope stability issues with housing close to cliff edge on both sides. Some evidence of movement is already evident along Iluka Avenue (Figure 3.40). A boat ramp is present within the bay. A small creek comes out in the middle of the bay.

3.15.2 Garden Bay

Some housing is close to the edge along the southern side but is probably founded on rock. Some evidence of light erosion is noticeable along the beach (Figure 3.41). A small creek comes out in the middle of the small beach. Wave climate is low due to the orientation of the beach and the presence of numerous reefs.

3.15.3 Malua Beach

Houses and shops at the northern end of the beach seem high enough to be safe from immediate coastal hazards (Figure 3.42). The beach is subject to moderate wave climate (around 80% of open wave climate). Some houses at the southern end are close to the beach with one house in particular on the berm (Figure 3.43). The seaward houses might be at immediate risk while the ones further inland might be at future risk. Good grass area and amenities (toilets, BBQ and picnic areas) are provided at the back of the beach. There is no natural dune and the gradient is very low. The low dune could be built up to protect the surf club and houses at the back of the beach.

3.15.4 McKenzie Beach

No issues were observed as there is no development on the beach and the road is far back and high enough compared to the beach, not to be impacted by wave impact.

3.16 Rosedale

The beach is subject to moderate wave climate (around 60% of open wave climate). There is a lot of sand on the beach forming a large healthy dune. Some boatsheds are on the beach at the northern end of the beach and some low-lying log cabins are at the southern end (Figure 3.44 and 3.45). Some housing is located on bluffs on both sides of the beach but the risk is low.

3.17 Guerilla Bay and Burrewarra Point

Nothing is at coastal risk at Guerilla Bay and Burrewarra Point. Northern end of Guerilla Bay Beach is considered a National Heritage Area.

3.18 Tomakin and Barlings Beach

The existing caravan park located at the eastern end of the beach is located at a fair distance back from the beach.

A new estate is under construction landward of the beach. The dune along the beach is healthy but marked by a high scarp of around one metre observed at the top of the dune (Figure 3.46). The beach has a relatively open wave climate (around 80% of open wave climate) especially towards southerly waves.

Developers of the new estate are preparing a separate Coastal Hazard Study as part of the Part 3A Assessment for the site.

3.19 Mossy Point and Tomaga River entrance

There is a high risk of breakthrough of the dune into the estuary where the dune arm is very narrow (Figure 3.47). The risk will be exacerbated by sea level rise. The breakthrough of the Tomaga River could change the beach morphology and some housing could become at risk upstream of the new entrance formed midway along the beach. The wave climate at Tomakin Beach is relatively strong (around 60% of open wave climate) and a high scarp of a recent storm (possibly the 2007 storm) was observed along most of the beach and particularly near the Tomaga River entrance (Figure 3.48).

At Mossy Point, several houses, private jetties and boatsheds along Tomaga River near the river entrance are low-lying and could be subject to future flooding (Figure 3.49). This flooding risk might be increased in case of breakthrough of the river where the dune arm is very narrow.

3.20 Broulee and Broulee Island

3.20.1 Broulee Beach (North Broulee)

Some houses along Candlagan Creek are low-lying near the entrance and are close to the shoreline. Some more houses at the northern end are relatively low but seem to be founded on rock (Figure 3.50). Wave climate at Broulee is around 80% of an open wave climate. The dune is in good condition and there appears to be a good buffer between the beachfront and development. The road could be at risk after 100 years.

3.20.2 Broulee Island

The tombolo linking Broulee Island to the coast is relatively narrow and there is a risk of breakthrough across the spit which has occurred in the 1970s. Moreover, there is a 4-wheel drive informal access flattening the dune at the narrowest area (Figure 3.51). There is no development directly at risk but the breakthrough might change the dynamics and the morphology of the whole area and lead to loss of snorkelling areas. Therefore, it is advised to close the informal 4-wheel drive access, or to at least regulate it by installing a formal vehicular board and chain access.

3.20.3 Bengello (South Broulee)

Some developments are present at the northern end of the beach, the rest of the beach remaining mainly natural (Figure 3.52). Broulee SLSC is far back from the beach and the only infrastructure at risk is the road and carpark located along the base of the northern headland. The dune is in good condition and the beach is fully exposed to wave climate.

3.21 Moruya

3.21.1 Moruya Airport

The wide natural dune along Moruya Airport is in good condition (Figure 3.53). The northern end of the airport grounds might be at possible risk in the long-term given the

orientation of the runway. There is a camping area directly south of the airport. Moruya River entrance is formed of numerous extensive breakwaters.

3.21.2 Moruya River

George Bass Drive is very low with some low-lying houses along the river. Some saltmarshes and mangroves were observed in significant low-lying lands on both sides of the road. Both embankments of the river are mostly protected by seawalls but some erosion was visible at the time of the site visit along George Bass Drive at some locations with some trees falling into the river (Figure 3.54). There is some sand deposition in the middle of the river upstream of Princes Highway Bridge, exposed at low tide (Figure 3.55).

3.21.3 Moruya Heads

Moruya Heads Beach is fully exposed to wave climate. The wide dune there appears to be accreting and the SLSC and toilet blocks are far back. The beach is currently recovering from summer storms.

3.22 Congo

Some low-lying houses are located at the northern end of the town along Congo Creek. The dune at Congo Beach is in good condition and high so there would not be any erosion issues despite the open wave climate (Figure 3.56). Flooding of access into town can occur which could isolate the town in case of a significant storm. Moreover, access roads on both sides to the town are unsealed and the unsealed section of the northern access to the town is private.

3.23 Meringo

Developments at Meringo are located at the top of bluffs with a fair distance from the edge and there is therefore no coastal hazard in this area.

3.24 Tuross Head

The whole coastline along Tuross Head is subject to open wave climate and is formed of small pocket beaches.

3.24.1 Coila Lake

Some 3-4 low-lying houses are located along Coila Lake on Monash Avenue (part of the road west of the golf club). Some stormwater issues were observed next to Coila Lake entrance along Tuross Boulevard due to the February 2010 flood event (Figure 3.57). The lake entrance is natural and composed of a high sand berm and the lake opens at the southern end (Figure 3.58).

3.24.2 Tuross Beaches

Houses along Tuross Head coastline are relatively high and the coastline is composed of natural rocks. Several pocket beaches are present along Tuross Head. The beach located between Tarandore Point and Boogumgoridge Point is composed of a large dune with a remnant scarp of around one metre resulting from the 2007 storm event (Figure 3.59). No development is at risk in this area. Some erosion is visible in front of a carpark behind One Tree Beach south (Figure 3.60).