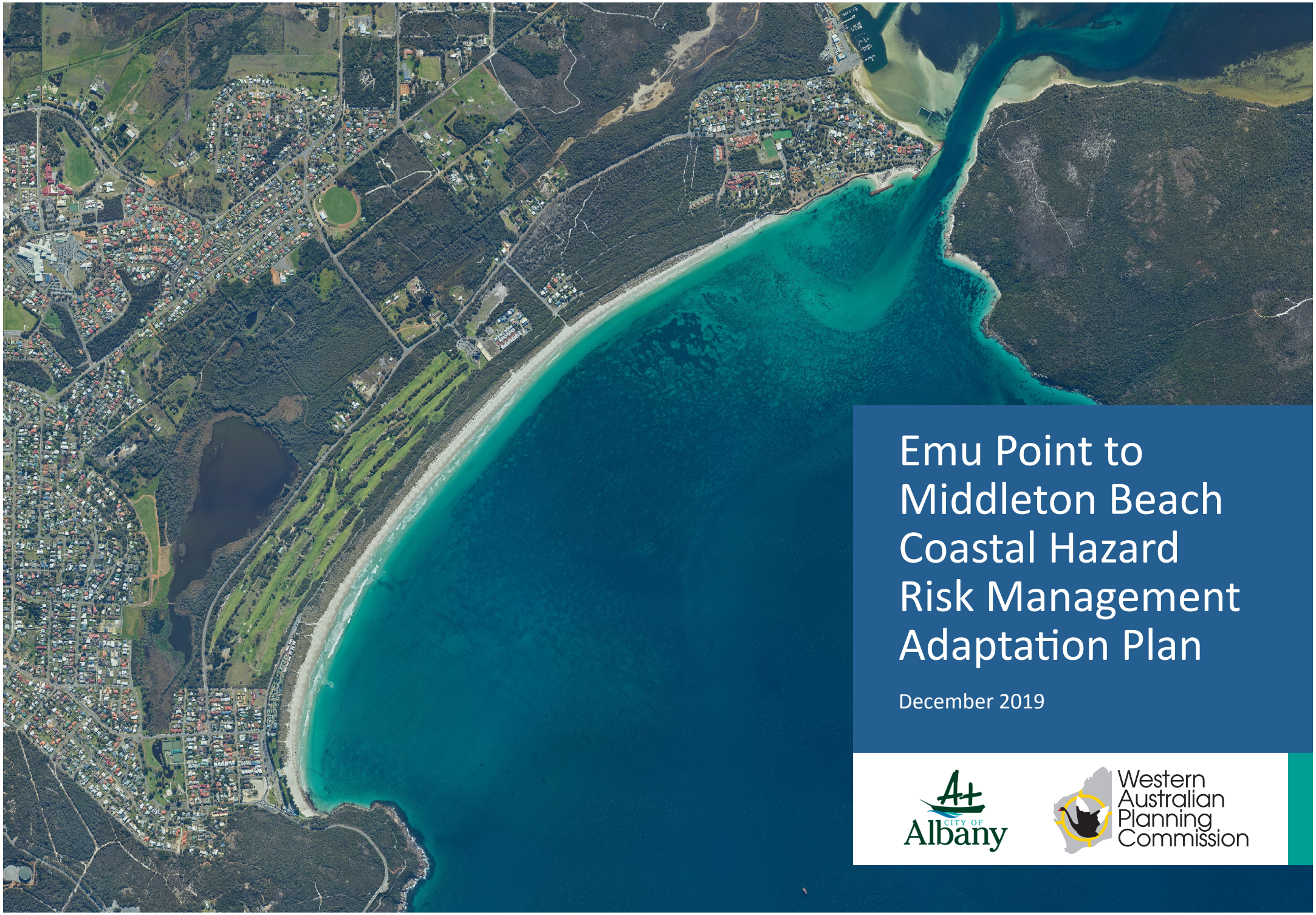

Emu Point to Middleton Beach Coastal Hazard Risk Management Adaptation Plan

December 2019

City of Albany

Western Australian Planning Commission

ACKNOWLEDGEMENT

The CHRMAP process acknowledges the traditional custodians of the study area, the Minang people of the Noongar Nation. We recognise their cultural heritage, beliefs and relationship to the land, which continues to be important to Noongar people today. The ancestors of the Noongar people saw the shorelines of Albany rise and fall and they were able to adapt to an ever-changing landscape. We acknowledge the input of Aboriginal community members into this plan and pay our respects to Elders past, present and future.

This project has been funded by the Western Australian Planning Commission/Department of Planning, Lands and Heritage - Coastal Management Plan Assistance Program 16/17 and the City of Albany.

Front Cover image: City of Albany

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Aurora Environmental has implemented a comprehensive range of quality control measures on all aspects of the company's operation. An internal quality review process has been applied to each project task undertaken by us. Each document is carefully reviewed and signed off by senior members of the consultancy team prior to issue to the client.

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Reviewed by: Melanie Price
Aurora Environmental

Date: 17 December 2019

Photo Source: City of Albany

Executive Summary

The City of Albany (The City) has undertaken development of a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) to provide strategic guidance on coordinated, integrated and sustainable planning and management for key coastal assets in the Emu Point to Middleton Beach area. The Emu Point to Middleton Beach area has been identified by the community as highly valued for economic, social and environmental reasons.

The study area has experienced historic storm erosion and is at risk of future erosion and inundation due to storm events and predicted sea level rise. The CHRMAP has been developed for the City based on the Western Australian Planning Commission (WAPC) CHRMAP guideline document (WAPC, 2014), which provides a risk management approach to dealing with forecast impacts from coastal hazards in the future. This approach will enable the community of Albany to proactively plan for change and manage impacts over the long-term.

Preparation of the CHRMAP has strongly focused on incorporating community and stakeholder values and input, while balancing the need for culturally and economically acceptable outcomes.

The report identifies the historical experience of coastal hazards along the coast between Middleton Beach and Emu Point and recognises that the City must act proactively to avoid ongoing risk to people and property. Technical studies have identified the potential extent of erosion and inundation for each of the timeframes 2017, 2030, 2050, 2070 and 2120. Using these studies and engagement with the community, this report highlights the assets at risk which include access to beach, coastal scenery and vistas, coastal vegetation and habitat, Ellen Cove Boardwalk and cafes. Stakeholders indicated that they were willing to pay for protection of significant coastal assets.

The report also highlights the existing controls available for the City in decision making, recognising gaps such as a lack of a suitable mechanism to warn private citizens of the existing risk to property.

Seven highly valued assets have been identified by this report as requiring adaptation in the short term (0-10 years), whilst the remaining assets within the 100 year hazard lines are likely to be at risk of erosion in long term (up to 100 years) and broader adaptation pathways are identified in this report to reduce the impacts of erosion.

The recommended adaptation options for the assets requiring short term management are as follows:

- MU1 Ellen Cove: Sand nourishment.
- MU2 Surfers and Golf Course: Avoid further development in existing developed areas impacted by coastal hazards.
- MU2 Big4 Middleton Beach: Staged relocation of assets.
- MU2 Big 4 Middleton Beach: Protect - seawall.
- MU3 Griffiths Street Properties: Managed retreat, relocate assets.
- MU3 Emu Beach Holiday Park and Dual Use Path: Managed retreat of assets in the southern portion.
- MU3 Emu Beach Holiday Park and Dual Use Path: Renovation/expansion of groynes (geotextile sand container).
- MU3 Emu Beach Holiday Park and Dual Use Path: Upgrade Existing Protection Structures.
- MU4 Emu Point: Maintain and enhance nearshore system – seagrass regeneration.
- MU4 Emu Point: Revetments and parkland development.
- MU5 Oyster Harbour - Southeast Beach: Sand nourishment.

Assessment of adaptation options was undertaken with broad stakeholder engagement, using tools such as multi-criteria analysis to illustrate the relative risks, capital and maintenance costs, environmental impacts, social and amenity impacts, reversibility and effectiveness.

A separate and standalone *Implementation Plan* also recommends key strategic planning, statutory planning, and policy or governance interventions that are relevant to all assets, including those at risk over the longer-term. The City of Albany will need to implement these options regardless of the final adaptation option chosen per at-risk asset.

The triggers for action and planning timelines provide guidance and also a degree of flexibility, as the approach to coastal erosion and inundation are likely to change over time.

The Implementation Plan should be read in conjunction with this CHRMAP, and is presented as a separate document to support ease of access.

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List of Abbreviations

3D	Three dimensional
AHD	Australian Height Datum
ALPS	Albany Local Planning Strategy
ARI	Annual Recurrence Interval
AS	Australian Standard
ASLSC	Albany Surf Life Saving Club
BCR	Benefit – Cost Ratio
CAP	Community Advisory Panel
CBA	Cost Benefit Analysis
CHRMAP	Coastal Hazard Risk Management and Adaptation Plan
CSES	Community and Stakeholder Engagement Strategy
DoT	Department of Transport
DLG	Department of Local Government

DPLH	Department of Planning, Lands and Heritage
FMP	Foreshore Management Plan
GSC	Geotextile sand container
LPS1	City of Albany Local Planning Scheme No. 1
MBAC	Middleton Beach Activity Centre
MCA	Multi Criteria Analysis
MU	Management Unit
MWL	Mean Water Level
PSWL	Peak Steady Water Level
SPP 2.6	State Planning Policy No. 2.6 State Coastal Planning Policy
WAPC	Western Australian Planning Commission

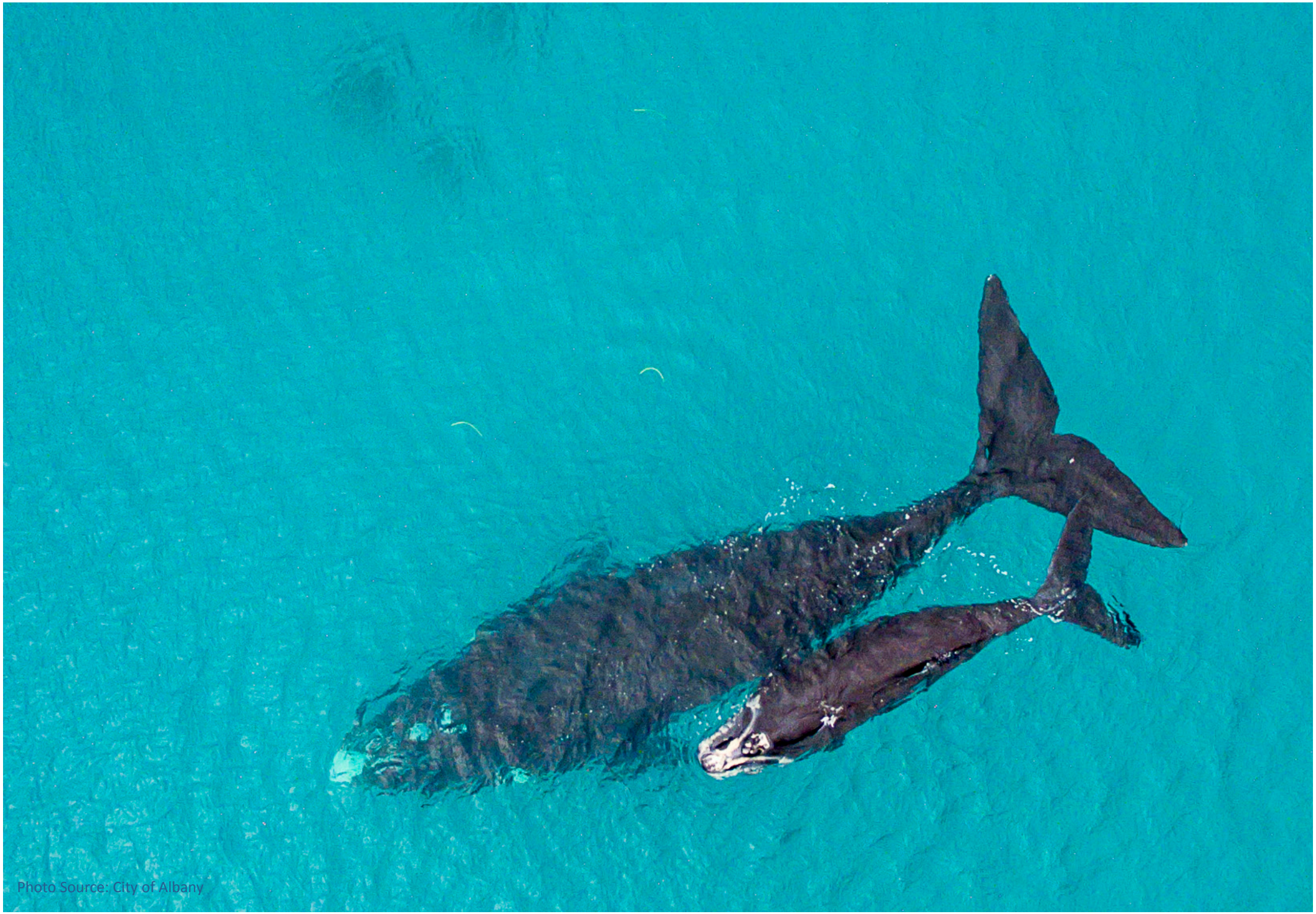


Photo Source: City of Albany

1. Context

1.1 INTRODUCTION

The Project Consultant Team (Aurora Environmental, Evo Coast, Shape Urban, Jeremy Benn Pacific (JBP) and Geoff Bastyan) was appointed by the City of Albany (the City) to prepare a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for the shoreline from Ellen Cove (Middleton Beach) to the Emu Point Boat Pens (Figure 1.1 and 1.2). The study area comprises some 36 assets identified as being at risk over the 100 year timeframe (see Figure 1.3).

The CHRMAP considers the impacts of the coastal hazards of erosion and ocean flooding (inundation) over the next 100 years, and is being prepared to provide strategic guidance on land use and development in the study area likely to be affected by coastal hazards (primarily erosion and inundation).

The plan will be a foundation for current and future risk management and adaptation. The beach, marine environment and vegetated coastal foreshore, as well as dedicated beach access points, foreshore parks and dual-use path, amongst other things, are a major focus for coastal recreation in the City as well as economically for tourism.

The study area has a long history of coastal erosion and management activities. Erosion events have been documented since the early 1900s. Severe storms in 1984 and 1987 caused significant erosion along the study area which is still evident in some sections today (changes in the foreshore vegetation). The storms also washed away large areas of seagrass around Lockyer Shoal, affecting the way sand moves through the shallow water in this area (see Figure 1.4 and 1.5).

Section 2 and Appendix A provide further detailed information relating to the physical coastal processes of the study area.

Figure 1.1 - Regional Location

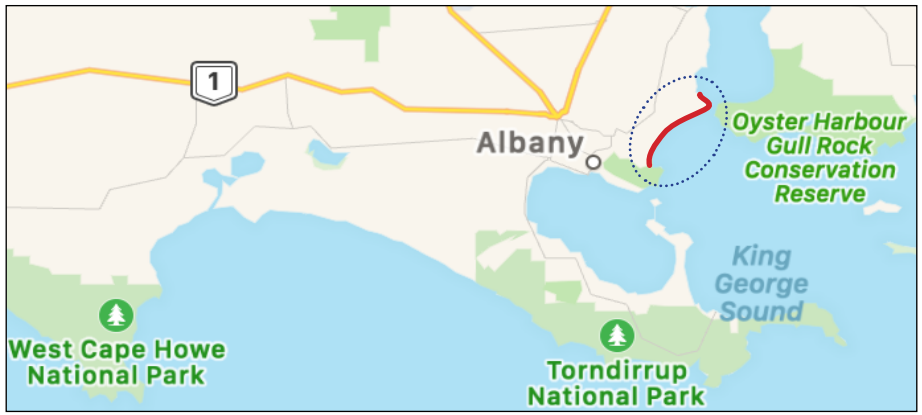
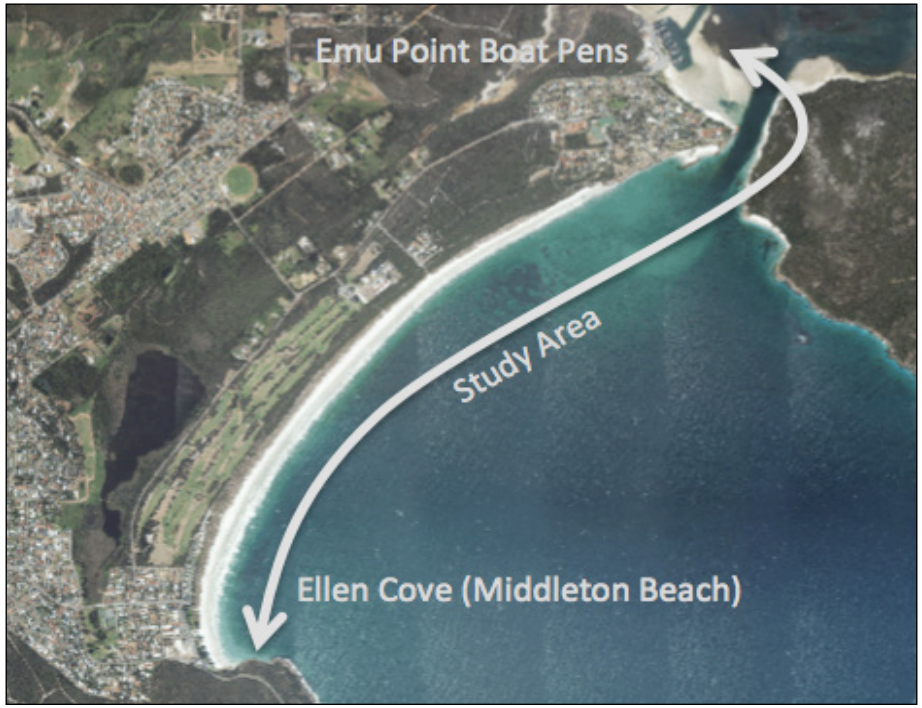
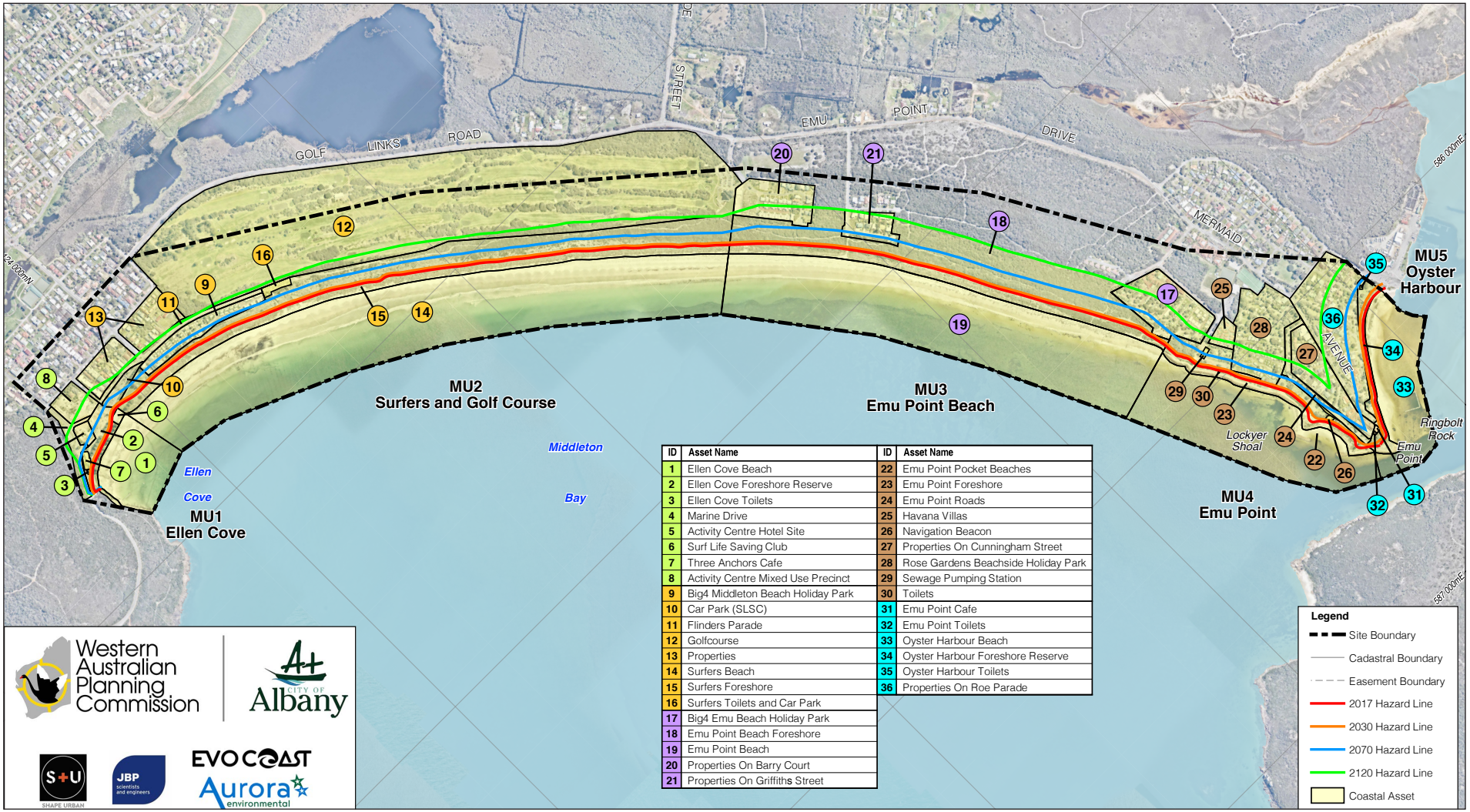


Figure 1.2 - Study Area



Source: Evo Coast

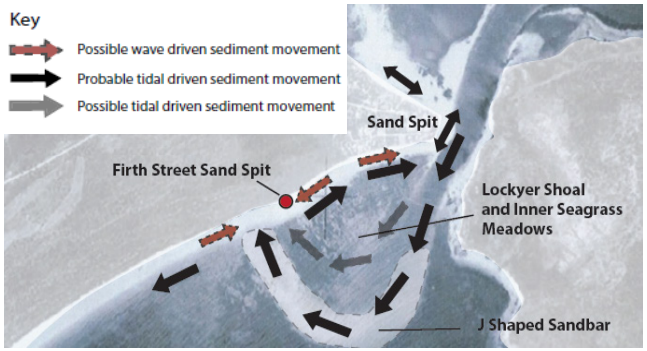
Figure 1.3 - Coastal Assets and Erosion Risk Map



ID	Asset Name
1	Ellen Cove Beach
2	Ellen Cove Foreshore Reserve
3	Ellen Cove Toilets
4	Marine Drive
5	Activity Centre Hotel Site
6	Surf Life Saving Club
7	Three Anchors Cafe
8	Activity Centre Mixed Use Precinct
9	Big4 Middleton Beach Holiday Park
10	Car Park (SLSC)
11	Flinders Parade
12	Golfcourse
13	Properties
14	Surfers Beach
15	Surfers Foreshore
16	Surfers Toilets and Car Park
17	Big4 Emu Beach Holiday Park
18	Emu Point Beach Foreshore
19	Emu Point Beach
20	Properties On Barry Court
21	Properties On Griffiths Street

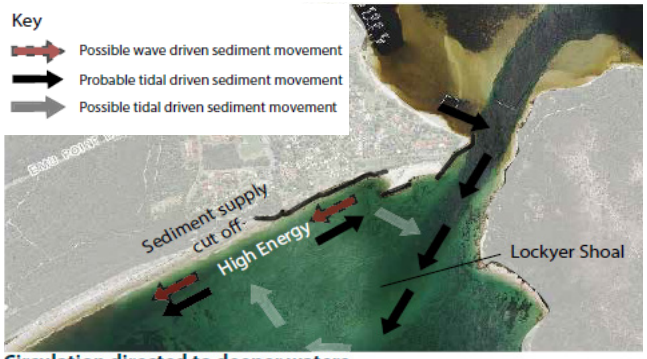
ID	Asset Name
22	Emu Point Pocket Beaches
23	Emu Point Foreshore
24	Emu Point Roads
25	Havana Villas
26	Navigation Beacon
27	Properties On Cunningham Street
28	Rose Gardens Beachside Holiday Park
29	Sewage Pumping Station
30	Toilets
31	Emu Point Cafe
32	Emu Point Toilets
33	Oyster Harbour Beach
34	Oyster Harbour Foreshore Reserve
35	Oyster Harbour Toilets
36	Properties On Roe Parade

Figure 1.4 - Indicative Diagram of Wave and Tide Driven Sand Transport around Lockyer Shoal up to the Early 1980s



Source: Royal Haskoning DHV, 2017

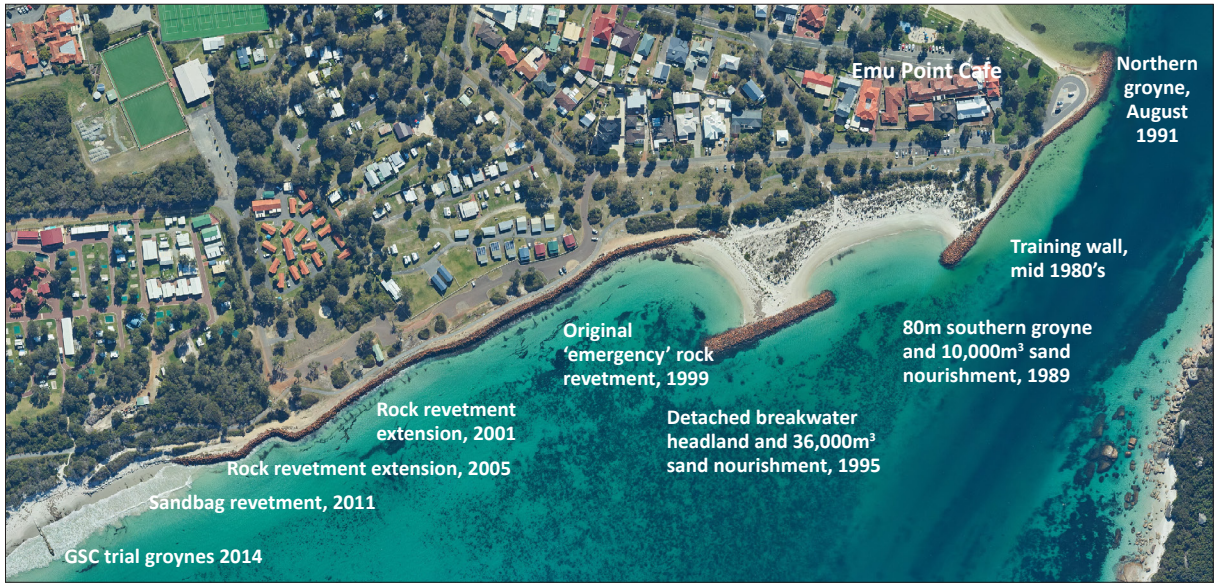
Figure 1.5 - Indicative Diagram of Post 1984 Wave and Tide Driven Sand Transport



Source: Royal Haskoning DHV, 2017

Emu Point has experienced the worst of the erosion problem in recent decades, which prompted the construction of various coastal management structures. In the 1980s a training wall was constructed to stabilise Emu Point and the boating channel into Oyster Harbour. The training wall was extended north and south by adding additional rock groynes. In the early 2000s the semi-attached breakwater/ headland and sections of rock and sandbag revetment to its west were constructed to manage the ongoing erosion problem (see Figure 1.6).

Figure 1.6 - Timeline of Coastal Protection Structures Built Around Emu point Between 1980 and 2014



Source: Adapted from Evo Coast

The coastal management approach taken by the City for the study area over recent years has primarily consisted of data collection and analysis to improve understanding of the local coastal processes; combined with temporary construction works (sandbag revetment and trial geotextile sand containers (GSC) groynes in 2011 and 2014) and maintenance as required. This approach has been effective in ensuring the condition of permanent structures does not rapidly deteriorate; and the vulnerability level of foreshore assets does not increase.

Various investigations and management option reports have been prepared for parts of the study area during the last 10 years. The CHRMAP will combine and update the available information to provide a dependable coastal management approach for the study area, focussing on the area's most at risk from coastal hazards.

1.2 AIMS AND OBJECTIVES

The primary aim of the CHRMAP is to provide a framework of options so that decisions are strategic, well informed and proactive rather than reactive. The CHRMAP provides a decision-making framework to allow the City and other key stakeholders to:

1. ensure land in the coastal zone is continuously provided for coastal foreshore management, public access, recreation and conservation;
2. ensure public safety and reduce risk associated with erosion and inundation;
3. avoid inappropriate land use and development of land at risk from coastal erosion and inundation;
4. ensure land use and development does not accelerate coastal erosion or inundation risks or have a detrimental impact on the functions of public reserves.

The specific objectives of the CHRMAP are to:

- improve the understanding of coastal features, processes and erosion hazards in the study area;
- gain an understanding of the vulnerability of the coastal zone;
- identify significant vulnerability trigger points and respective timeframes for each sector to mark the need for short and long-term risk management and adaptation action;
- identify assets (natural and man-made) and the services and functions they provide in the coastal zone;
- identify the value of the assets that are vulnerable to adverse impacts from coastal hazards;
- determine the likelihood and consequence of the adverse impacts of coastal hazards on the assets and assign a level of risk, identify possible (effective) management and adaptation measures (or 'actions') and how these can be incorporated into short and longer-term decision-making;
- engage stakeholders and the community in the planning and decision-making process; and
- ensure that stakeholders understand the implications of possible treatment options including trade-offs, costs and possible negative aspects.

1.3 METHODOLOGY & REPORT STRUCTURE

The CHRMAP assessment is presented based on the CHRMAP template, logically progressing from the context of the study area through to recommended adaptation options, as illustrated in Figure 1.7.

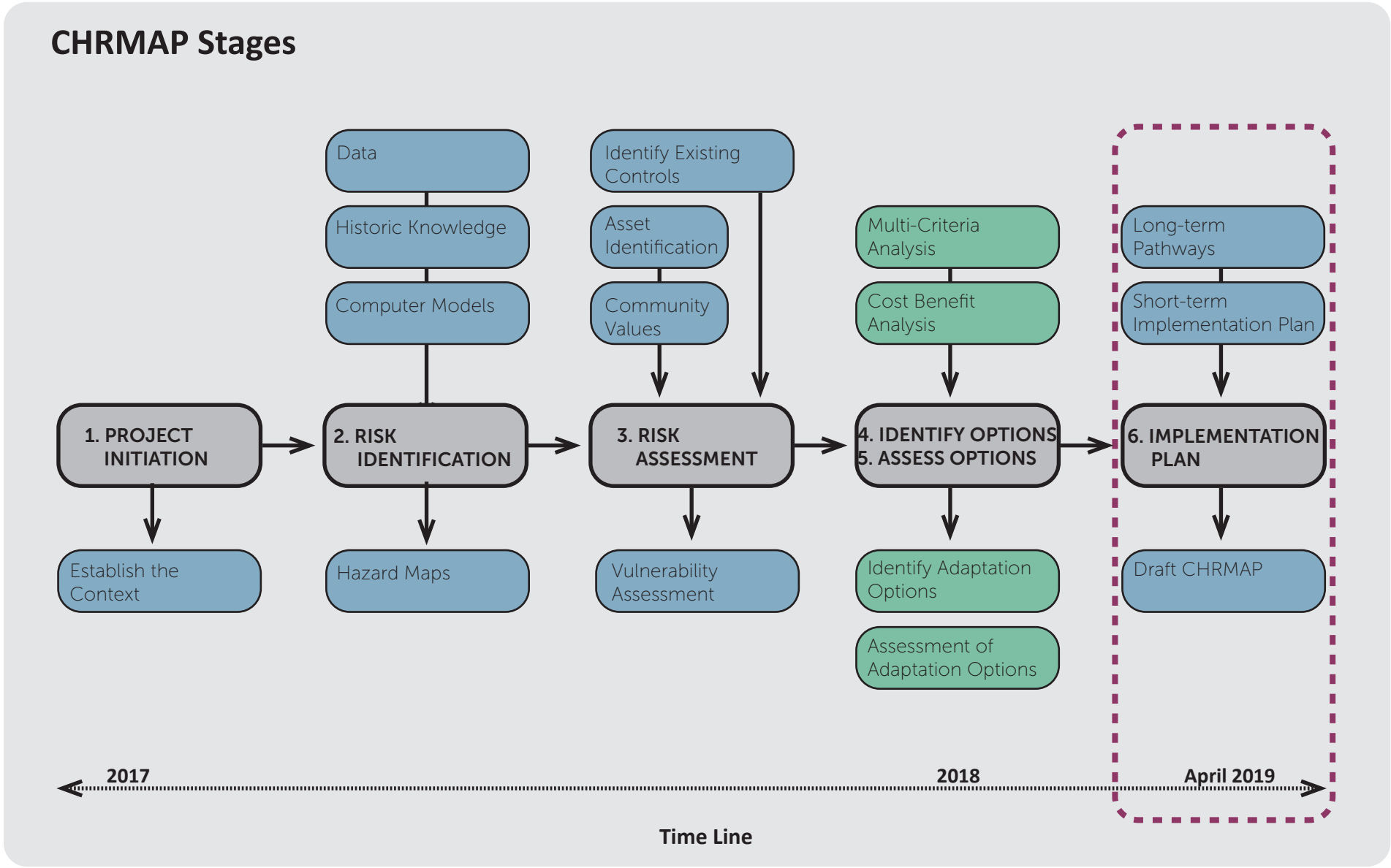


Figure 1.7 - CHRMAP Stages

The methodology to complete these stages is further decsribed as:

Project Initiation

1. Context - outlines the purpose, aims and objectives for management of these key coastal areas and identifies practical solutions compatible with Western Australian and City of Albany strategic planning. This stage also confirms the community and stakeholder consultation requirements, delivering the Stakeholder and Community Engagement Plan and commencing early engagement activities to establish community values. Section 1 of this report.

Risk Identification

2. Hazard Identification – the potential extent of erosion and inundation for this CHRMAP has been based on the hazard mapping undertaken by Royal Haskoning DHV (RHDHV, 2017) which was completed for each of the timeframes 2017, 2030, 2050, 2070 and 2120. This mapping was based on the methodology outlined in SPP2.6 State Coastal Planning Policy using key factors such as risk of storm erosion, historic shoreline movement trend, future sea level rise and risk of storm surge identify the extent of coastal erosion/ inundation within the coastal zone. Section 2 of this report.
3. Asset identification – a preliminary inventory of coastal assets was developed by EvoCoast (2017a) and was tested though stakeholder engagement to determine the five most valued assets which included access to beach, coastal scenery and vistas, coastal vegetation and habitat, Ellen Cove Boardwalk and cafes. Through this process stakeholders indicated that they were willing to pay for protection of significant coastal assets. Section 3 of this report.

Risk Assessment - Risk Analysis

4. Determine Likelihood – identifies each asset's exposure to coastal hazards and determines the likelihood of each asset being impacted by erosion/inundation for each timeframe of interest. Section 4 of this report.
5. Determine Consequence – identifies each asset's sensitivity to coastal hazards and determines the consequence of each asset being impacted by erosion/ inundation. This Stage includes consideration of assets and values from stakeholder engagement. Section 4 of this report.
6. Determine Level of Risk – characterises the potential impacts of coastal hazards to each asset by taking into consideration likelihood *and* consequence and allocating a risk rating. Section 4 of this report.

Risk Assessment - Vulnerability Analysis

7. Determine Adaptive Capacity – identifies the ability of assets to accommodate (cope with) potential coastal hazards with asset vulnerability factored in to indicate susceptibility to risk. Section 4 of this report.
8. Determine Level of Vulnerability – characterises the vulnerability of each asset by taking into consideration the potential impacts and the asset's adaptive capacity and allocating a vulnerability rating. Section 4 of this report.

Risk Assessment - Risk Evaluation

9. Identify Existing Controls – examines existing controls, including legislation and policy at the State, regional and local government levels provide tools to assist in planning and decision making. In addition, physical controls in each management unit provide a starting point for future decision making. Current physical controls already assist in mitigating some coastal hazards over a range of time frames. Section 5 of this report.

10. Determine Tolerable Risk – determines tolerable risk levels for each asset or asset group impacted by coastal hazards. Section 6 of this report.
11. Identify Assets Requiring Adaptation – identifies assets for which risk treatment is required to reduce risks to an acceptable level. Section 6 of this report.

Identify Options - Risk treatment

12. Identify Adaptation Options – identifies a short list of potential risk management and adaptation measures to reduce risks to an acceptable level using the hierarchy of avoid, managed retreat, accommodation and/ or protection for each management unit. Section 7 of this report.

Identify Options - Assess Options

13. Evaluate Adaptation Options – evaluates the suitability of risk management and adaptation options using multi-criteria analysis (MCA) and cost benefit analysis (CBA). Section 8 of this report.

Implementation Plan

14. Implementation Plan – details short term (0 – 10 years) implementation actions and long-term (up to 100 years) adaptation pathways required to reduce risks to an acceptable level. This stage also identifies action triggers and monitoring requirements in Section 9 of this report. A separate stand-alone Implementation Plan is available and provides an easy to read reference.

The CHRMAP builds on the previous studies commissioned by the City which include the 2017 Coastal Hazard and Vulnerability Study (undertaken in two parts) and the 2013 Community Values Assessment.

1.4 PLANNING FRAMEWORK

The CHRMAP process is a requirement of *State Planning Policy 2.6 State Coastal Planning Policy* (SPP 2.6) to support decision makers in addressing risks associated with coastal erosion and inundation. The CHRMAP is consistent with the requirements of SPP 2.6 and associated guidelines.

The CHRMAP also has regard for the relevant legislated planning requirements and strategic planning frameworks including:

- Planning and Development Act 2005
- Planning and Development (Local Planning Schemes) Regulations 2015
- State Planning Policy 3.4: Natural Hazards and Disasters
- Draft Planned or Managed Retreat Guidelines
- Lower Great Southern Strategy 2016
- City of Albany Local Planning Strategy (2010)
- City of Albany Local Planning Scheme (2014)
- Planning Bulletin 21 – Cash-in-lieu of Public Open Space
- Planning Bulletin 49: Caravan Parks
- Planning Bulletin 91: Restrictive Covenants

In terms of facilitating stakeholder outcomes, the CHRMAP aligns with the City of Albany Community Strategic Plan.

1.5 STUDY AREA & MANAGEMENT UNITS

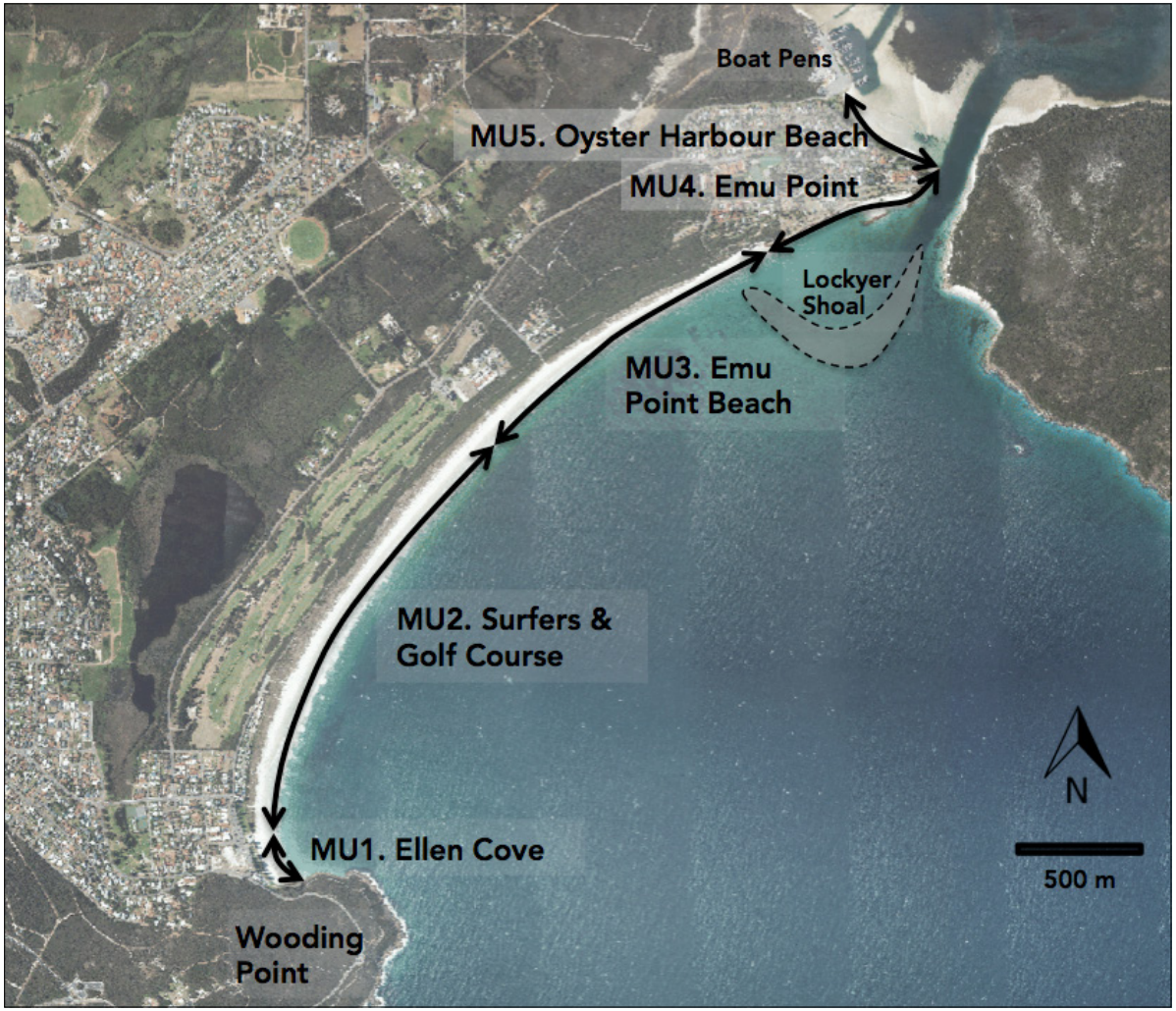
Based on the work undertaken by RHDHV (2017) the study area has been broken into five management units. The management units define sections of the coastline which share similar characteristics and provides a framework for monitoring and management.

The management units are illustrated in Figure 1.8 and listed with a description of their characteristics in Table 1. Typical photos of each unit are also provided in Figure 1.9.

The management units correspond to the sectors used by Royal Haskoning DHV (2017) to define the study area, with the following exceptions:

- For simplicity, MU3 and MU4 have been combined into a single management unit: MU3 Emu Point Beach.
- The boundary between MU2 and MU3 (Golf Course and Emu Point Beach) was moved slightly southwards, based on review of the coastal assets, to incorporate the properties on Barry Court and Griffiths Street within the same management unit.

Figure 1.8 - Management units



Source: Evo Coast

Table 1.1 - Management Unit Characteristics

Management Unit	Sector (Rdhv 2017)	Boundaries	Characteristics
MU1. ELLEN COVE	1	Wooding Point Headland to Ellen Cove – Albany Surf Life Saving Club (ASLSC)	Section of shoreline in the lee of Wooding headland. Shoreline is strongly controlled by the headland, resulting in a curving alignment and relative sheltering. The beach is relatively stable and artificially maintained to provide recreational amenity. The beach is backed by a grouted rock wall.
MU2. SURFERS & GOLF COURSE (Also known as Dog Beach)	2	Ellen Cove ASLSC to Northern boundary of the Golf Course	This section of shoreline has been accreting (growing) in recent years. This section of shoreline has the greatest exposure to storm events and it is susceptible to storm erosion. However it has the ability to rebuild and naturally repair. In the short-term it is expected to be stable with a large natural buffer to shoreward assets.
MU3. EMU POINT BEACH	3 & 4	Northern boundary of the Golf Course to start of Emu Point Revetment	This section of shoreline is strongly controlled by the feature of the Lockyer Shoal. It transitions from a stable accreting shoreline to the eroded area adjacent to the Emu Point revetment. It is possible that the erosion adjacent to the revetment is beginning to reach an equilibrium, with a reduction in recent years. This section of shoreline is relatively sheltered from normal storm events. However, it can be subject to significant erosion during less frequent storms with a more southerly aspect.
MU4. EMU POINT	EP	Emu Point Start of revetment to Northern Groyne	This section of shoreline is defined by the existing coastal protection structures (rock revetment, breakwater/headland, training wall and groyne). It extends through the mouth into Oyster Harbour. The shoreline is controlled by the structures and the risk to assets is dependent on the structures' integrity.
MU5. OYSTER HARBOUR BEACH	OH	Northern Groyne to Boat Pens	This section of the shoreline is sheltered from the ocean storms and is a low energy environment. The shoreline is controlled by locally generated waves. The presence of the swimming facility causes wave sheltering resulting in a bulge in the shoreline and adjacent erosion requiring periodic sand management to maintain a stable beach profile. The beach is backed by a grouted rock wall.

Figure 1.9 - Typical Photos of Management Units Photo Source: Evo Coast

MU1. Ellen Cove

MU2. Surfers & Golf Course

MU3. Emu Point Beach

MU4. Emu Point

MU5. Oyster Harbour

1.6 STAKEHOLDER ENGAGEMENT

Previous stakeholder engagement by Green Skills (2013) indicates that the community strongly values the social and recreational amenity of the study area, including retention of the character of the coastal zone between Emu Point and Middleton Beach as primarily residential, natural and recreational.

Evidence supports a strong appreciation for the facilities that provide family based, safe, clean and accessible recreation and offer a launch pad for activities (e.g. for children swimming). The naturalness of the environment with areas of native vegetation, large setback/ foreshore reserves, wide active beaches and shady quiet areas provide an important sense of place. The safety, cleanliness, ocean vistas and the beach are highly valued.

The current restaurants and cafés are valued as meeting places, focal points, with accessibility for all. In addition, the proximity to a range of amenities such as the Ellen Cove picnic area, Ellen Cove Boardwalk, Dual Use Paths, beaches and views are rated highly. Scenic, land-based recreation, social space, water-based recreation, sense of place and ecosystem are highly valued across the study area. The users of Surfers Beach in particular rated the scenic, land recreation, social space, ecosystem and sense of place very highly, reflecting the kinds of activities undertaken there and the familiarity with the location due to frequent use of the beach.

As part of this CHRMAP process, a Community and Stakeholder Engagement Strategy was prepared (Aurora Environmental et al. 2018) to:

- Identify stakeholders, including decision makers, ratepayers, community members, user groups, residents, educational institutions and businesses;
- Develop a framework for sharing information, engaging with a broad cross section of the community and measuring community and stakeholder values;
- Ensure that communicate is wholistic, comprehensive and inclusive.

Key outcomes sought from the stakeholder engagement process included:

1. Providing information to key stakeholders regarding the potential impacts of a changing coastal environment to allow for consideration of which built and natural assets are likely to be impacted by coastal processes as a result of changing sea level.
2. Identifying coastal hazard risks to properly plan for adaptive land uses and management along the Emu Point and Middleton Beach coast in response to a changing coastal environment.
3. Incorporating community feedback regarding the importance of coastal values to influence the recommendations of the CHRMAP.
4. Demonstrating consideration of social, economic and environmental issues along with costs and other trade-offs to treatment options.
5. Providing confidence to the community that the City of Albany and key decisionmakers are working collaboratively to identify adaptation options to address the vulnerability of the Emu Point to Middleton Beach coastline.
6. Transparently demonstrating how the CHRMAP complies with the State Governments State Coastal Planning Policy No 2.6, while taking into account local needs and desires.
7. In consultation with key stakeholders, developing adaptation plans, triggers and pathways to address identified vulnerabilities.
8. Demonstrating that the CHRMAP provides a clear and easily understood framework for the management of the future coastal environment for the Emu Point to Middleton Beach area.

9. Providing consistent and regular updates to inform the community, actively seeking feedback on likely impacts and concerns of affected community members or groups to ensure that the recommended adaptation outcomes were robust, fair and respectful of community values.

Primary, secondary and tertiary stakeholders are listed in Appendix B and the key activities associated with stakeholder and community engagement are summarised in Table 1.2. Results and outputs of the stakeholder engagement undertaken are discussed in key sections of the CHRMAP. The Stage 1 engagement is summarised in this section.

Stage 1 Community Engagement

Between 20 March and 15 June 2018 in Stage 1 of the stakeholder engagement program, a survey was publicly available to identify valued assets. 201 responses were received from respondents aged from under 18 to 71+ years).

Table 1.2 - Summary of Stakeholder Engagement Activities

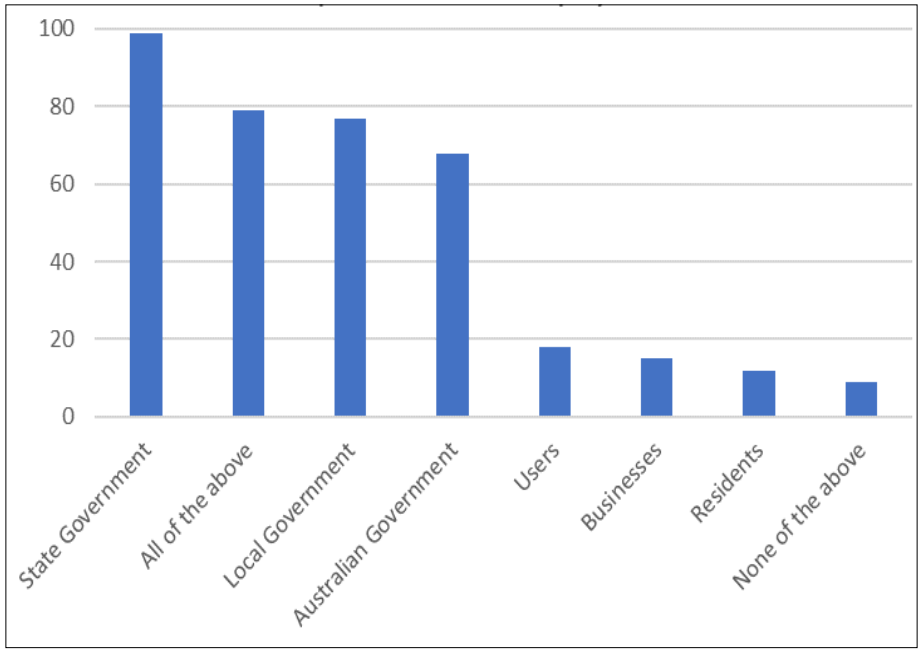
Information Sharing	Collecting Information	Bringing People Together
City of Albany website City of Albany Media Liaison Updates (emails) Letter of introduction to all identified stakeholders (email and post) in contact list, and direct contact. Email follow up (events and advertising) Newspaper articles (City of Albany spread) Supporting material: Infographics, PowerPoint, posters and maps showing risk areas, assets and treatments Display (drop in at events e.g. Vancouver Street Festival, on-site at Emu Point and Albany Show) Social Media (Facebook, Twitter, Instagram) Use Steering Committee members and organisations as a conduit for sharing information. Key stakeholder workshops including a Community Advisory Panel	Social Pinpoint (mapping and surveys) Paper Surveys Primary stakeholder interviews Community information sessions Workshops	Council Briefings Steering Committee Meetings City of Albany Project Control Team Meetings Focus Group Workshop Attendance at events (e.g. Vancouver Street Festival) Community information sessions Interviews, meetings and events with individuals and groups

In terms of setting the context for values relating to Emu Point and Middleton Beach, the community indicated the following:

- Loss or modification of a valued coastal assets would impact on the respondent's life. 161 of 201 respondents (80%) said they would be impacted, 25 (12%) said they would not be impacted and 15 people (8%) said they could easily access similar assets elsewhere.
- Respondents indicated that they would be willing to pay for protection of valued coastal assets (Figure 1.9). 143 (71.2%) of 201 responded that they would be willing to pay, 44 (21.9%) said they would not be willing to pay and 14 (6.9%) said they would access similar assets elsewhere.
- Regardless of whether people were from Albany and non-local respondents, they indicated that they were willing to pay for coastal management. There was no effect of age, gender, or postcode on willingness to pay responses.
- When asked who should pay for protection of valued assets (Figure 1.10) the following responses were given (total of 377 responses as people could choose more than one option):
    1. State Government via taxes and levies (99 people, 26%)
    2. All (including users, businesses, residents, local, State and Australian governments) should pay (79 people, 21%)
    3. Local Government (77 people, 20%)
    4. Australian Government (68 people, 18%)
    5. Users (18 people, 5%)
    6. Businesses (15 people, 4%)
    7. Residents (12 people, 3%)
    8. None of the above (including users, businesses, residents, local, State and Australian governments) should pay (9 people, 2%)
- There was no significant age effect on who respondents believe should pay. Gender had a significant effect on respondent's response to 'who pays' with females saying that everyone should pay (users, business, residents, local, State and Australian governments) and males saying that State Government (21.3%), Australian Government (18.3%) and local government (18.1%) should pay for management of coastal erosion.
- There was no significant difference between Albany and other locations in relation to 'who pays'.

Figure 1.10 - Survey Responses - Who should pay for Coastal Asset Protection?

Note: 201 respondents to survey, 377 responses to this question



In addition to the survey responses summarised above, school aged children were involved in a similar survey. This included a marine science class at Albany Senior High School (20 students) and a Year 3 class at Parklands Primary School (19 students).

The marine science class indicated that assets related to recreation, environment/habitat, scenery and tourism/ business related were valued (Figure 1.11).

The year 3 students indicated that assets relating to recreation, aesthetics, café (businesses), Albany Surf Life Saving Club, heritage, nature, scenery and socializing were important (Figure 1.12).

Figure 1.11 - Marine Science Class: Most Valued Assets

Note: Students were able to choose more than one valued asset.

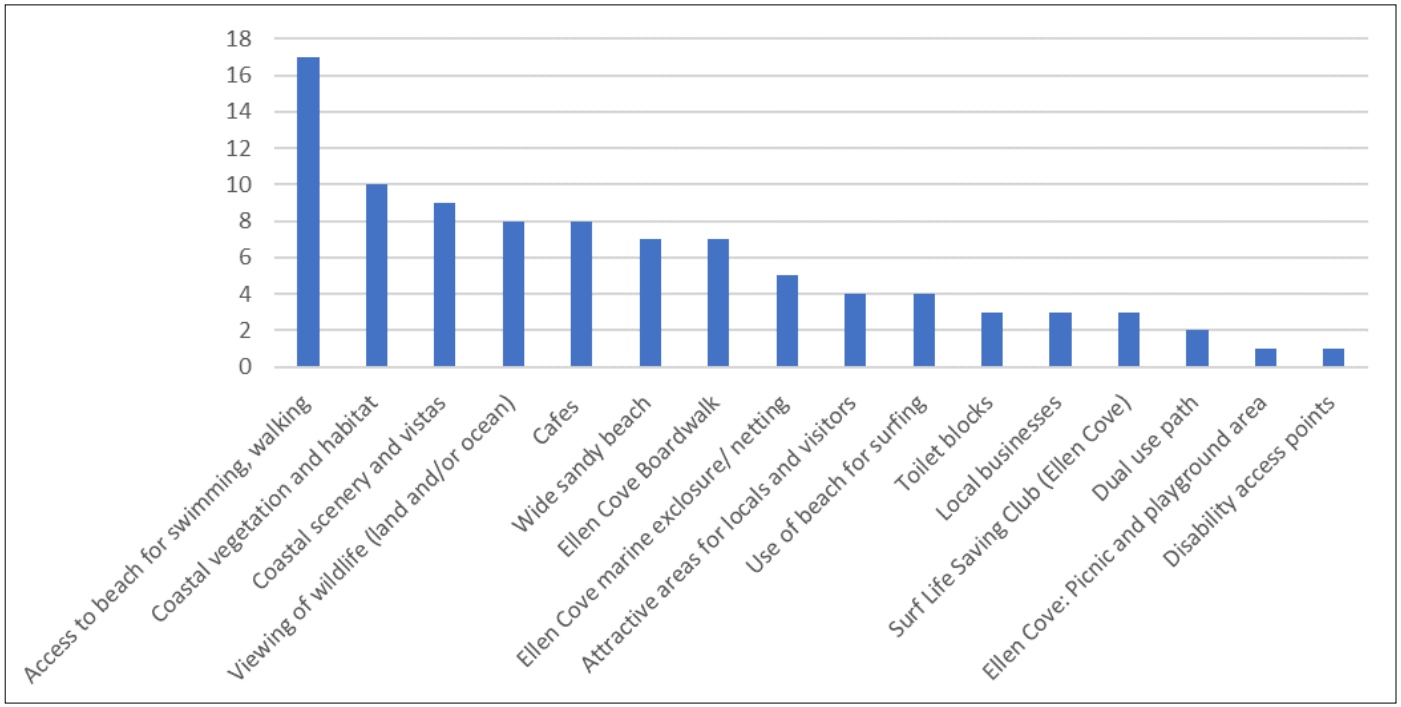


Figure 1.12 - Year 3 Class: Most Valued Assets

Note: Students were able to choose more than one valued asset.

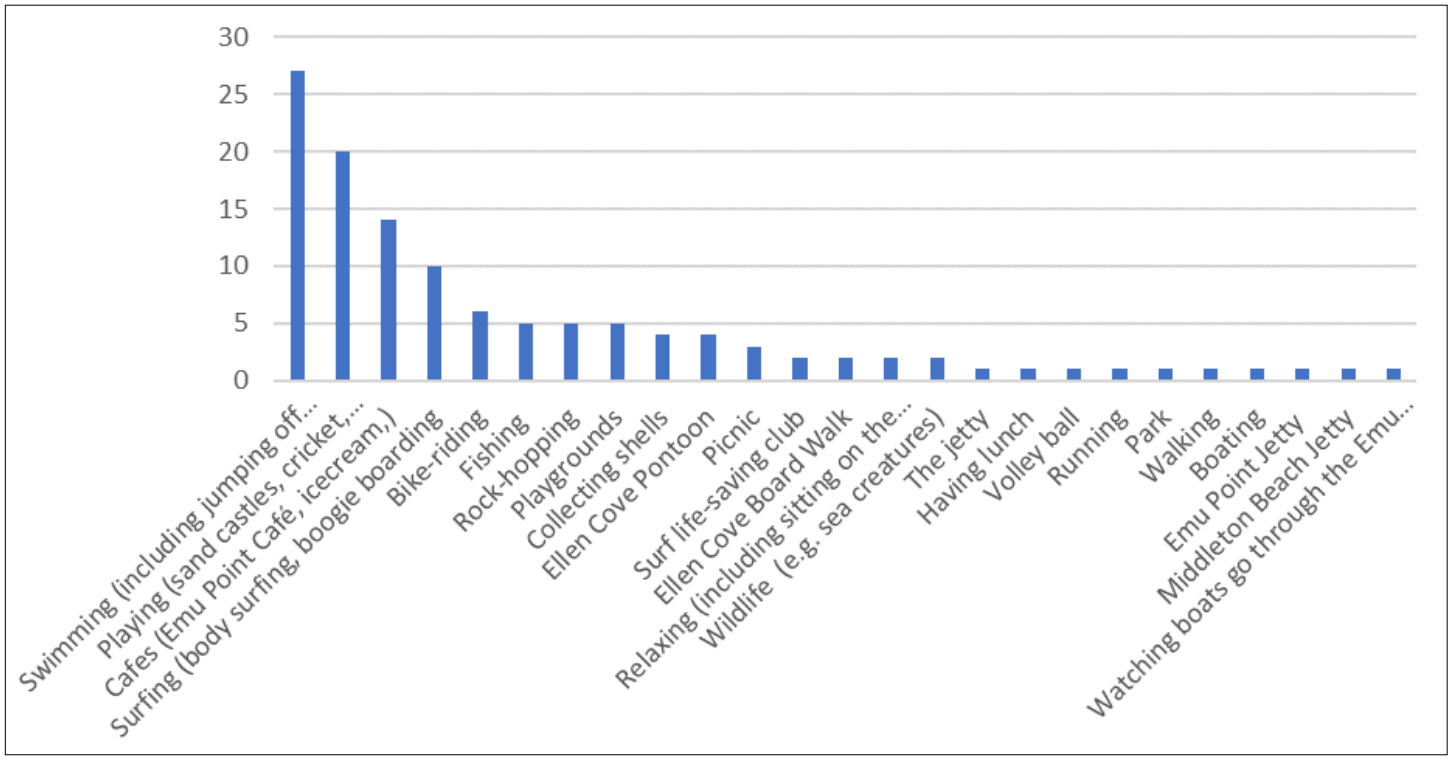



Photo Source: City of Albany

2. Hazard Identification

The potential extent of erosion and inundation for this CHRMAP has been based on the hazard mapping undertaken by RHDHV (2017) which was completed for each of the timeframes 2017, 2030, 2050, 2070 and 2120. To consider the differing potential impacts of erosion and inundation, assessment of the two hazards was undertaken independently. Linework has been simplified for erosion and inundation hazard areas and is included in Appendix C.

The methodology adopted by Royal Haskoning DHV follows the requirements of SPP 2.6, whereby the extent of erosion and inundation is determined by considering the sum of the following key factors:

EXTENT OF EROSION

The extent of erosion at each of the timeframes is estimated as the sum of the following factors:

- Current risk of storm erosion (referred to as S1) – this takes into account the rapid erosion, sometimes termed the 'storm-bite' which can occur during a significant storm event. In some instances, the shoreline may subsequently recover from this erosion. (Figure 2.1 illustrates the extent of erosion caused by the 1984 storm).
- Historic shoreline movement trend (referred to as S2) – this takes into account the long-term change in the shoreline based on review of aerial photography since the early 1950s.
- Future sea level rise (referred to as S3) – this takes into account the likely recession of the shoreline which will occur as sea level rises.

EXTENT OF INUNDATION

The extent of inundation at each of the timeframes is estimated as the sum of the following factors:

- Current risk of storm surge (referred to as S4) – this takes into account the temporary inundation which can occur during a significant storm event.
- Future sea level rise – this takes into account the increased inundation which is likely to occur as sea level rises.

Figure 2.1 - Severe Storm Erosion Emu Beach

August 1984 storm event caused approximately 40m of erosion (Photo credit: Briss family as reported in URS, 2012)

April 2017 similar location showing the reformation of the dunes (Photo source: Evo Coast)

2.1 EROSION DISTANCES & INUNDATION LEVELS

Tables 2.1 and 2.2 provide the summary of erosion distances and inundation levels estimated by RHDHV (2017), which form the basis of the hazard mapping provided in Appendix C. The hazard lines assume that there are no protective structures in place (e.g. the rock structures at Emu Point) and are indicative of potential erosion, not water levels or permanent shorelines.

The erosion distances have been applied from the present day active limit of the shoreline under storm activity (horizontal shoreline datum). This is typically the back of the beach, often the toe of dunes or the start of vegetation. For the purpose of this vulnerability assessment, the peak steady water level (PSWL) has been used to represent the maximum extent of inundation. PSWL is the highest average elevation of the sea surface caused by the combined effect of storm surge, tide and wave setup during a storm event.

In some instances, wave run-up and overtopping may result in inundation extending further inland. However, this is not anticipated to be sufficient to cause a significant change to the vulnerability of assets and is not anticipated to influence the subsequent evaluation of management measures and adaptation options.

In the next 50 years (to approximately 2070) the existing storm conditions and historic trends largely define the extent of erosion and inundation. However, in later timeframes the component of sea level rise becomes the dominant factor determining the extent of the hazards.

More detailed information regarding vulnerability can be found in Royal Haskoning DHV (2017) *Emu Point to Middleton Beach – Coastal Adaptation and Protection Strategy. Coastal Vulnerability Study and Hazard Mapping. Part 1: Coastal Processes and Hazard Mapping*. [hyperlink]

Table 2.1 - Predicted Extent of Coastal Erosion with No Structures

TIME-FRAME	ELLEN COVE (MANAGEMENT UNIT 1)	SURFERS & GOLF COURSE (MANAGEMENT UNIT 2)	EMU POINT BEACH (MANAGEMENT UNIT 3)	EMU POINT (MANAGEMENT UNIT 4)	OYSTER HARBOUR BEACH (MANAGEMENT UNIT 5)
2017	15 m	35 m	40 m	20 m	5 m
2030	24 m	35 m	40 m	29 m	5 m
2050	41 m	51 m	66 m	46 m	37 m
2070	64 m	68 m	89 m	69 m	64 m
2090	91 m	89 m	116 m	96 m	95 m
2120	133 m	122 m	158 m	138 m	143 m

Source: RHDHV, 2017

Table 2.2 - Predicted Level of Coastal Inundation

TIMEFRAME	PEAK STEADY WATER LEVEL (PSWL) AT THE SHORELINE
2017	1.65 m AHD
2030	1.71 m AHD
2050	1.84 m AHD
2070	2.03 m AHD
2090	2.26 m AHD
2120	2.62 m AHD

Source: RHDHV, 2017. Note AHD: Australian Height Datum

Photo Source: City of Albany

3. Asset Identification

This section provides an overview of the assets within each management unit that may potentially be impacted by coastal hazards over the next 100 years. A preliminary inventory of coastal assets was undertaken by Evo Coast (2017) as part of the initial vulnerability assessment. This CHRMAP builds on the previous work by incorporating the findings of the recent stakeholder and community engagement outcomes (Section 1.6 and Appendix D).

3.1 STAKEHOLDER ENGAGEMENT - ASSET VALUES

Community engagement undertaken in 2018 as part of this CHRMAP have confirmed that the community values and aspirations for the study area are generally consistent with the outcomes reported in Study of Coastal Values and Character (Green Skills, 2013) as shown in Table 3.1.

Table 3.1 - Comparision: Study of Coastal Values (GreenSkills 2013) and Current Values and Assets (CHRMAP Survey 2018)

Summary - Study of Coastal Values and Character (GreenSkills, 2013)	**Values Assets - Stakeholder Engagement (CHRMAP, 2018)**		
Social and cultural values – the area is highly valued for a wide range of family-based and recreational activities with suitability for people of all ages. Character: primarily residential and passively recreational. Evidence supported a strong appreciation for the facilities that provide family based, safe, clean and accessible recreation and offer a launch pad for activities for children in the water.	• Access to beach for swimming, walking • Ellen Cove Boardwalk • Emu Point picnic and playground areas • Dual use path • Dog exercising	• Fishing areas • Diving areas • Cultural heritage • Use of beach for surfing • Albany Surf Lifesaving Club	• Ellen Cove swimming enclosure • Ellen Cove picnic and playground area • Access for horse exercising • Local seaside feel
Natural values – scenic and naturalness of the environment and ecosystem rated strongly through the study area and highest for Dog Beach [Golf Course]. The safety, cleanliness, vistas across the ocean and the beach were highly valued. Character: naturalness of the environment with areas of wilderness, large setback/ foreshore reserves, wide active beaches and shady quiet beaches.	• Coastal scenery and vistas • Coastal vegetation and habitat	• Viewing of wildlife (land and/ or ocean) • Healthy dune system	• Soft beach sand • Wide sandy beach
Economic values – Businesses and services related to tourism, cafes and accommodation. Character: Further commercial development, particularly in areas such as currently 'undeveloped' areas such as Surfer's Beach not viewed as 'in character'.	• Cafes • Disability access points • Tourist accommodation	• Toilet blocks • Car parks and access points • Local businesses	• Attractive areas for locals and visitors • Golf course

As part of this CHRMAP process, in 2018, a suite of engagement methodologies, including interviews, meetings with key stakeholders and a survey were used to determine community valued assets within the 100 year erosion hazard area.

Results of the Assets and Values engagement are included in Appendix D. Age groups of respondents who participated in the survey are outlined in Table 3.2.

Table 3.2 - Respondents by Gender and Age

Gender	Female	Male	Grand Total
up to 18	9	8	17
19 - 30	16	2	18
31 - 50	65	23	88
51 - 70	38	30	68
71 +	4	6	10
Grand Total	**132**	**69**	**201**

Of the 201 participants, 176 were from the City of Albany municipality. 25 respondents were from the Great Southern (10), South West (4), Perth (10) or interstate (1). 157 people associated with being users of Middleton Beach and 170 of Emu Point (with many users indicating that they use both areas). Only 9 people indicated that they do not use either Middleton Beach or Emu Point.

In summary, of the 201 people surveyed the most valued assets were:

1. Access to beach
2. Coastal scenery and vistas
3. Coastal vegetation and habitat
4. Ellen Cove Boardwalk
5. Cafes

Other valued assets are included in Figure 3.1. People highlighted these assets because of their recreational, environmental and intrinsic values. People also commented that these assets allowed for socialising, family activities and provided a 'sense of place'.

There were no significant differences between Albany and non-Albany responses with respect to valued assets. There were significant age differences in how people responded to valued assets with under 18 year olds valuing assets differently from 31 to 50 year olds and 51 to 70 year olds.

Under 18 year olds were more likely to value the Albany Surf Life Saving Club while 31 – 50 year old respondents were more likely to value coastal scenery and vistas and coastal vegetation and habitat.

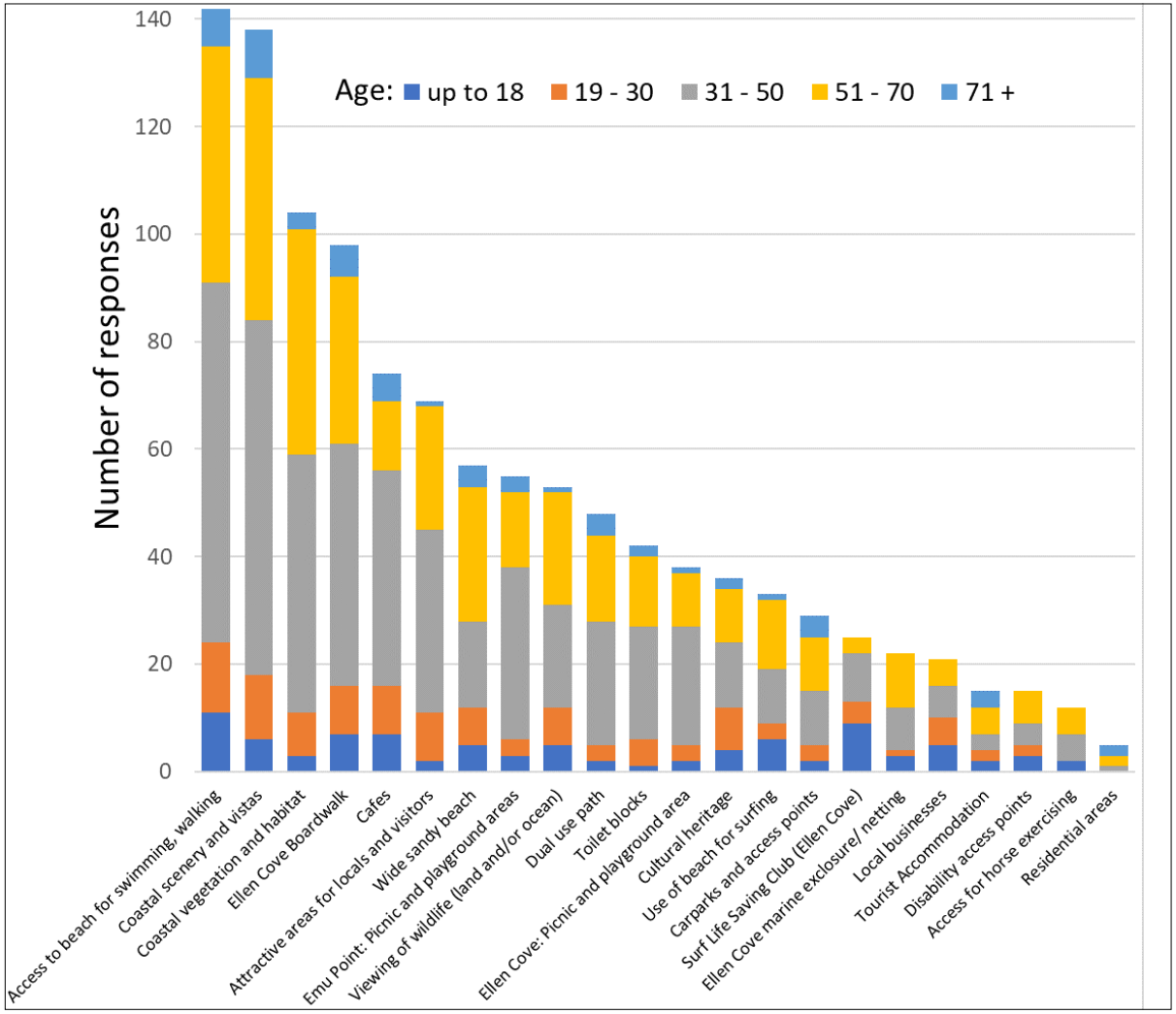
Under 18 year olds were more likely to value the Albany Surf Life Saving Club while 51 – 70 year old respondents were more likely to value coastal vegetation and coastal scenery.

31 – 50 year olds value different assets to 51 to 70 year olds. 31 – 50 year olds valued Ellen Cove Boardwalk, Cafes and access to the beach, while 51 to 70 year olds ascribe value to coastal vegetation.

There were significant differences between gender for valued assets with women valuing coastal vegetation, access to beach and coastal scenery while men value cafes and wide sandy beaches.

Other assets identified by respondents include natural areas, the dog exercise area, clean water, places for socialising, exercise assets, the local seaside feel and fishing areas. Also identified were shady trees with picnic facilities, the golf course, diving areas, a health dune system, soft beach sand and the native flora (orchids). These assets are discussed in the management unit summaries.

Figure 3.1 - Valued Assets by Age



3.2 ASSET TYPE & GROUPING

Assets within the coastal zone were identified based on a review of the GIS datasets held by the City, aerial photography, site inspection and stakeholder engagement. The following types of assets have been considered:

- **Western Power assets** – streetlights, power poles, pits, overheads, transformers.
- **Water Corporation assets** – water pipes, sewage pipes, hydrants, pumping stations.
- **City of Albany assets** – trees, playgrounds, reticulation, storm water drains, pumps & bores, reserves, toilets.
- **Transport networks** – local/major roads, parking bays, paths, trails.
- **Private land/property** – residential land and buildings.
- **Commercial land/property** – tourist accommodation, cafes/restaurants.
- **Developable land** – vacant or re-zoned land with the potential for development.
- **Cultural assets** – registered Aboriginal sites and heritage places.

The delineation and grouping of assets takes into consideration the zoning and approved land uses within the City of Albany Local Planning Scheme No. 1 (City of Albany, 2010) and the presence of existing controls (planning controls, leases, structures).

Assets with common values, or where adaptation is likely to consider a group of assets as a whole, have been grouped for simplicity. These include:

- **Private property, local roads and utilities** - adjacent private properties and ocean side local roads have been grouped. Where utilities such as power, sewerage, water also exist within the road reserve these have been included in the grouping. In these locations the viability of the private property is linked to the ability to maintain legal access and utilities.
- **Roads and car parks** – some small car parks have been grouped with roads.
- **Foreshore reserve** – community 'park' assets have been grouped as foreshore reserves: playgrounds, reticulated grassed areas, park furniture, BBQs, sun shelters, trees, shared footpaths, park lighting and water supply.

3.3 MU1 ELLEN COVE

The management unit of Ellen Cove extends southward from the Albany Surf Life Saving Club (ASLSC). It includes the recently rezoned special use area (SU25) containing the Middleton Beach Activity Centre (MBAC). For the purpose of this CHRMAP it has been assumed that development of the MBAC precinct is imminent and will occur as per the Foreshore Management Plan (RPS, 2018).

The assets within Ellen Cove are identified on Figure 3.2 and listed in Table 3.4.

Figure 3.2 - MU1 Ellen Cove Assets Source: Evo Coast

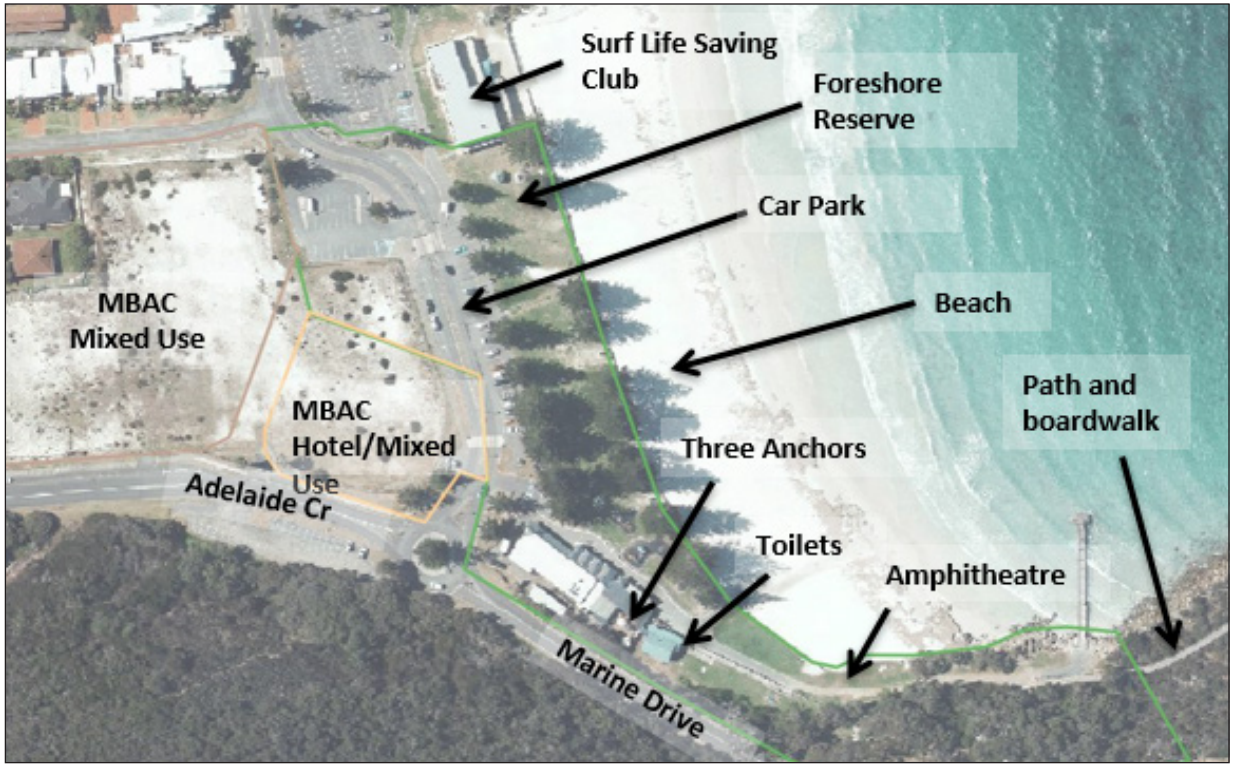


Table 3.4 - MU1 Ellen Cove Assets *Note: This list includes assets identified through the engagement process – shown in green.*

ASSET	LOCAL PLANNING SCHEME ZONING	DESCRIPTION
Beach (sand area only)	Parks & Recreation	Sand – includes volleyball courts and quality of sand. Ocean – jetty, swimming enclosure, swimming pontoon, fishing spots, snorkelling and diving areas. Overall – visual amenity, vistas and ambiance.
Foreshore Reserve	Parks & Recreation	Park area south from ASLSC to jetty. Incorporates area of public open space identified in LPS SU25. Includes Ellen Cove Boardwalk, grassed areas, reticulation, playground, amphitheatre, lighting, utilities e.g. water, outdoor showers, BBQs, mature pine trees, shared pathway, stormwater drainage, portion of Flinders Pd.
Toilets	Parks & Recreation	Toilet block.
Three Anchors	Parks & Recreation	Café/restaurant.
Marine Drive/ Adelaide Crescent	Priority road	Road - includes street lighting, adjacent car park.
MBAC Hotel/ Mixed Use	SU25 Special use area (Hotel / Mixed Use Precinct)	Development area.
MBAC Mixed Use	SU25 Special use area (Mixed Use Precinct)	Development area.
Albany Surf Life Saving Club	Parks & Recreation	Surf life saving club.

3.4 MU2 SURFERS BEACH & GOLF COURSE ASSETS

The management unit of Surfers Beach and the Albany Golf Course extends from the Albany Surf Lifesaving Club at Ellen Cove to the northern boundary of the golf course. The assets within Surfers Beach and Albany Golf Course are identified on Figure 3.3 and listed in Table 3.5. These are consistent with those identified in EvoCoast (2017c).

Figure 3.3 - MU2 Surfers & Golf Course Assets Source: Evo Coast

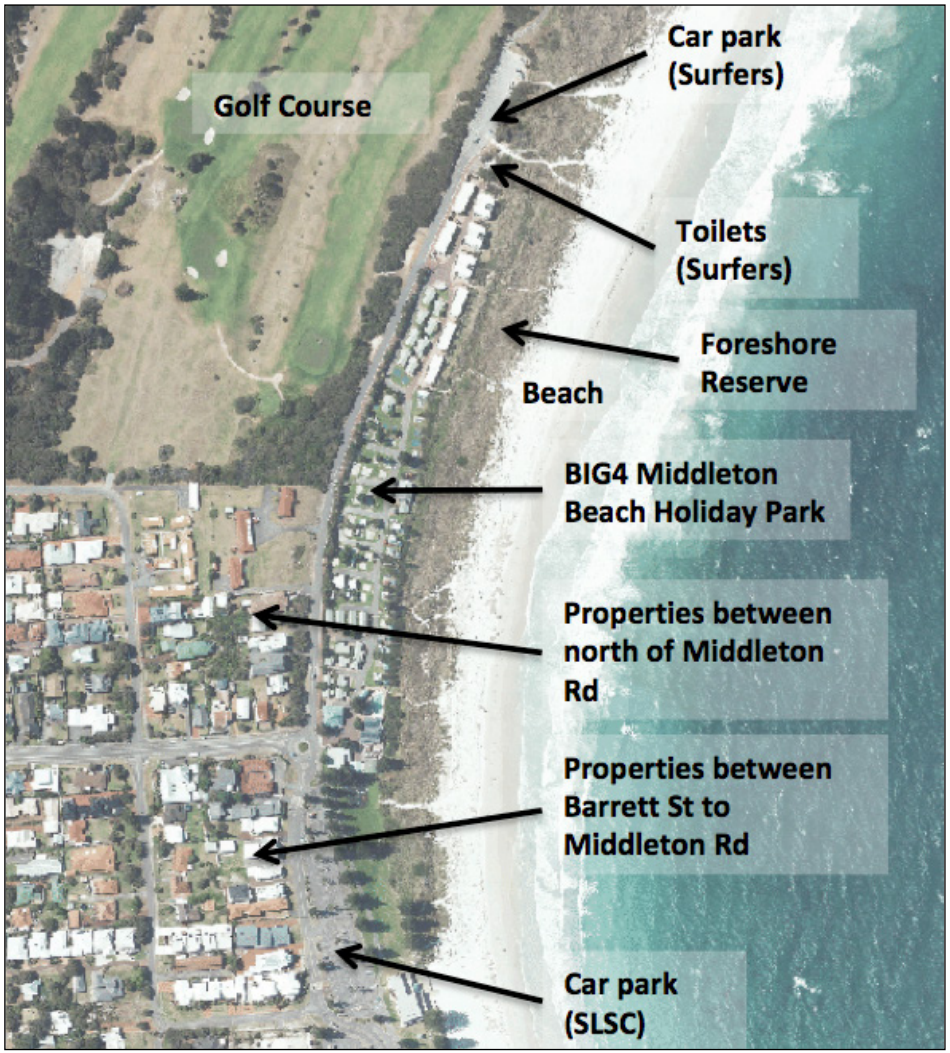


Table 3.5 - MU2 Surfers & Golf Course Assets *Note: This list includes assets identified through the engagement process – shown in green.*

ASSET	LOCAL PLANNING SCHEME ZONING	DESCRIPTION
Beach (sand area only)	Parks & Recreation	Sand – recreation areas, dog walking, fishing, places for socialising, quality of sand.
Foreshore reserve	Parks & Recreation	Park area north of ASLSC and established dunes. Includes grassed area, established trees, lighting, water, BBQ, park furniture, dual use path, established dunes, access paths, viewing decks. Coastal vegetation and habitat.
Car park	Parks & Recreation	Large car park north of ASLSC.
Flinders Parade	Local road, parks & recreation	Barnett St northwards. Includes street lighting, power and water utilities.
Properties between Barrett St to Middleton Rd	R60/R80 Tourist residential	Mixture of residential and tourist properties.
Properties between north of Middleton Rd	R60/R80 Tourist residential	Mixture of residential and tourist properties.
Big4 Middleton Beach Holiday Park	Caravan and camping	Caravan park with chalets.
Car park (Surfers)	Parks & Recreation	Car park at Surfers.
Toilets (Surfers)	Parks & Recreation	Toilets at Surfers.
Golf Course	Parks & Recreation	Heritage listed golf course.

3.5 MU3 EMU POINT BEACH

The management unit of Emu Point Beach extends from the northern boundary of the golf course to the Emu Point revetment. The assets within Emu Point Beach are identified on Figure 3.4 and listed in Table 3.6. These are consistent with those identified in EvoCoast (2017a), with the exception of the foreshore reserve which has been noted as a part of an ecological corridor (including habitat for Western Ringtail Possum, orchids and other flora and fauna).

Figure 3.4 - MU3 Emu Point Beach Assets Source: Evo Coast

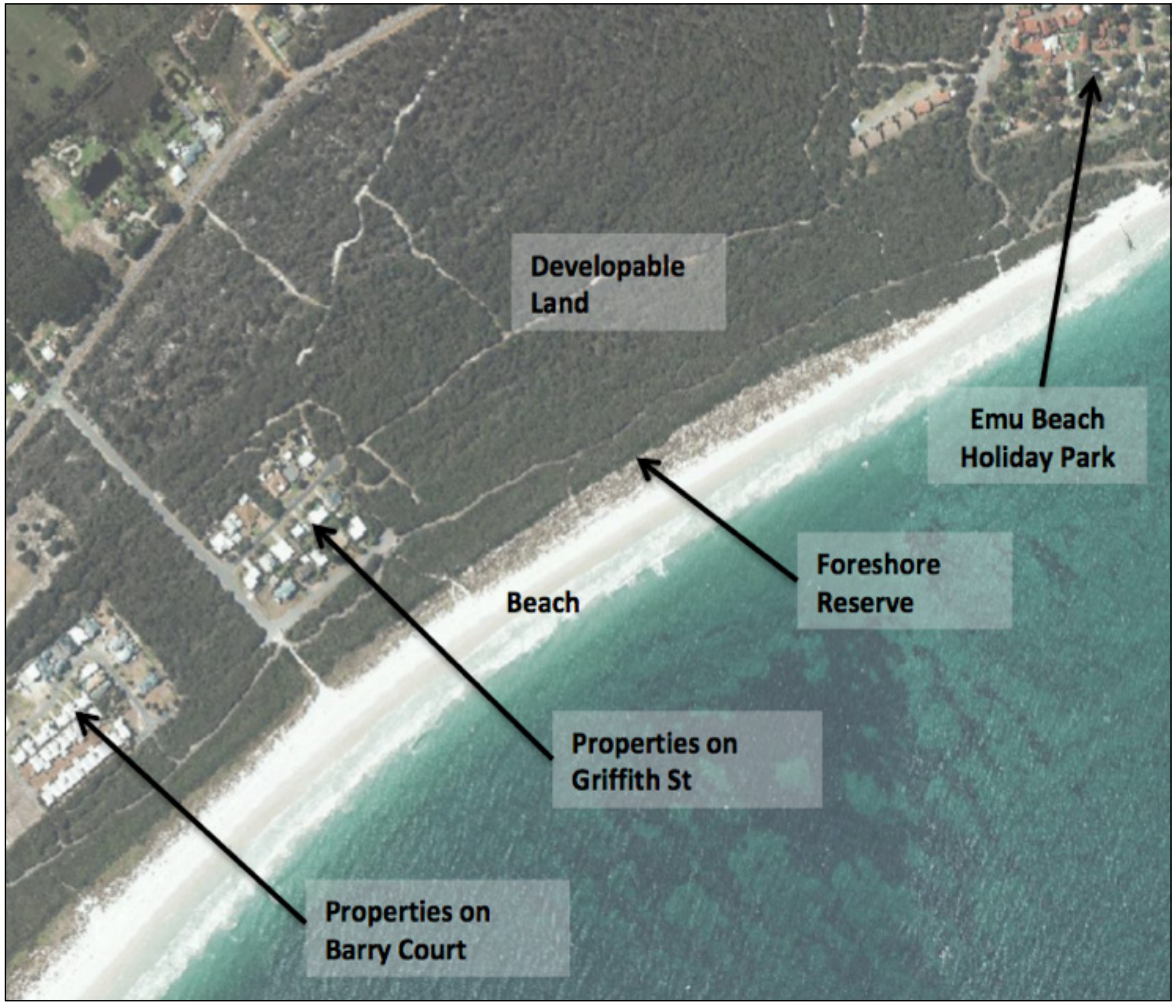


Table 3.6 - MU3 Emu Point Beach Assets *Note: This list includes assets identified through the engagement process – shown in green.*

ASSET	LOCAL PLANNING SCHEME ZONING	DESCRIPTION
Beach (sand area only)	Parks & Recreation	Sand – recreation areas, clean water, beach in its natural state.
Foreshore reserve	Parks & Recreation	Established dunes and bush, ecological corridor for Western Ringtail Possum and other flora and fauna. Includes dual use path.
Properties on Barry Court	R30/R50 Tourist Residential, Hotel/ Motel	Mixture of residential and tourist developed land and undeveloped lots. Includes local roads and utilities within the road reserve.
Properties on Griffiths Street	R17.5 Residential	Residential buildings. Includes local roads and utilities within the road reserve.
Developable land	Rural small lot holdings	Site of proposed LandCorp subdivision.
Emu Beach Holiday Park	Tourist residential	Caravan park with chalets.

3.6 MU4 EMU POINT

The management unit of Emu Point extends from the start of the revetment to the entrance to Oyster Harbour. The asset comprising the foreshore reserve has been split into two portions to reflect the relative community values associated with the asset and the relative benefits provided by the existing controls of the revetment wall and detached breakwater headland.

The assets within Emu Point are identified on Figure 3.5 and listed in Table 3.7.

Figure 3.5 - MU 4 Emu Point Assets Source: Evo Coast

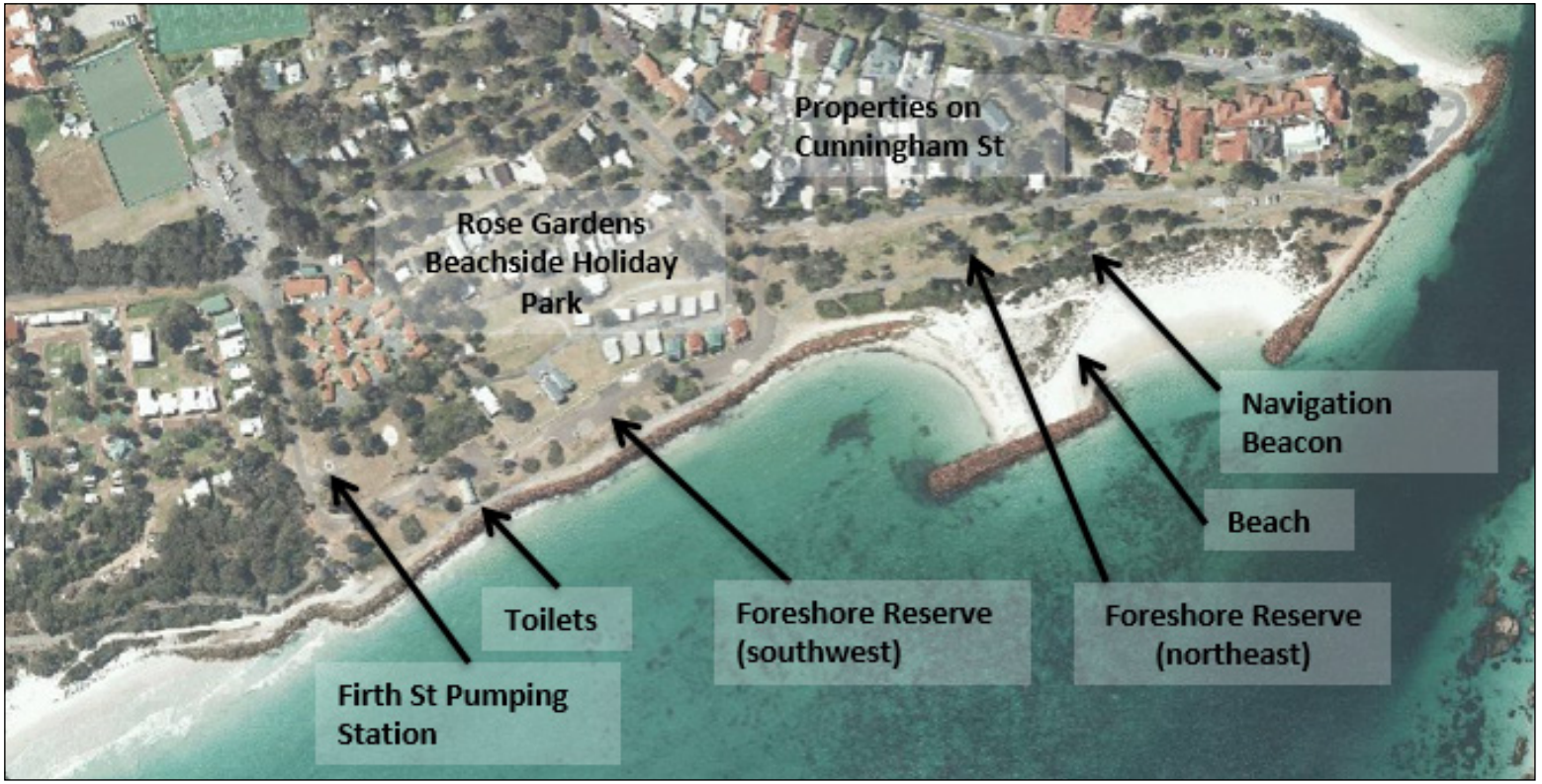


Table 3.7 - MU4 Emu Point Assets *Note: This list includes assets identified through the engagement process – shown in green.*

ASSET	LOCAL PLANNING SCHEME ZONING	DESCRIPTION
Beach (sand area only)	Parks & Recreation	Artificial beach formed by the detached breakwater.
Foreshore reserve (northeast)	Parks & Recreation	Includes grassed area, established dunes and bush, shared path, portion of Boongarrie St, local utilities (power and water), new exercise equipment.
Foreshore reserve (southwest)	Parks & Recreation	Includes grassed area, shared path, playground, parking, local utilities (power and water), native vegetation and habitat.
Toilets	Parks & Recreation	Toilets behind revetment.
Firth St Pumping Station	Parks & Recreation	Sewerage pumping station.
Rose Gardens Beachside Holiday Park	Tourist Residential	Caravan park with chalets.
Properties on Cunningham St	R20 Residential, Local Road	Residential buildings and portion of Cunningham St, Boongarrie St Burgess Street, Includes local roads and utilities within the road re-serve.
Navigation Beacon	Port Industry	Navigation mark.

3.7 MU5 OYSTER HARBOUR

The management unit of Oyster Harbour Beach extends from the entrance to Oyster Harbour to the Emu Point Boat Pens. The asset of the foreshore reserve and beach have been split into two portions, at the boundary of vehicle access, to take into account the different uses (e.g. vehicle access vs exclusion).

The assets within Oyster Harbour Beach are listed in Table 3.8 and identified on Figure 3.6.

Figure 3.6 - MU5 Oyster Harbour Beach Assets Source: Evo Coast

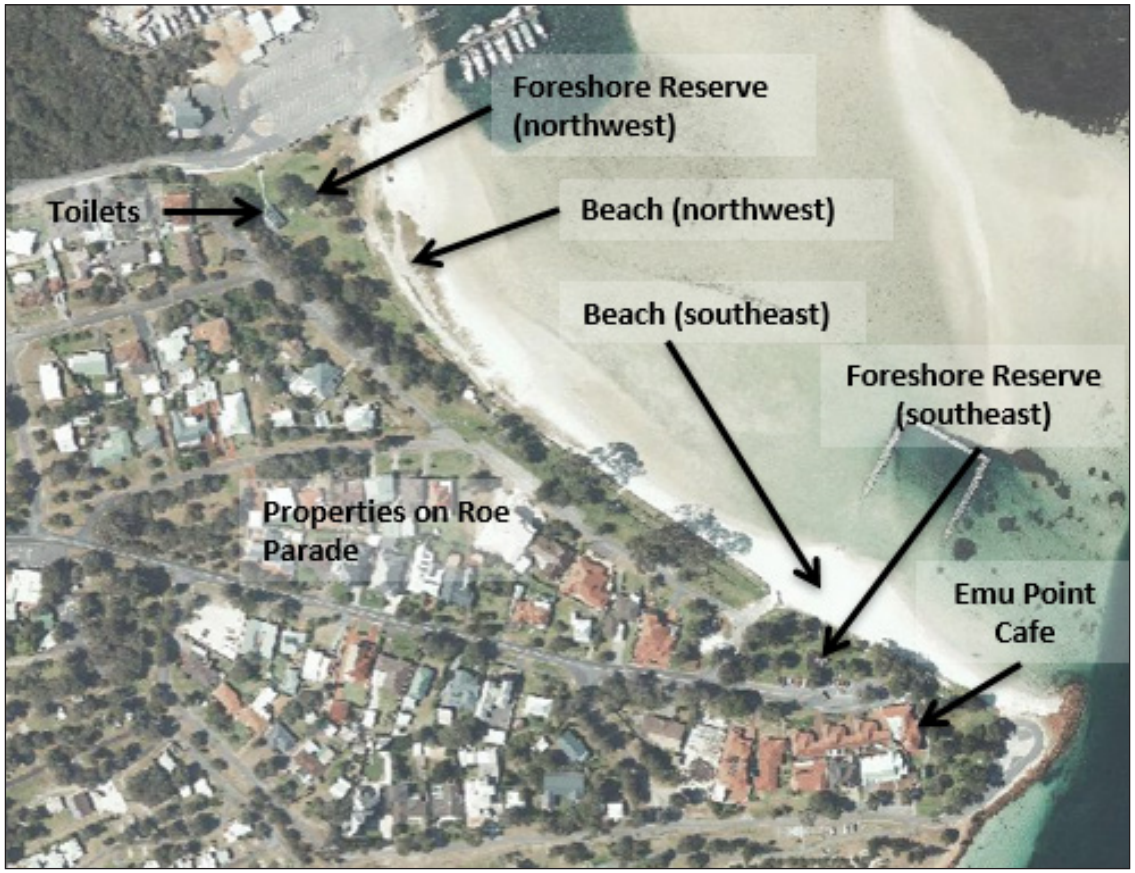


Table 3.8 - MU5 Oyster Harbour Beach Assets *Note: This list includes assets identified through the engagement process – shown in green.*

ASSET	LOCAL PLANNING SCHEME ZONING	DESCRIPTION
Oyster Harbour		Registered Aboriginal Site – mythological.
Beach (north-west)	Parks & Recreation	Northwest portion of the beach, includes vehicle access area.
Beach (southeast)	Parks & Recreation	Southwest portion of the beach, defined as the area where vehicle access is not permitted. Includes swimming pontoon.
Foreshore reserve (northwest)	Parks & Recreation	Northern portion of foreshore reserve seaward of the existing grouted vertical rock wall. Includes grassed area, BBQs, lighting, water, navigation aids.
Foreshore reserve (southeast)	Parks & Recreation	Southern portion of foreshore reserve landward of the existing grouted vertical rock wall. Includes grassed area, playground, lighting, water, turn around and parking at the end of the Cunningham St.
Emu Point Café	SU14 Restaurant, Con-venience Store, Parks & Recreation	Café including toilets.
Properties on Roe Parade	R20 Residential, Local Road	Residential buildings and portion of Roe Parade, Mermaid Ave, Hunter St, Bedwell St. Includes utilities within the road reserve (power, water, sewage).
Toilets	Parks & Recreation	Toilets at the end of Bedwell St.

4. Risk & Vulnerability Analysis

This section provides details of the risk and vulnerability analysis for each asset or asset group. The process involves:

- Evaluating the likelihood and consequence of coastal hazards to obtain a risk rating for each asset.
- Evaluating the influence of each asset's adaptive capacity on its risk rating to obtain a vulnerability rating for each asset.

EvoCoast (2017a) undertook a detailed vulnerability analysis for the study area to identify the unmitigated risk (i.e. presuming no protective treatments) and vulnerability of each asset. This CHRMAP builds on the previous work to determine the influence of existing controls (both planning and physical) in alleviating the impacts of coastal hazards. Wherever possible, the risk and vulnerability methodology is consistent with the City of Albany's Enterprise Risk and Opportunity Management Framework (City of Albany, 2017c).

The methodology applied for this CHRMAP is consistent with the approach by EvoCoast (2017a), with the addition of:

- Review of coastal assets based on additional community engagement (Section 3.1).
- Review of consequence ranking for each asset based on additional community engagement.
- Review of the adaptive capacity ranking of built assets based on additional stakeholder consultation.
- Evaluation of the mitigating impact of existing controls (not previously undertaken).

The risk and vulnerability assessment tables detailing the rating for each asset are included in Appendix E.

4.1 LIKELIHOOD OF EROSION & INUNDATION

Likelihood is the term used to describe the chance of something happening (Australian Standard (AS) 5334-2013 Climate Change Adaptation for Settlements and Infrastructure – A Risk Based Approach). Within the context of a vulnerability assessment it is used to consider the exposure of an asset to coastal hazards.

A detailed assessment of the coastal dynamics within the study area was undertaken by RHDHV (2017) which included hazard mapping denoting the potential extent of erosion and inundation at different timeframes (Section 2.1).

To factor in the uncertainty associated with hazard mapping and to consider a range of likelihood scenarios consistent with EvoCoast (2017a), the results of the hazard mapping have been evaluated using the likelihood hazard matrix in Table 4.1 and likelihood rating in Table 4.2. An example of how the likelihood scale is applied is shown in Figure 4.1.

Figure 4.1 - Likelihood Of Erosion At Different Timeframes Source: Evo Coast

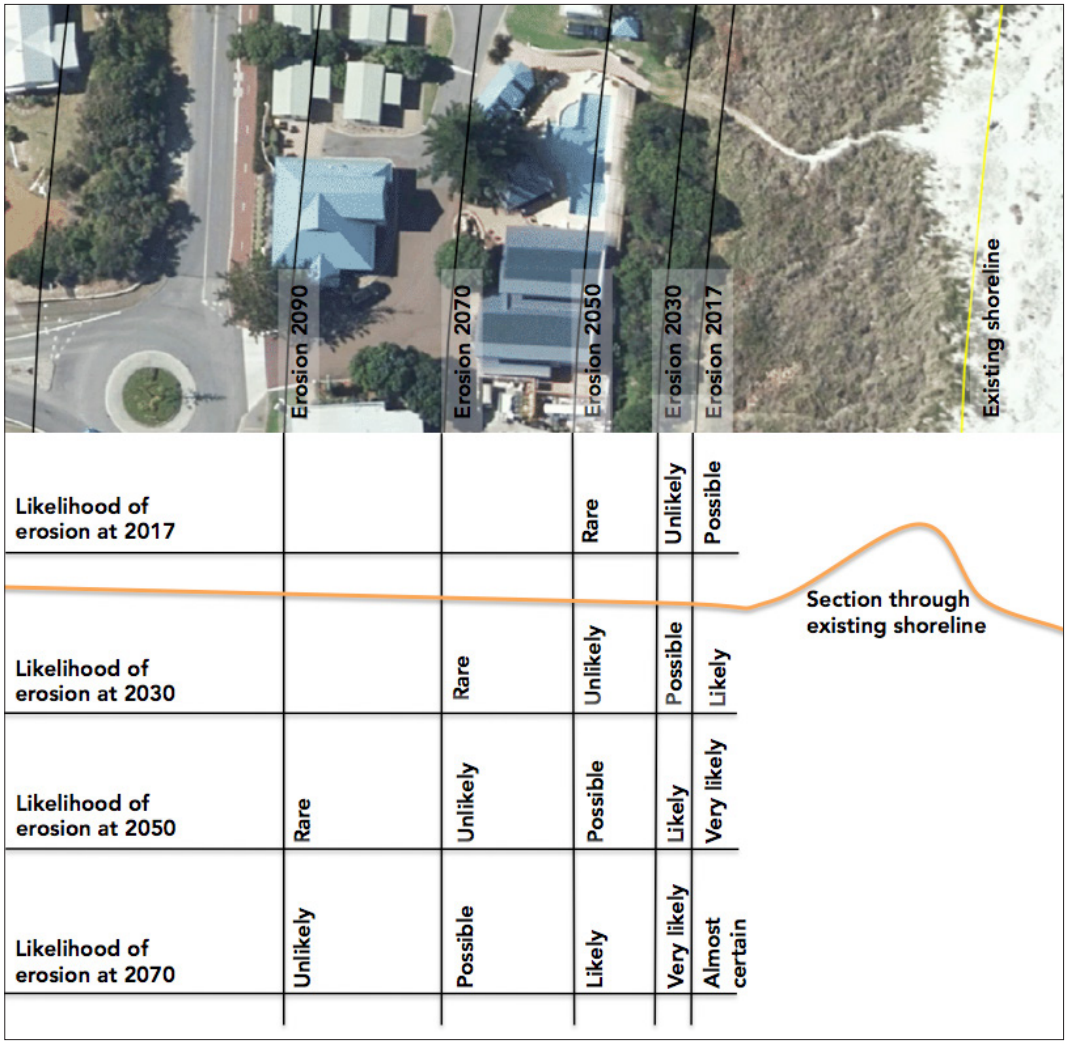


Table 4.1 - Likelihood Rating

Likelihood Rating	**Descriptor**
Almost Certain	Expected to occur in most circumstances
Likely	Will probably occur in most circumstances
Possible	Should occur at some time
Unlikely	Could occur but not expected
Rare	May occur, only in exceptional circumstances

Source: EvoCoast (2017a) Note: Originally adapted from the CHRMAP guidelines (WAPC, 2014)

Table 4.2 - Likelihood Hazard Matrix

Likelihood Rating	Present Day (2017)	2030	2050	2070	2090	2120
Almost Certain	-	-	2017	2030	2050	2070
Likely	-	2017	2030	2050	2070	2090
Possible	2017	2030	2050	2070	2090	2120
Unlikely	2030	2050	2070	2090	2120	-
Rare	2050	2070	2090	2120	-	-

Source: EvoCoast (2017a) Note: Originally adapted from the CHRMAP guidelines (WAPC, 2014)

4.2 CONSEQUENCE OF EROSION & INUNDATION

The consequence is defined as the outcome of an event or change in circumstances affecting the achievement of objectives (DLG, 2013). In the context of a vulnerability assessment, consequence is used to consider the sensitivity of an asset to coastal hazards.

The consequences may be both immediate, with outcomes during a storm event, or with impacts only being realised after the event. In this context it is useful to understand whether the consequence will be short-lived and if the impacts are reversible, versus persistent, long-term impacts.

When considering a broad range of consequences, the impacts of erosion and inundation have been evaluated for each asset using the consequence scale shown in Table 4.3. The consequence scale was developed for the study area by EvoCoast (2017a), based on the scales presented in the CHRMAP guidelines (WAPC, 2014) AS 5334, and DLG (2013). It was adapted for the study area to be consistent with the City's Enterprise Risk and Opportunity Management Framework (City of Albany, 2017c) which considers the objectives of the Albany Local Planning Strategy (City of Albany, 2010) and incorporate the results of the previous community values consultation by Green Skills (2013).

Table 4.3 - Consequence Scale

CONSEQUENCE RATING	PEOPLE HEALTH & SAFETY	SOCIAL & CULTURAL	PROPERTY & FINANCIAL	NATURAL ENVIRONMENT
Insignificant	No injuries	Minimal or no loss/damage/interruption to services, recreational activities, employment, wellbeing, culture or heritage. Little or no disruption to the community. Less than 5% of community affected. Many alternative sites or facilities exist.	Inconsequential or no damage to infrastructure, property, or equipment. Less than $10,000 or 2% of annual operating budget.	Negligible to no loss of flora, fauna or land-form. Scenic, naturalness of the environment unchanged.
Minor	One or more minor injuries such as first aid treatments.	Short-term, temporary loss/damage/interruption to services, recreational activities, employment, wellbeing, culture or heritage. Minor disruption to the nearby community. 5 - 10% of community affected. Alternative sites or facilities exist.	Localised damage rectified by internal arrangements. Loss or damage to infrastructure, property, or equipment of $10,000 - $100,000 or 2 - 5% of annual operating budget.	Short-term loss of flora, fauna or landform (strong recovery) with local impact. Localised or minor impact on the scenic, naturalness of the environment.

CONSEQUENCE RATING	PEOPLE HEALTH & SAFETY	SOCIAL & CULTURAL	PROPERTY & FINANCIAL	NATURAL ENVIRONMENT
Moderate	One or more injuries, not severe, such as those requiring minor medical treatments.	Medium-term, temporary loss/damage/ interruption to services, recreational activities, employment, wellbeing, culture or heritage. Significant disruption to the nearby community. 10 - 25% of community affected. Regional impact, limited alternative sites or facilities exist.	Localised damage rectified by internal and external arrangements. Permanent loss or damage to infrastructure, property, or equipment of $100,000 - $2 million or 5 - 10% of annual operating budget.	Medium-term loss of flora, fauna or land-form (recovery likely) with regional impact. Moderate loss of scenic, naturalness of the environment.
Major	One or more severe injuries such as temporary or permanent disabilities	Long-term, prolonged loss/damage/interruption to services, recreational activities, employment, wellbeing, culture or heritage. Substantial disruption to widespread community. 25 - 50% of community affected. Regional impact, very limited alternative sites or facilities exist.	Significant damage requiring external resources. Permanent loss or damage to infrastructure, property, or equipment of $2 - $5 million or 10 - 20% of annual operating budget.	Long-term loss of flora, fauna or landform (limited chance of recovery) with regional impact. Widespread or major loss of scenic, naturalness of the environment.
Severe	One or more fatalities or multiple severe injuries.	Permanent, prolonged loss/damage/interruption, recreation-al activities, employment, wellbeing, culture or heritage. Major/multiple disruption to widespread community. More than 50% of community affected. National impact, no suitable alternative sites or facilities exist.	Extensive damage resulting in a prolonged period of recovery. Permanent loss or damage to infrastructure, property, or equipment of more than $5 million or 20% of annual operating budget.	Permanent loss of flora, fauna or landform (no chance of recovery) with national impact. Total loss of scenic, naturalness of the environment.

4.3 RISK OF EROSION & INUNDATION

The consequence is defined as the outcome of an event or change in circumstances affecting the achievement of objectives (DLG, 2013). In the context of a vulnerability assessment, consequence is used to consider the sensitivity of an asset to coastal hazards.

The consequences may be both immediate, with outcomes during a storm event, or with impacts only being realised after the event. In this context it is useful to understand whether the consequence will be short-lived and if the impacts are reversible, versus persistent, long-term impacts.

When considering a broad range of consequences, the impacts of erosion and inundation have been evaluated for each asset using the consequence scale shown in Table 4.3. The consequence scale was developed for the study area by EvoCoast (2017a), based on the scales presented in the CHRMAP guidelines (WAPC, 2014) AS 5334, and DLG (2013). It was adapted for the study area to be consistent with the City's Enterprise Risk and Opportunity Management Framework (City of Albany, 2017c) which considers the objectives of the Albany Local Planning Strategy (City of Albany, 2010) and incorporate the results of the previous community values consultation by Green Skills (2013).

Table 4.4 - Risk Rating Matrix

Likelihood Rating	Consequence Rating				
	Severe	Major	Moderate	Minor	Insignificant
Almost Certain	Extreme	Extreme	High	High	Medium
Likely	Extreme	High	High	Medium	Low
Possible	High	High	Medium	Medium	Low
Unlikely	High	Medium	Medium	Low	Low
Rare	Medium	Low	Low	Low	Low

Source: City of Albany (2017)

Table 4.5 - Risk Tolerance Scale

Risk Level	Action Required	Acceptance
Extreme	Immediate action required to eliminate or re-duce risk to acceptable levels.	Unacceptable
High	Immediate to short term action required to eliminate or reduce risk to acceptable levels.	Urgent action is required
Medium	Short to medium term action to reduce risk to acceptable levels or accept risk.	Monitor
Low	No action required.	Acceptable

Note: Adapted from CHRMAP guidelines (WAPC, 2014) and City of Albany (2017)

4.4 ADAPTIVE CAPACITY

An asset's adaptive capacity defines its ability to accommodate the potential impacts of coastal hazards with minimum disruption or additional cost (OEH, 2011).

The adaptive capacity of each asset in the study area was evaluated using the scale shown in Table 4.6. The adaptive capacity scale has taken from EvoCoast (2017a) and originally adapted from the CHRMAP Guidelines (WAPC, 2014) and AS 5334 (Australian Standards, 2013) to increase its relevance to coastal assets within the project area. The scale takes into consideration the design, function or form of the assets. The adaptive capacity of each asset to accommodate the impacts of erosion and inundation have been considered independently.

Table 4.6 - Adaptive Capacity Scale

Rating	Adaptive Capacity
Very High	Impact of coastal hazard will cause minimal or no reduction in asset's function or performance.
High	Impact of coastal hazard will cause short-term or localized reduction in asset's function or performance. Minor modifications may be required but could be undertaken as part of routine maintenance. Early renewal of infrastructure by 10–20%.
Moderate	Impact of coastal hazard will cause medium-term or moderate reduction in asset's function or performance. Minor modifications will be required. Early renewal of infrastructure by 20–50%.
Low	Impact of coastal hazard will cause long-term or significant reduction in asset's function or performance. Major modifications will be required. Early renewal of infrastructure by 50–90%.
Very Low	Impact of coastal hazard will cause complete loss of asset's function or performance. Asset will require redesign, rebuilding and/or relocating. Early renewal of infrastructure by more than 90%.

Notes: Adapted from CHRMAP Guidelines (WAPC, 2014) and AS 5334 (Australian Standard, 2013). Early renewal indicates that the structure may have required modification or replacement prior to the end of its predicted lifespan.

4.5 ASSET VULNERABILITY

Vulnerability rating defines the degree to which an asset is susceptible to, and less adaptable to adverse effects of coastal hazards. The vulnerability rating for each asset was determined by combining the risk rating (to account for the potential impacts of the coastal hazards) and the adaptive capacity rating. This approach is consistent with the methodology of EvoCoast (2017a), using the vulnerability matrix shown in Table 4.7.

The vulnerability rating and tolerance scale (described in Table 4.8) provides an indication of the susceptibility of assets to the impacts of coastal hazard. A low vulnerability level indicates the asset is likely to be able to accommodate the impacts of coastal hazards with minimal or no additional management. Whereas at the other end of the scale, assets identified as extremely vulnerable will be prioritised for additional analysis, as they are likely to require significant adaptation. Discussion on the outcomes of this assessment are contained in Section 6 following the evaluation of existing controls (Section 5).

Table 4.7 - Vulnerability Matrix

RISK RATING	ADAPTIVE CAPACITY RATING				
	Very Low	Low	Moderate	High	Very High
Extreme	Extreme	Extreme	Extreme	High	Medium
High	Extreme	Extreme	High	Medium	Low
Medium	Extreme	High	Medium	Low	Low
Low	High	Medium	Low	Low	Low

Note: Adapted from CHRMAP guidelines (WAPC, 2014).

Table 4.8 - Vulnerability Tolerance Scale

Vulnerability Level	Prioritisation	Acceptance
Extreme	Asset has minimal ability to cope with the impacts of coastal hazards without additional support. Adaptation will need to be considered as a priority. Establishment and implementation of controls is likely to be required.	Unacceptable
High	Asset has limited ability to cope with the impacts of coastal hazards. Immediate to short-term adaptation is likely to be required to reduce risk to acceptable levels. Establishment and implementation of controls is likely to be required.	Urgent action is required
Medium	Asset has some ability to cope with the impacts of coastal hazards. However short to medium term actions are likely to be required to reduce risk to acceptable levels. Observing, assessing and improving current controls and procedures is likely to be required.	Monitor
Low	Asset has high resilience, it is able to cope with the impacts of coastal hazards without additional support. No immediate action required. Likely to be adequately managed by routine procedures.	Acceptable

Note: Adapted from CHRMAP guidelines (WAPC, 2014).

Photo Source: City of Albany

Photo Source: City of Albany

5. Existing Controls

The combination of the likelihood and consequence described in previous sections generally identifies the unmitigated risk of a coastal hazard. However, there may be controls and measures already in place to manage and/or adapt to the risk. For example, in an area where unmitigated risk of inundation has been identified as being extreme, imposing floodplain development controls may reduce the risk level to low, so that it becomes acceptable or tolerable and does not require further management and adaptation, as opposed to if it were extreme without any existing controls and measures. Existing controls which apply to this CHRMAP area are discussed below.

5.1 LEGISLATIVE AND PLANNING CONTROLS

The existing planning framework is briefly described in Section 1.4. The impact that these controls may have on the CHRMAP are further examined in this section.

5.1.1 State Controls

Planning and Development (Local Planning Schemes) Regulations 2015

The Planning and Development (Local Planning Schemes) Regulations 2015 (the Regulations) exist to guide the preparation and amendment of Local Planning Strategies and Local Planning Schemes in Western Australia. This includes model provisions for Zones and Reserves and general development requirements.

The Regulations also include a set of deemed provisions that will form part of every local planning scheme in the State.

Sections of specific note include:

- Schedule 1, Part 4, Clause 35: Restrictive Covenants. These can be used to control the number of residential dwellings or type of developments which may be constructed on the land. This may limit the development capability of a site to less than that allowed under the Scheme.
- Schedule 1, Part 5, Clause 36: Special Control Areas. These are areas that are significant for a particular reason and require specific planning responses and controls which can be inserted into the Scheme;
- Schedule 2, Part 6: Local Development Plans. These guide the preparation of plans setting out specific and detailed guidance for a future development where specific site and development standards are to apply.

The sections listed are relevant to this CHRMAP process as they can be used to 'isolate' sites with specific needs and plan for them. In this instance, that could include using these controls to 'isolate' areas impacted by coastal hazards.

5.1.2 State Planning Policies

State Planning Policy 2.6: State Coastal Planning Policy

State Planning Policy 2.6: State Coastal Planning Policy (SPP 2.6) exists to provide guidance for decision-making within the coastal zone, including managing development and land use change; establishment of foreshore reserves; and to protect, conserve and enhance coastal values. SPP 2.6:

- Recognises and responds to regional diversity in coastal types;
- Requires that coastal hazard risk management and adaptation is appropriately planned for;
- Encourages innovative approaches to managing coastal hazard risk; and
- Provides for public ownership of coastal foreshore reserves.

SPP 2.6 is entirely relevant to the subject area. Sections of specific note include:

- 5.2 Development and Settlement: which requires the appropriate placement of new development near existing development and that new development enhances and does not adversely affect the environment;

- 5.3 Water Resources and Management: which requires new development on the coast to maintain or restore pre-existing or desirable environmental flows and hydrological cycles within foreshore reserves;
- 5.4 Building Height Limits: which allows Local Governments to specify building heights for consistency in built form, topography and landscape;
- 5.5 Coastal Hazard Risk Management Adaptation Planning (CHRMAP): which suggests a process that to establish detailed background, risk assessment, options assessment and implementation guidelines. The CHRMAP should be prepared to take into account, and be consistent with, the requirements of SPP 2.6, the SPP 2.6 Guidelines and the CHRMAP Guidelines;
- 5.6 Infill Development: which requires new development to be built on the least vulnerable portion of a site and include CHRMAP measures to reduce risk;
- 5.7 Coastal Protection Works: which requires coastal protection works be carried out only where necessary and where the environment will not be unacceptably altered;
- 5.8 Public Interest: which requires that community participation and input is considered in coastal planning and management;
- 5.10 Coastal Strategies and Management Plans: which requires any structure plan, zoning, subdivision, strata subdivision or development proposal for public purposes, residential, industrial, commercial, tourist, special rural and similar uses on the coast is only approved based on or in conjunction with a current detailed coastal planning strategy or foreshore management plan; and
- 5.11 Precautionary Principle: which states that where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason to postpone measures to prevent environmental degradation.

SPP 2.6 provides integral information needed to undertake this CHRMAP process. It also provides guidance on methods to reduce the risk of hazards within undeveloped areas, such as the proposed LandCorp development area within Management Unit 3 (Emu Point Beach).

State Planning Policy 3.4: Natural Hazards and Disasters

State Planning Policy 3.4: Natural Hazards and Disasters (SPP 3.4) exists to integrate planning for natural hazards and disasters into all statutory and non-statutory planning documents, specifically town planning schemes and amendments, and local planning strategies. SPP 3.4 is utilised to minimise the adverse impacts of natural disasters on communities, the economy and the environment.

Sections of specific note include:

- 5.1 General Measures: which requires new planning and development proposals to give due consideration to relevant hazards and disasters; and
- 5.2 Hazards Considerations: which contains definitions and actions for specific natural disasters. Relevant sections require that where storm surge and/or erosion studies have been undertaken and show that inundation and/or erosion may occur, new permanent buildings should be constructed to take account of the effects of storm surge and/or coastal erosion.

SPP 3.4 is relevant in that it requires action to be taken in areas which are at risk of storm surge, inundation and/or erosion. However, it is primarily an overarching policy and as such relies on other policy documents to provide the detailed planning outcomes.

Coastal Hazard Risk Management and Adaptation Planning Guidelines

The CHRMAP Guidelines (WAPC, 2014a) were produced to support the implementation of SPP 2.6 by assisting decision-makers in developing and implementing effective CHRMAPs. They provide an overview and explanation of the

process for undertaking CHRMAPs, determining appropriate content for CHRMAPs and assessing options for appropriate management and adaptation to risk.

The CHRMAP Guidelines have been used in the preparation of this CHRMAP.

Draft Planned or Managed Retreat Guidelines

The Draft Planned or Managed Retreat Guidelines (the Retreat Guidelines, WAPC, 2017) provide guidance on how to implement a policy of planned or managed retreat. The guidelines are applicable to 'brownfield' and 'infill' development, as it is these locations that are particularly vulnerable to coastal hazards, with limited opportunities to introduce less vulnerable forms of use or development through planning controls.

The Retreat Guidelines should be considered in the use of 'managed retreat' as a management option to reduce the risk of impacts from coastal erosion and inundation. The study includes at-risk assets that may be suitable for managed retreat and as such these guidelines are very relevant.

5.1.3 State Planning Bulletins

Planning Bulletin 21: Cash-in-Lieu of Public Open Space

Planning Bulletin 21: Cash-in-Lieu of Public Open Space (PB21, WAPC, 1997) exists to guide the process of receiving cash-in-lieu of public open space and determining the appropriate amount.

Sections of specific note include:

- 3. Cash-in-lieu of Public Open Space: which gives examples of instances where it is appropriate to receive cash-in-lieu of public open space. These include instances in which the land received would be too small to be effective or there is already ample public open space; and
- 6. Appropriate Uses for Cash-in-Lieu Funds: which outlines appropriate uses of public open space, including for the purchasing of or improvement to parks, recreation grounds or public open space.

PB21 is relevant to this CHRMAP as it provides potential funding for the implementation of adaptation options (e.g. funding managed retreat or protection options), due to the fact the subject site has ample public open space that cash-in-lieu could be used to protect.

Planning Bulletin 49: Caravan Parks

Planning Bulletin 49: Caravan Parks (PB49; WAPC, 2014b) exists to guide the development of caravan parks. PB49 recognises that the commercial sustainability of caravan parks requires some flexibility in product mix, site design and risk mitigation approaches. This is achieved through the development and redevelopment of caravan parks in a manner that responds appropriately to the environment, economy and context.

A section of specific note to this CHRMAP is:

- 8. Criteria to assess new, and/or the redevelopment of existing caravan parks states that caravan parks should be designed in response to a CHRMAP.

PB49 is relevant to this CHRMAP as the area comprises several caravan and holiday park assets within the at-risk area.

Planning Bulletin 91: Restrictive Covenants

Planning Bulletin 91: Restrictive Covenants (PB91; WAPC, 2017b) guides the use of restrictive covenants. A restrictive covenant is an agreement which restricts a landowner in the use or enjoyment of the landowner's land ('burdened land') for the benefit of other land ('benefited land') or for the benefit of a public authority. Restrictive covenants which benefit a public authority are referred to as restrictive covenants 'in gross' where there is no benefited land.

A restrictive covenant binds not only the present landowner but also subsequent owners of that land, where the burden of the covenant is intended to run with the land.

Restrictive covenants:

- Can prohibit the construction of more than one house on the burdened land;
- Can prohibit the building of a structure on the burdened land above a certain height;
- Can require the purchaser not to conduct a particular business or trade on that land, such as where the seller owns land in the vicinity which can benefit from the restrictive covenant; and
- When in favour of a local government prevents the landowner from clearing the burdened land.

PB91 is relevant to the CHRMAP process because restrictive covenants could be used as an alternative to Special Control Area provisions to control the use of affected land.

5.1.4 Regional Planning

Lower Great Southern Strategy 2016

The purpose of the Lower Great Southern Strategy (WAPC, 2016) is to guide land use planning and provide strategic direction for the Lower Great Southern to 2036. Specifically, the strategy aims to:

- Provide guidance at a sub-regional level in the use of land to balance economic, social and environmental considerations;
- Assist local government in preparing, reviewing and implementing local planning strategies and schemes, and other local planning and development matters;
- Identify additional land of regional significance that may be required for regional open space purposes; and
- Ensure land required for important regional infrastructure, priority agricultural land, economic growth opportunities, water sources and basic raw materials is identified and retained for those purposes.

A section of specific note is:

- 2.12.2 Management of Foreshores and Land Use Conflicts: which provides goals for the management of coastal assets and actions to achieve those goals. Actions include preparations of foreshore reserves and management plans.

The Lower Great Southern Strategy 2016 provides regional support for a response to coastal planning issues, particularly those related to CHRMAPs. Foreshore reserves and foreshore management plans may be required for part of, or the whole study area.

5.1.5 Local Planning

City of Albany Local Planning Strategy

The Albany Local Planning Strategy (ALPS; City of Albany, 2010) (the Strategy) exists to set long-term planning direction for the City, while providing greater detail on the planning framework including interpretation of the Local Planning Scheme and actions that need to be implemented to guide the City's growth. The City is currently preparing a new Local Planning Strategy, which has been advertised.

Sections of specific note include:

- 4.1.1 Ecosystems and Biodiversity: which includes actions to encourage development that incorporates or re-establishes ecologically sound vegetation and waterway corridors;

- 4.1.3 Climate Change: which includes actions to incorporate measures to deal with rises in sea levels as they occur and modify building height policies if necessary;
- 4.3.2 Coastal Development: which includes actions to include appropriate planning based on coastal processes, including setback and height restrictions;
- 4.4.5 Harbours and Marine: which include actions to adequately address environmental, recreational and commercial requirements to help achieve an overall positive benefit to the community; and
- 5.4.3 Ecotourism: which requires developments with specific tourism uses, such as the project area, are protected and maintained.

The Strategy provides context for the actions required by the CHRMAP and the sections listed above provide priorities related to coastal development. The ALPS could be used to highlight areas of concern within the scheme area through identifying the at-risk area as an investigation area.

5.1.5 City of Albany Local Planning Scheme No. 1

The Local Planning Scheme No. 1 (LPS1) exists to set out the way land is to be used and developed, classify areas for land use and include provisions to coordinate infrastructure and development within the local government area.

The Scheme was gazetted in April 2014, prior to the gazettal of the Planning and Development (Local Planning Schemes) Regulations 2015. Any future amendments to the Scheme are required to bring it into greater accordance with the Regulations.

The Scheme contains the zones and the land uses that are permissible or will be allowed at the discretion of the Local Government under those zones. The zones include:

- Parks and Recreation;
- Tourist Residential R60-80/ R30-50;
- Caravan and Campsite;
- Residential R17.5/ R20;
- Hotel/ Motel;
- Future Urban;
- Local Centre;
- Special Use Area 25;
- Special Use Area 14; and
- Restricted Use Area 2.

Within each of these zones are several use classes which are either permitted or have some likelihood of permissibility through the exercise of discretion. Through these zones, LPS1 provides existing controls to utilise within the City. It provides guidance for certain issues related to CHRMAP, such as restricted development, minimum floor heights on affected sites, the protection of vegetation and erosion mitigation.

LPS1 contains zones with restrictive land uses that can be used to guide development in areas with higher natural risk. In addition, the Scheme can consider the application of 'Restricted Use' and 'Special Use Areas' that identify sites with specific needs and plan for them. In this instance, these designations could be used to guide land use in areas at risk from coastal hazards.

Further sections of specific note include:

- 5.3.2 Coastal Development: which requires that the assessment of land uses and developments give due consideration to Southern Shores 2001-2021 – A Strategy to Guide Coastal and Marine Planning and Management in the South Coast Region of Western Australia (Coffey Environments, 2009);

- 5.3.3 Vegetation Protection: which states that the local Government may require protection of existing vegetation where it prevents land degradation; and
- 5.3.7 Land Subject to Flooding and/or Inundation: which restricts development in the 100 year annual recurrence interval (ARI) floodway, prevents developments from altering natural drainage systems, and reduces the risk of damage to buildings by ensuring minimum height levels are reached and/or moisture barriers are used. Non-habitable buildings may be granted approval where the Local Government is satisfied that they have assessed the floodway and provide adequate justification.

LPS1 would be the primary tool to introduce management options such as Special Control Areas or mandatory requirements for foreshore management plans or similar.

5.2 PHYSICAL CONTROLS

The study area contains a number of existing coastal protection structures with a variety of different functions and designs. These structures act to directly influence the likelihood of assets being impacted by coastal hazards.

This section provides a summary of the existing coastal protection structures within each management unit and evaluates their effectiveness at reducing the impacts of coastal hazards.

5.2.1 MU1. Ellen Cove

As a condition of the development of the Middleton Beach Activity Centre (MBAC), LandCorp prepared a Foreshore Management Plan (FMP) to incorporate adaptation planning for the development area.

The FMP (RPS, 2018) prepared for LandCorp and the City of Albany, commits to interventions in relation to coastal protection over the next 100 years on a staged basis:

- Stage 1 - Construction of a buried sea wall and culvert within 5 years.
- Stage 2 - Construction of promenade and seating/deflection wall within 10 years.
- Stage 3 - Construction of foreshore improvements within 25 years.
- Stage 4 - Assessment and possible construction of coastal protection additions after 50 years.

LandCorp and the City are jointly responsible for implementation of Stage 1 and the City is responsible for Stages 2, 3 and 4. The buried seawall and subsequent stages are illustrated in Figures 5.1 and 5.2.

Given the endorsement of the FMP by LandCorp and the City, for the purpose of this CHRMAP it has been assumed:

- A buried sea wall will be constructed, which will mitigate the risk of erosion to the landward assets. Given its expected imminent construction this has been considered as an existing physical control.
- The buried seawall will act as an existing control over the next 50 years. This is based on the design guidance of the FMP which identifies that the seawall is intended to be designed for a 50 year life beyond which adaptation of the structure will be required. During which period (0-50 years) the FMP anticipates the seawall will require only minimal maintenance.

Figure 5.1 - Middleton Beach Activity Centre

Source: RPS (2018)

Although the buried seawall will mitigate the risk of erosion to landward assets it is expected to reduce the adaptive capacity of the beach. With the presence of the buried seawall at Ellen Cove, over time the beach will not be able to naturally retreat to accommodate changes in sea level or storm activity.

Accordingly, the adaptive capacity of the Ellen Cove beach was reduced to 'very-low' in the risk and vulnerability assessment, resulting in an immediate and ongoing 'extreme vulnerability'. It is understood the City will adopt a 'soft protection' approach to the beach by carrying out sand renourishment as required after significant erosion events. Further consideration of this option is provided in Section 7.

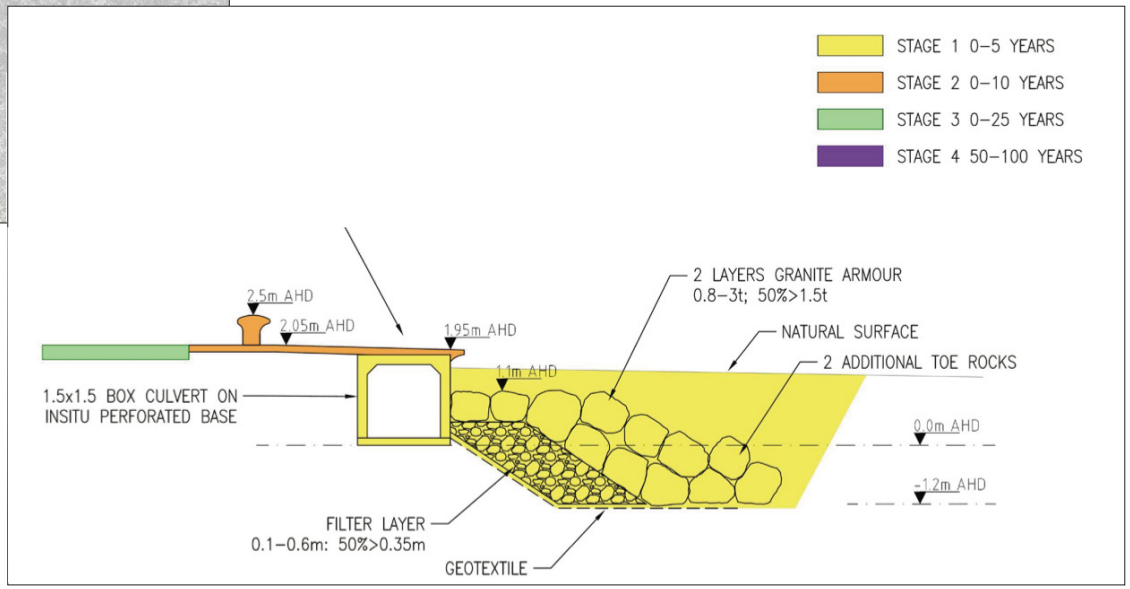


Figure 5.2 - Middleton Beach Activity Centre – Buried Seawall Cross-Section

Source: RPS (2018)

5.2.2 MU2 Surfers & Golf Course

There are no existing coastal protection structures in this management unit.

5.2.3 MU3 Emu Point Beach

There are no existing coastal protection structures in this management unit. The northwest boundary of the management unit marks the commencement of the protection structures at Emu Point (refer to next section).

5.2.4 MU4 Emu Point & MU5 Oyster Harbour

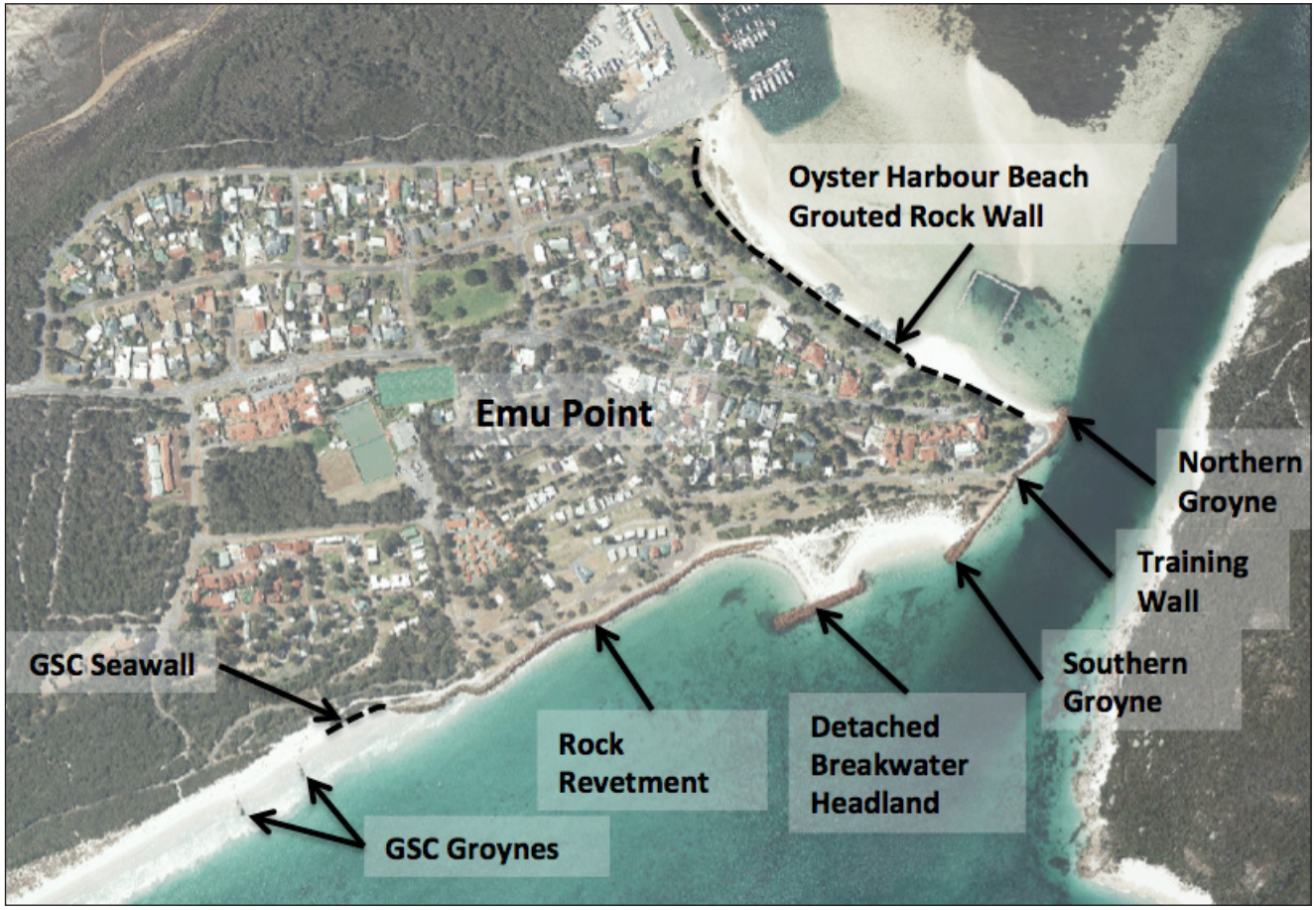
The management units of Emu Point and Oyster Harbour contain several existing coastal protection structures, many of which are interconnected.

The existing structures, as illustrated in Figure 5.3, are:

- Geotextile sand container (GSC) groynes;
- GSC seawall;
- Rock revetment;
- Detached headland breakwater; and
- Southern groyne (which continues into the training wall within the Oyster Harbour MU).

Example photos each of these structures are provides in Figure 5.4.

Figure 5.3 - Coastal Protection Structure Names At Emu Point & Oyster Harbour Source: Evo Coast



GSC Seawall

GSC Groyne

Southern Groyne & Training Wall

Detached Breakwater Headland

Rock Revetment

Grouted Rock Wall

Northern Groyne

Figure 5.4 - Typical Photos - Coastal Protection Structures (9 March 2017) Photo Source: Evo Coast

A condition inspection of the coastal protection structures within the Emu Point and Oyster Harbour management units was undertaken in March 2017 by EvoCoast (2017b and 2017c). This work also identified the remaining design life based on the structure's condition, by assuming:

- Very good condition – remaining life 100% or 25 years
- Good condition – remaining life 90% or approximately 22 years
- Moderate condition – remaining life 60% or approximately 15 years
- Poor condition – remaining life 20% or approximately 5 years
- Very poor condition – remaining life 0% or 0 years

Condition, design life and assumed impact on assets is summarised in Table 5.1. For consistency, the remaining design life for each structure, as identified in EvoCoast (2017b), has been assumed for this CHRMAP. During the designated period, the structure is assumed to mitigate the risk of erosion landward. Some routine maintenance may be required to maintain the integrity of the structure, however significant modifications, upgrades and/ or repairs are not anticipated. Significant works are considered as effectively 'new' structures and discussed in Section 7. This is consistent with SPP2.6 Clause 5.7(ii):

"Existing coastal protection works that require significant upgrade or maintenance over the planning timeframe should be considered as new coastal protection works, including consideration of the most appropriate form."

Table 5.1 - Summary Of Existing Coastal Protection Structures In Emu Point & Oyster Harbour Management Units

Protection Structure	Description	Current Condition	Assumed Remaining Design Life	Assumed Impact On Assets
GSC groynes	Sandbag beach groynes. Constructed 2014	Moderate	9 years	Reduction in immediate risk from erosion for small portion of Emu Point Beach
GSC seawall	Sloping sandbag revetment. Constructed 2011	Very Poor	0 years	No impact
Rock revetment	Sloping rock revetment. Staged construction 1999, 2001, 2005	Poor	5 years	Mitigates the immediate likelihood of erosion to Emu Point foreshore reserve (southwest) and toilets

Protection Structure	Description	Current Condition	Assumed Remaining Design Life	Assumed Impact On Assets
Detached breakwater headland	Sloping rock break-water. Constructed 1995	Very Good	25 years	Mitigates the short-term likelihood of erosion to Emu Point foreshore reserve (northeast), pocket beaches, properties on Cunningham St. and navigation beacon.
Southern groyne	Rock groyne connected to training wall. Constructed 1989	Good	22 years	
Training wall	Sloping rock revetment connecting southern groyne and northern groyne. Constructed mid 1980's	Moderate	15 years	Mitigates the short-term likelihood of erosion to Oyster Harbour foreshore reserve (portion), Emu Point Cafe
Northern groyne	Rock groyne connect-ed to training wall. Constructed 1991	Moderate	15 years	
Grouted rock wall	Vertical grouted rock wall. estimated original construction 1980s. Grouting replaced in 2018.	Moderate	15 years	Mitigates the short-term likeli-hood of erosion to Oyster Harbour foreshore reserve and properties on Roe Parade


Photo Source: City of Albany

6. Assets Requiring Adaptation

Based on the risk and vulnerability analysis (Section 4) and the evaluation of existing controls (Section 5) this section provides a summary of the key assets requiring additional management controls.

Tables 6.1 and 6.2 provide a summary of the erosion and inundation existing vulnerability rating for impacted assets over a 100 year timeframe. This rating takes into account the influence of existing controls. The full erosion and inundation vulnerability tables including details on the likelihood, consequence, risk and adaptive capacity assumed for each asset are provided in Appendix E.

Assets found to have a high or extreme vulnerability rating are assumed to have an unacceptable vulnerability level and are likely to require management actions in order to further reduce their vulnerability.

6.1 EROSION VULNERABILITY IN SHORT-TERM (0-10 YEARS)

The following assets have been identified as a priority for the evaluation of additional controls (adaptation options) in Section 7. A detailed map of the assets is included in Figure 6.1.

MU1 Ellen Cove

- Beach – Extreme erosion vulnerability, due to the very low adaptive capacity resulting from the buried seawall

MU2 Surfers & Golf Course

- Foreshore reserve – High erosion vulnerability
- BIG4 Middleton Beach Holiday Park – High erosion vulnerability

MU3 Emu Point Beach

- Foreshore – High erosion vulnerability
- Properties on Griffiths Street – Extreme erosion vulnerability, due to their very low adaptive capacity

Emu Beach Holiday Park is not included as an asset requiring immediate action, however, it is affected by adaptation options for MU4 Emu Point. This asset is considered further in Section 8.

MU4 Emu Point

- Foreshore reserve (southwest portion) – Extreme erosion vulnerability, due to the poor condition of the revetment
- Toilets (within foreshore reserve) – Extreme erosion vulnerability, due to the poor condition of the revetment

MU5 Oyster Harbour Beach

- Beach – Extreme erosion vulnerability, due to the very low adaptive capacity resulting from the vertical grouted wall

6.2 EROSION VULNERABILITY IN LONG-TERM (UP TO 100 YEARS)

The majority of assets were found to be vulnerable to erosion over the longer-term (up to 100 years). Broader adaptation pathways will be required of all management units to identify long-term management strategies to reduce the impacts of erosion. It is noted that rapid change in vulnerability ican occur, due to the asset having a low adaptive capacity.

6.3 INUNDATION VULNERABILITY

The impacts from inundation are relatively minor in comparison to erosion throughout the study area (noting that there are some areas outside of the current CHRMAP boundaries that may be more vulnerable). There are no assets identified as having high or extreme vulnerability to inundation in the short-term (0-10 years). In the long-term (up to 100 years) the key areas requiring consideration are MU1 Ellen Cove and the northwest portion of the foreshore reserve within MU5 Oyster Harbour, both with high inundation vulnerability projected in 2070.

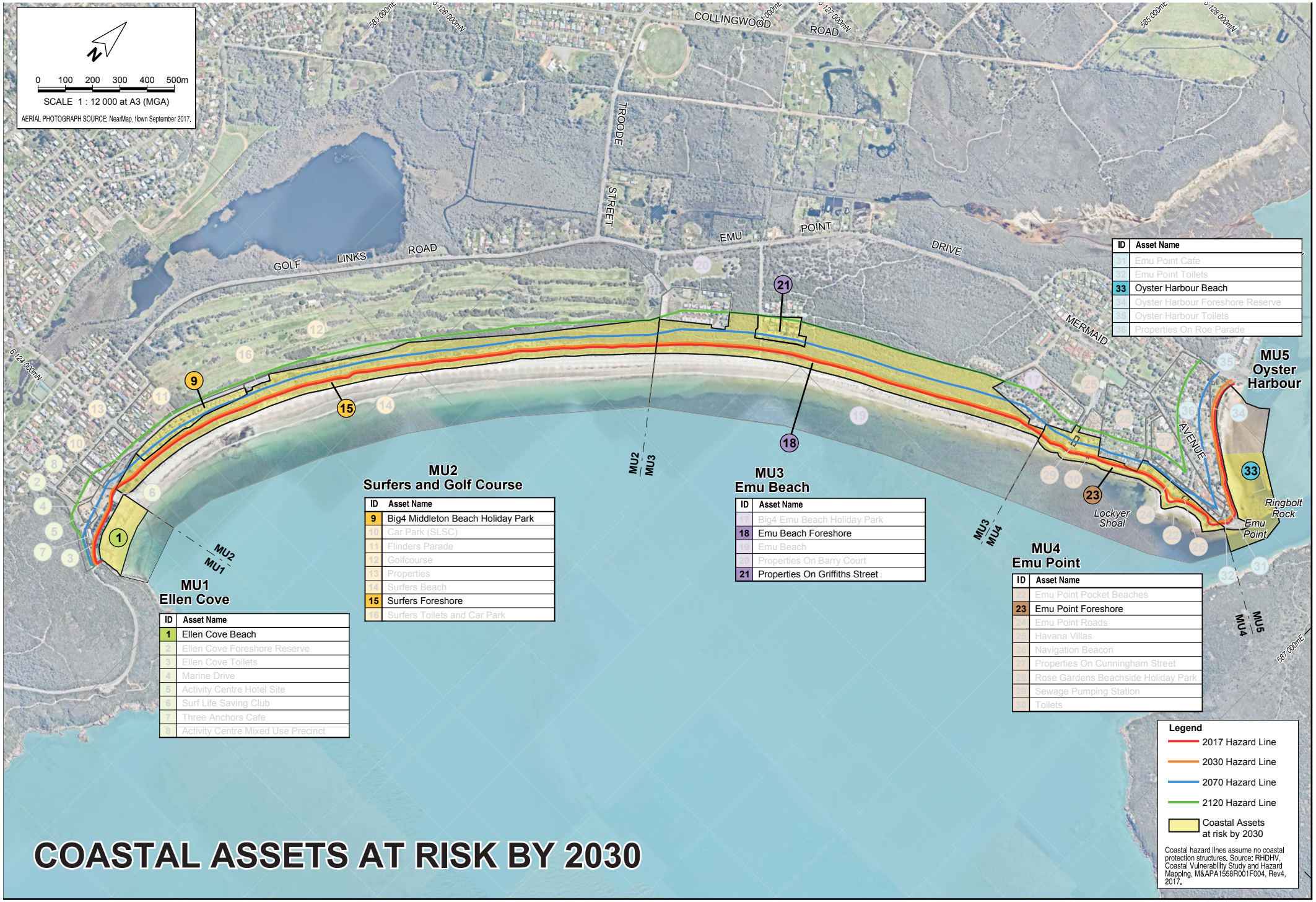


Figure 6.1 - At Risk Assets by 2030

Table 6.1 - Summary of Erosion Vulnerability

Management Unit		Asset	Erosion Vulnerability				Existing Physical Controls
			2017	2030	2070	2120	
1	Ellen Cove	Beach	Extreme	Extreme	Extreme	Extreme	Impact of buried seawall expected to reduce the adaptive capacity to very low.
		Foreshore Reserve	-	-	Extreme	Extreme	***Buried Seawall - Likelihood of erosion hazard mitigated to 2060 through the construction of a buried seawall as part of the MBAC de-velopment as detailed in the draft FMP.
		Toilets	-	-	Extreme	Extreme	
		Three Anchors	-	-	Extreme	Extreme	
		Marine Dr/Adelaide Cr	-	-	Medium	High	
		MBAC Hotel/Mixed Use	-	-	Extreme	Extreme	
		MBAC Mixed Use	-	-	Extreme	Extreme	
		Albany Surf Life Saving Club	-	-	Extreme	Extreme	

Management Unit		Asset	Erosion Vulnerability				Existing Physical Controls
			2017	2030	2070	2120	
2	Surfers & Golf Course	Beach	Low	Medium	Medium	Medium	-
		Foreshore reserve	Medium	High	High	Extreme	-
		Car park (ASLSC)	Low	Low	Medium	High	-
		Properties between Barrett St to Middleton Rd	-	-	Extreme	Extreme	-
		Properties between north of Middleton Road	-	-	Extreme	Extreme	-
		Big4 Middleton Beach Holiday Park	Medium	High	Extreme	Extreme	-
		Flinders Parade (north)	-	-	High	Extreme	-
		Car park (Surfers)	-	-	Low	Low	-
		Toilets (Surfers)	-	-	Extreme	Extreme	-
		Golf Course	-	-	Low	Low	-
3	Emu Point Beach	Beach	Low	Medium	Medium	Medium	-
		Foreshore reserve	Medium	High	High	Extreme	-
		Properties on Barry Court	-	-	Extreme	Extreme	-
		Properties on Griffiths Street	-	Extreme	Extreme	Extreme	-
		Developable land	Low	Low	Low	Low	-
		Emu Beach Holiday Park	Low	Low	Medium	High	-

Management Unit		Asset	Erosion Vulnerability				Existing Physical Controls
			2017	2030	2070	2120	
4	Emu Point	Beach	-	-	High	High	***Detached Breakwater Headland - Based on current condition structure is expected to mitigate the likelihood of coastal erosion over the next 25 years with only routine maintenance required.
		Foreshore reserve (northeast)	-	-	Extreme	Extreme	
		Foreshore reserve (southwest)	-	Extreme	Extreme	Extreme	***Emu Point Rock Revetment - Based on current condition structure expected to mitigate the immediate likelihood of erosion.
		Toilets – Boongarrie S	-	Extreme	Extreme	Extreme	
		Firth St Pumping Station	-	-	Extreme	Extreme	
		Rose Gardens Beachside Holiday Park	-	Low	Medium	Medium	
		Properties on Cunningham St	-	-	Extreme	Extreme	***Detached Breakwater Headland & Southern Groyne - Based on current condition structures are expected to mitigate the likelihood of coastal erosion over the next 25 years with only routine maintenance required.
		Navigation Beacon	-	-	High	High	
5	Oyster Harbour Beach	Oyster Harbour	Medium	Medium	High	High	-
		Beach (northwest)	Medium	Medium	High	High	Impact of grouted retaining wall expected to reduce the adaptive capacity from high to very low.
		Beach (southeast)	Extreme	Extreme	Extreme	Extreme	
		Foreshore reserve (northwest)	-	-	Extreme	Extreme	***Grouted Retaining Wall - Based on current condition structures are expected to mitigate the likelihood of coastal erosion over the next 15 years with only routine maintenance required.
		Foreshore reserve (southeast)	-	-	Extreme	Extreme	***Grouted Retaining Wall, Northern Groyne, Training Wall - Based on current condition structures are expected to mitigate the likelihood of coastal erosion over the next 15 years with only routine maintenance required.
		Emu Point Café	-	-	Extreme	Extreme	
		Properties on Roe Parade	-	-	Extreme	Extreme	***Grouted Retaining Wall - Based on current condition structures are expected to mitigate the likelihood of coastal erosion over the next 15 years with only routine maintenance required.
		Toilets (near boat pens)	-	-	Extreme	Extreme	

Table 6.2 - Summary of Inundation Vulnerability

Management Unit		Asset	Inundation Vulnerability				Existing Physical Controls
			2017	2030	2070	2120	
1	Ellen Cove	Beach	Low	Low	Low	Low	
		Foreshore Reserve	-	Low	Low	Low	
		Toilets	-	-	Medium	High	Redevelopment of the Foreshore area may increase levels and reduce likelihood of inundation. However, as construction is not yet complete any potential reduction in vulnerability has not been assumed.
		Three Anchors	-	-	High	Extreme	
		Albany Surf Life Saving Club	-	-	Medium	High	
2	Surfers & Golf Course	Beach	Low	Low	Low	Low	
		Foreshore reserve	-	-	Low	Low	
		Car park (ASLSC)	-	-	Low	Low	
		Properties between Barrett St to Middleton Rd	-	-	Low	Medium	
3	Emu Point Beach	Beach	Low	Low	Low	Low	
		Foreshore reserve	-	-	Low	Low	
4	Emu Point	Beach	Low	Low	Low	Low	
		Foreshore reserve (northeast)	-	-	Low	Low	
		Navigation Beacon	-	-	Low	Low	

Management Unit		Asset	Erosion Vulnerability				Existing Physical Controls
			2017	2030	2070	2120	
5	Oyster Harbour Beach	Beach (northwest)	Low	Low	Low	Low	
		Beach (southeast)	Low	Low	Low	Low	
		Foreshore reserve (seaward of existing seawall)	-	Low	Low	Low	
		Foreshore reserve (landward of existing seawall)	-	Low	Low	Low	
		Toilets (near boat pens, within northern portion of foreshore reserve)	-	Medium	High	Extreme	

Photo Source: City of Albany

7. Identification of Adaptation Options

There are many different adaptation options which can be applied to reduce the impacts of coastal hazards. Within the CHRMAP process these adaptation options are also termed 'controls' as they act to reduce the risk and vulnerability of coastal assets. This section identifies the range of adaptation options and their applicability across the study area. Both legislative, planning and physical controls have been identified.

Where assets have high or extreme vulnerability in the short-term, management action or planning is likely to be needed now. Short-term options have been considered and shortlisted to inform multi-criteria analysis and targeted stakeholder and community consultation (see Section 8). Shortlisting has been undertaken based on the feasibility and applicability of options to each asset. The results of the stakeholder engagement undertaken (see Sections 3.1 and 4.2) and subsequent discussion with City of Albany staff has informed this shortlisting process. Subsequent long-term pathways will be developed based on the preferred/selected short-term options.

For assets which do not have high or extreme vulnerability in the short-term, it is not appropriate to consider detailed short-term options. Instead long-term pathways and trigger points are considered at the management unit scale. These pathways will inform future monitoring and decision-making (including development of legislative and planning controls).

Typically, triggers relating to coastal hazards are taken from RHDHV (2017) Emu Point to Middleton Beach Coastal Adaptation and Protection Strategy - Coastal Vulnerability Study and Hazard Mapping - Part 1 – Coastal Processes and Hazard Mapping.

However, triggers relating to coastal amenity, primarily reduction in usable beach width at Ellen Cove and Oyster Harbour Beach, were proposed based on an assessment of values undertaken with the communty and consultation with the City.

7.1 HIERARCHY OF CONTROLS

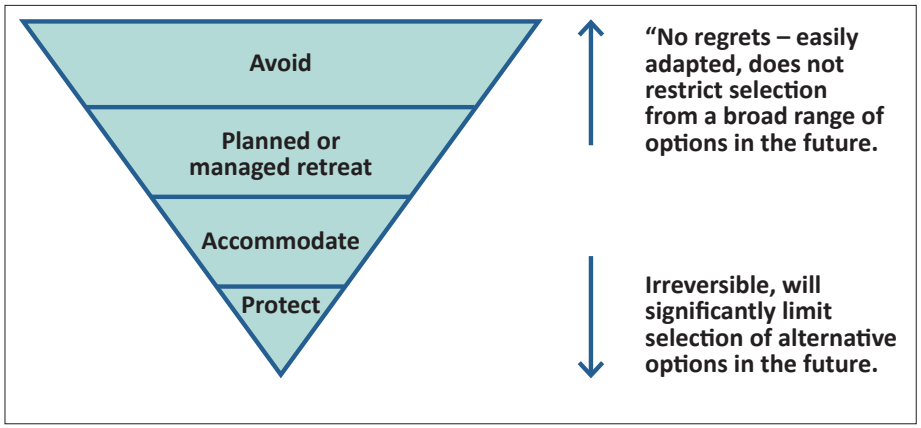
In order to guide the selection of adaptation options SPP 2.6 identifies the hierarchy of controls which are required to be considered on the sequential and preferential order (avoid to protect) (Fgure 7.1):

1. **Avoid** – Options which aim to eliminate the risk of coastal hazards by avoiding development within areas identified as being impacted by erosion or inundation.
2. **Managed Retreat** – Options which allow for the progressive retreat of the shoreline and removal/relocation of development.
3. **Accommodation** – Options which seek to enhance the adaptive capacity and resilience of assets to cope with the temporary impacts of coastal hazard events.
4. **Protection** – Options which seek to artificially protect the coast to reduce the likelihood of coastal hazards impacting on assets.

In interpreting the hierarchy of controls the following guiding principles should be considered:

- Options towards the top of the hierarchy which seek to remove assets from areas at risk should be considered more favourably, as these are the only options which act to eliminate the risk from coastal hazards. At the bottom of the scale, protection options only reduce the likelihood of an event and therefore a residual risk will still exist.
- Adaptation options that allow for a wide range of future options should be considered more favourably compared to those that (either directly or indirectly) limit future risk management options. These options are often referred to as 'no-regrets' options.

Figure 7.1 Hierarchy Of Management Controls



7.2 RANGE OF ADAPTATION OPTIONS

Within the hierarchy of controls there are a number of different adaptation options which can be applied to reduce the impacts from coastal hazards. These are broadly listed in Table 7.1 and are discussed in detail for each management unit and vulnerable asset in the following sections. In many cases options can be combined to improve the outcome.

Table 7.1 - Types Of Adaptation Options

Hierarchy	Option	Adaptation Options - General Description
Avoid	AV1. Avoid new development in undeveloped areas impacted by coastal hazards	Locate new assets in areas not likely to be subject to coastal hazards. Allows for the natural recession and realignment of the shoreline over the long-term. Requires clear legislative direction to deter further development activity.
	AV2. Avoid further development in existing developed areas impacted by coastal hazards	Prevent further development, prohibit expansion of existing use rights. Aims to prevent increases in the consequence of coastal hazards. Requires clear legislative direction to deter further development activity.
Retreat	MR1. Leave assets unprotected	Accept losses during/following a hazard event. Requires emergency management to maintain public safety pre/post event. Requires assets to be removed when they are no longer safe to use. Private assets condemned when no longer habitable (unsafe or unable to be serviced by utilities or road). Allows for the natural recession and realignment of the shoreline.
	MR2. Relocate assets	Progressively remove/relocate assets at risk from coastal hazards. Requires changing or removing land use rights. Existing private development may require compensation and/or incentives. Can allow for the progressive recession of natural assets (e.g. beach/ foreshore/ wetlands).
	MR3. Removal of protection structures	Removal of coastal protection structures to allow the shoreline to return to a natural equilibrium. May also require implementation of option MR1 and MR2. Eliminates ongoing maintenance cost and management responsibilities associated with structures. Allows for the natural recession and realignment

Hierarchy	Option	Adaptation Options - General Description
Accomm-odate	AC1. Design assets to withstand impacts	Construct new assets or modify existing assets to accommodate the impacts of temporary erosion and/or inundation events. Aims to increase the adaptive capacity of built assets.
	AC2. Maintain and enhance beach system	Beach scraping or back passing to move sand from accreting areas to eroding areas. Preserves or enhances the beach's ability to absorb the impacts of storm events and/or assists in post storm recovery. Aims to increase the resilience of the natural beach system
	AC3. Maintain and enhance dune system	Dune management, including management of access tracks, control of dune blowouts, revegetation, sand fencing. Preserves and enhances the dune's ability to absorb the impacts of storm events and provide a source of sand for beach recovery. Aims to increase the resilience of the natural beach and dune system.
	AC4. Maintain and enhance nearshore system – Seagrass regeneration	Increase seagrass density, may include replanting or the placement of sand off-shore to accelerate growth and/or the formation of natural bars/shoals. Aims to dampen incoming wave energy and encourage the natural accretion of sediments. Aims to increase the resilience of the natural beach system to assist in absorbing the impact of storm events and post storm recovery.
	AC4. Maintain and enhance nearshore system – Seagrass regeneration	Increase seagrass density, may include replanting or the placement of sand off-shore to accelerate growth and/or the formation of natural bars/shoals. Aims to dampen incoming wave energy and encourage the natural accretion of sediments. Aims to increase the resilience of the natural beach system to assist in absorbing the impact of storm events and post storm recovery.
	AC5. Beach dewatering	Lowering of the ground water table at the back of the beach face to promote the accretion of sand. Requires the installation of drains at the back of the beach and a pumping system. Aims to promote the accretion of the beach and increase its capacity to absorb the impacts of storm events.

Hierarchy	Option	Adaptation Options - General Description
Protect	PR1. Sand nourishment	Placement of large volumes of sand on the beach, dunes or nearshore. May be undertaken pre/post storm event. Requires available sources of compatible sand. Aims to restore or enhance the beach profile to provide a natural buffer to absorb the impacts of storm events.
	PR2. Offshore structures – artificial reefs/shoals	Larger submerged structures, placed further off-shore, which aim to dampen wave energy similar to natural reefs and reduce the impacts of storm events. Typical construction materials are rock, concrete, or geotextile sand filled tubes. May have a negative impact on the adjoining shoreline.
	PR3. Offshore structures – detached breakwaters/ headlands	Large structures, visible above the waterline placed some distance off-shore. Typical construction materials are rock or geotextile sand filled tubes. In comparison to option PR2, typically require significantly more construction materials. Aims to stop/redirect incoming waves to capture/retain sand at the beach and improve the capacity of the beach system to absorb the impacts of storm events. May have a negative impact on the adjoining shoreline.
	PR4. Nearshore structures – breakwaters/ headlands	Large structures placed in shallow water zone, attached to land by a sand spit that may generally stay dry or be regularly wet by medium to high tides. Typical construction materials are rock or geotextile sand filled tubes. Aims to stop/redirect incoming waves to capture/retain sand at the beach and improve the capacity of the beach system to absorb the impacts of storm events. May have a negative impact on the adjoining shoreline.
	PR5. Nearshore structures – groynes	Shore perpendicular structures which extend into the water. Range of construction materials (incl. rock, concrete, steel sheet pile, timber, geotextile sand filled tubes/bags). Aim to trap sand moving along the coast and retain a natural buffer to assist in absorbing the impacts of storm events. May have a negative impact on the adjoining shoreline.
	PR6. Levees/dykes	Artificial barrier aimed to prevent inundation. Typically constructed as a large earth mound. May have a negative impact on the adjoining shoreline and/or beach due to medium to long term reduction of sandy beaches, may have a negative visual impact on long range water views from inland assets
	PR7. Seawalls/revetments	Structure providing a fixed barrier to coastal erosion. May be “active” in contact with ocean or “passive” and buried as a last line of defence. May be designed with a raised crest to also protect against inundation. Range of construction materials (incl. rock, concrete, steel sheet pile, timber, geotextile sand filled tubes/bags). May have a negative impact on the adjoining shoreline and/or beach due to medium to long term reduction of sandy beaches (hard landscaped waterfronts).
	PR8. Storm surge barriers	Artificial barrier designed to be closed during a storm event to prevent high ocean water levels entering an estuary or inlet. May have a negative visual impact.
	PR9. Upgrade of existing protection structures	Reassessment of design conditions for existing coastal protection structures and refurbish/upgrade for long-term design conditions.

Following review of these options for the study area and in consultation with the City of Albany, options AV1, MR3, AC5, PR6 and PR8 were not considered appropriate for a variety of reasons. Table 7.2 provides the explanation for removing these options in the short term.

Table 7.2 - Adaptation Options Not Considered Appropriate For Study Area

Hierarchy	Option	Reason For Removing Option
Avoid	AV1. Avoid new development in undeveloped areas impacted by coastal hazards	This option applies to identified land/assets which are identified as vulnerable. 'New' development does not yet exist and as such cannot be identified as at-risk. Existing planning controls (SPP2.6) will capture new subdivisional development. This option is applied generally by using hazard information to identify undeveloped areas that may be suitable for future development. Any potential new development areas would be covered by development of legislative controls as part of a decision to implement AV2 (e.g. constraintson built form).
Retreat	MR3. Removal of protection structures	Not considered an option in isolation due to public liability and community safety concerns. Could be implemented as part of a larger decision to implement MR1 or MR2.
Accommodate	AC5. Beach dewatering	Technical feasibility of the option in this location is uncertain. Requires installation of significant drainage and pumping infrastructure to be run frequently and in perpetuity.
Protect	PR6. Levees/ dykes	Does not suit this study area as primary issue is erosion, with inundation a secondary factor. Does not meet community value expectations around natural vegetation foreshores.
	PR8. Storm surge barriers	Does not suit this study area as primary issue is erosion, with inundation a secondary factor. Would only benefit a small section of Oyster Harbour foreshore at long-term timeframes.

7.3 SHORT-TERM (0-10 YEARS) ADAPTATION OPTIONS

Short-term adaptation options have been listed by management unit for each of the assets identified as having a high or extreme vulnerability in the short-term. All options except the five removed have been considered for each asset.

Options that are dentified as technically feasible, applicable to the asset and acceptable to the City and Community have been shortlisted and identified for further consideration by multi-criteria analysis (Section 8).

7.3.1 MU1 Ellen Cove

Due to the proposed construction of the buried seawall, the only key asset identified as vulnerable in the short-term is the sandy portion of the beach. The beach is currently stable and benefits from being in the shelter of the large headland (Wooding Point). However, the presence of the seawall will act to reduce the adaptive capacity of the beach. Should the seawall become exposed during a severe event it may accelerate loss of the beach and restrict the natural ability of the beach to recover post-storm.

In the short-term this is unlikely to result in the total loss of the beach but may result in the exposure of the seawall and a reduction in the beach width and/or height. It is acknowledged the City is likely to adopt a soft protection approach of sand nourishment (Option AC2, Figure 7.2 and/or PR1, Figure 7.3) after severe erosion events to maintain a sandy beach. Short-term adaptation options are listed in the following table.

Figure 7.2 - MU1 Beach – Shortlisted Option AC2: Maintain And Enhance Beach System

Sand excavation undertaken regularly at Lancelin Jetty and trucking of sand along the beach at the Gold Coast. Photo Source: Evo Coast

Figure 7.3 - MU1 Beach – Shortlisted Option PR1: Sand Nourishment

Sand nourishment works at Mandurah Photo Source: Evo Coast

Table 7.3 - MU1 Beach Short-Term (0-10 years) Adaptation Options

Option	Description Of Application To Asset – MU1: Beach	Shortlist
AV2. Avoid further development in existing developed areas impacted by coastal hazards	N/A - further development and intensification of land use already approved.	No
MR1. Leave assets unprotected	Based on results of community values assessment not consider an acceptable option for the beach at Ellen Cove because: • It is essentially a 'do nothing' option and would leave the beach unprotected and require progressive removal or modification of temporary assets as they are impacted (swimming enclosure, volley ball courts). • It would essentially accept the progressive reduction in the beach width and height until no dry sandy beach present. • It would essentially accept likely future exposure of the buried seawall.	No
MR2. Relocate assets	Based on results of stakeholder engagement it is not considered an acceptable option for there to be no accessible beach at Ellen Cove.	No
AC1. Design assets to withstand impacts	Not feasible for beach as a natural asset.	No
AC2. Maintain and enhance beach system	Undertake beach scraping to move sand from the beach face, nearshore areas and adjacent beach to the back of the beach after storm events to enhance beach recovery. The trade-offs are: • Accessible dry sandy beach maintained. • Access to water provided by beach. • Suits a preference for a natural vista. • Limited to smaller volumes of sand. • Could be detrimental to beach area where sand is sourced. Requires ongoing costs of plant and equipment mobilisation and demobilisation (and requires relevant plant to be available in a timely manner).	Yes
AC3. Maintain and enhance dune system	N/A – existing seawalls rather than natural dune system.	No

Option	Description Of Application To Asset – MU1: Beach	Shortlist
AC4. Maintain and enhance nearshore system – Seagrass regeneration	N/A for MU1 - seagrass system not identified as key sediment control.	No
PR1. Sand nourishment	Placement of a larger volume of sand on the beach to reinstate the beach profile. Typically triggered by erosion following a severe storm event(s) Requires a compatible sand source. This may be inland, marine or other areas of the beach which are experiencing accretion. Initially sufficient volumes may be available within study area but in medium to longer-term likely to need external source. Trade-offs: • Accessible dry sandy beach maintained. • Access to water provided by beach. • Suits a preference for a natural vista. • Requires suitable source with significant quantities. • Requires ongoing costs of plant and equipment mobilisation and demobilisation (and requires relevant plant to be available in a timely manner). • Results in additional truck movements in and out of the area.	Yes Yes
PR2. Offshore structures – artificial reefs/shoals	Not required with buried seawall, and sand nourishment undertaken as required.	No
PR3. Offshore structures – detached breakwaters/ headlands	Not required with buried seawall, and sand nourishment undertaken as required.	No
PR4. Nearshore structures – breakwaters/ headlands	Not required with buried seawall, and sand nourishment undertaken as required.	No
PR5. Nearshore structures – groynes	Not required with buried seawall, and sand nourishment undertaken as required.	No
PR7. Seawalls/revetments	Buried seawall already implemented with effect on the beach considered and planned for.	No
PR9. Upgrade of existing protection structures	N/A – buried seawall design considers likely conditions for next 50 years.	No

7.3.2 MU2 Surfers & Golf Course

Within the Surfers and Golf Course management unit the assets identified as vulnerable in the short-term are the **foreshore reserve** and tourist facility **Big4 Middleton Beach Holiday Park**. Although the Big4 Middleton Beach Holiday Park was only found to have a rare likelihood of being impacted by erosion in the short-term, the asset was identified as having a low adaptive capacity due to current built form and narrow footprint, resulting in a high vulnerability. The Big4 Middleton Beach Holiday Park is situated on a Crown Reserve which is leased to operators by the City. Consequently, adaptation options have been considered in context of the lease as an existing control.

The foreshore reserve was also found to have a high vulnerability, influenced by its relatively narrow footprint, in particular through the southern portion where it is backed by the Big4 Middleton Beach Holiday Park. However, the beach and foreshore area within the management unit has been steadily accreting over the past decades following significant erosion during a period of severe storms in the 1970s and 1980s. This indicates a natural onshore feed of sediment. As a result, there is a significant dune buffer through much of the management unit which provides natural protection against the impacts of coastal hazards and allows for the post storm recovery of the beach. Over the short-term it is expected that the beach and foreshore will continue to follow an accretion trend with the natural ability to recover after a storm event.

Given the difference in the assets, adaptation options are listed separately for each asset. Adaptation options MU2 Foreshore are shown in Table 7.4 and presented in Figures 7.4, 7.5 and 7.6 and adaptation options for MU2 Big4 Middleton Beach are shown in Table 7.5 and presented in Figures 7.4, 7.7, 7.8 and 7.9.

Figure 7.4 - MU2 Foreshore – Shortlisted Option Av2 Avoid Further Development In Existing Developed Areas

Source: GHD

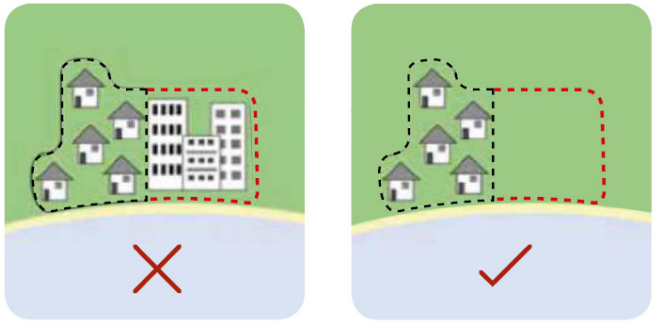


Figure 7.5 - MU2 Foreshore – Shortlisted Option Mr1 Leave Assets Unprotected

Erosion of an unprotected foreshore reserve at Seabird. Photo Source: Evo Coast

Figure 7.6 - MU2 Foreshore – Shortlisted Option AC3: Maintain And Enhance Dune System

Sand fencing of dune access track and associated revegetation at Rottnest Island.

Photo Source: Evo Coast

Table 7.4: MU2 Foreshore Short-Term (0-10 Years) Adaptation Options

Option	Description Of Application To Asset - MU2: Foreshore	Shortlist
AV2. Avoid further development in existing developed areas impacted by coastal hazards	New assets compatible with the foreshore land use (e.g. shared paths, car parks, viewing platforms etc.) be sited and designed to allow for the intermediate erosion cycles. Requires appropriate legislative controls through the planning system and may include Special Control Areas or Foreshore Management Plans with ongoing funding arrangements linked to rates and other sources. Could be linked to responses under MR1 and MR2 for asset replacement. Trade-offs: • Minimises value at risk. • Provides for ongoing use of low-value assets until impacted. • Provides for ongoing use of existing assets until hazards are imminent. • May require urgent monitoring and action during or after a severe event. • May require preparation of emergency plans for some public assets. • Requires strong commitment to retaining existing natural areas and deterring incremental redevelopment.	Yes
MR1. Leave assets unprotected	"Do nothing" option. Allow the foreshore to naturally recede and change. Suitable for low-value assets (e.g. fencing, dual use paths) where the risk to public can be adequately managed during/after a storm event. Requires an appropriate management strategy potentially including an emergency management plan. A foreshore management plan may be an option linked with appropriate funding for staged relocation of low-value assets. Acceptable because this MU has an accretion trend. Trade-offs: • Provides for ongoing use of low-value assets until impacted. • Provides for ongoing use of existing assets until hazards are imminent. • May require urgent monitoring and action during or after a severe event. • May require preparation of emergency plans for some public assets.	Yes

Option	Description Of Application To Asset - MU2: Foreshore	Shortlist
MR2. Relocate assets	Not feasible to relocate foreshore landward where it is backed by Big 4 Holiday Park, as decision making regarding this asset will control the possibilities.	No
AC1. Design assets to withstand impacts	Not feasible for foreshore as a natural asset.	No
AC2. Maintain and enhance beach system	Not feasible for foreshore. See AC3.	No
AC3. Maintain and enhance dune system	Manage beach access track to prevent erosion or degradation of the dunes. Regular replanting opportunities and partnerships with Coast Care groups Trade-offs: • Accessible foreshore reserve maintained. • Access to beach provided through reserve. • Suits a preference for a natural vista. • Limited to lower erosion vulnerability scenarios.	Yes
AC4. Maintain and enhance nearshore system – Seagrass regeneration	N/A for MU2 - seagrass system not identified as key sediment control.	No
PR1. Sand nourishment	Not required for this foreshore, because this MU has accretion trend.	No
PR2, PR3, PR4, PR5, PR7 Coastal protection structures	Not considered applicable for this foreshore because: • This MU has accretion trend. • Stakeholder engagement has identified natural beach and foreshore as highly valued at this MU. • No long-term plan identified for high levels of development of land behind this foreshore (as compared to Ellen Cove).	No
PR9. Upgrade of existing protection structures	N/A	No

Figure 7.7 - MU2 Big 4 Middleton Beach Holiday Park – Shortlisted Option MR1. Leave Assets Unprotected

Beach erosion at Nobby Beach (Source: ABC, 2018).

Figure 7.8 - MU2 Big 4 Middleton Beach Holiday Park – Shortlisted Option PR7: Buried Seawall

Buried seawall at the Gold Coast under construction (Source: Coast to Coast 2018).

Figure 7.9 - MU2 Big 4 Middleton Beach Holiday Park – Shortlisted Option MR2 Relocate Assets

Relocation of holiday accommodation at Busselton between November 2015 (Left) and November 2017 (Right). Source: Evo Coast

Table 7.5 - MU2 Big4 Middleton Beach Holiday Park Short-Term (0-10 Years) Adaptation Options

Option	Description Of Application To Asset - MU2 Big4 Middleton Beach Holiday Park	SHORTLIST
AV2. Avoid further development in existing developed areas impacted by coastal hazards	Allow continued use of land until impacts are imminent. Restrict further development of infrastructure/assets within the seaward portion of the lease area using lease conditions. Do not allow increase in density. Requires development of an emergency management plan. Site new assets on the least vulnerable portions of the lease area and all infrastructure perpendicular to the coastline to allow for staged retreat Do not enhance land use rights, e.g. do not rezone land to freehold in future. Ensure lessee and prospective future lessees are made aware of the risk. Requires appropriate legislative controls through the planning system; may include Special Control Areas and/or Foreshore Management Plans. Could be linked to responses under MR1 and MR2 for asset replacement. Trade-offs: • Minimises value at risk. • Provides for ongoing use of existing assets until hazards are imminent. • May require urgent monitoring and action during or after a severe event. • May require preparation of emergency plans. • Requires strong commitment to collaborating with the operator and controlling development activities and management of existing natural areas.	Yes

Option	Description Of Application To Asset - MU2 Big4 Middleton Beach Holiday Park	SHORTLIST
MR1. Leave assets unprotected	'Do nothing' option. Accept losses during/following a hazard event. Implement emergency management to maintain public safety pre/post event. Requires assets to be removed when they are no longer safe to use. Trade-offs: • Provides for ongoing use of existing assets until hazards are imminent and requires a private entity to accept risk/loss. • Requires a partnership arrangement between landowner and leaseholder. • May require urgent monitoring and action during or after a severe event, in line with emergency management plans, including urgent removal of damaged assets – e.g. buildings collapsed onto beach or into ocean. • Does not provide for much time to coordinate removal of assets.	Yes
MR2. Relocate assets	Progressively remove/relocate assets at risk from coastal hazards. Requires appropriate legislative controls through the planning system to enforce relocation in private property; may include Special Control Areas and/or Foreshore Management Plans developed in conjunction with the lessee, with ongoing funding arrangement agreed. May require early termination of the lease, modifications or changes to the lease area. Requires maintaining a minimum setback from the back of the beach (start of vegetation) to built assets of nominally 35m (S1 distance). Trade-offs: • Provides for ongoing use of existing assets until coastal hazard risk becomes unacceptable. • Provides for time to coordinate removal of assets – allowing deconstruction, not removal of damaged assets. • The cost of relocation may be unviable and result in loss of a caravan park for the City. • Requires development of a staging and design strategy that reduces longer term risk. • Requires ongoing funding to ensure care, control and maintenance.	Yes

Option	Description Of Application To Asset - MU2 Big4 Middleton Beach Holiday Park	Shortlist
AC1. Design assets to withstand impacts	Not possible to design land parcels against erosion.	No
AC2. Maintain and enhance beach system	N/A – Included in options for foreshore which is in front of Holiday Park	No
AC3. Maintain and enhance dune system	N/A – Included in options for foreshore which is in front of Holiday Park	No
AC4. Maintain and enhance nearshore system – Seagrass regeneration	N/A for MU2 - seagrass system not identified as key sediment control.	No
PR1. Sand nourishment	N/A – Included in options for foreshore which is in front of Holiday Park	No
PR2, PR3, PR4, PR5 Coastal protection structures	Not considered applicable for this asset because: This MU has accretion trend. Stakeholder engagement has identified natural beach and foreshore as highly valued at this MU. No long-term plan identified for high levels of development of land behind this foreshore (as compared to Ellen Cove).	No

Option	Description Of Application To Asset - MU2 Big4 Middleton Beach Holiday Park	Shortlist
PR7. Seawalls/revetments	Construct a buried seawall to act as a last line of defence in the event of severe erosion. This could be along lease boundary or within foreshore reserve. If exposed the seawall may have a negative impact on the shoreline to the south and inhibit the natural recovery of the beach. Wall could be a temporary structure (e.g. sandbags) to allow time to implement another planned option. Trade-offs: • Provides for ongoing use of existing assets. • Likely to result in loss of sandy beach in front of the wall – resulting in no accessible beach. • May limit public access to foreshore – depends on where it would be built. • Likely to shift erosion problem to adjacent beach in future. • Requires ongoing funding to ensure care, control and maintenance. • May have a negative visual impact. • Potential negative impacts on the adjacent environment.	Yes
PR9. Upgrade of existing protection structures	N/A – no protection structures exist within management unit.	No

7.3.3 MU3 Emu Point Beach

Within the Emu Point Beach management unit, the assets identified as vulnerable in the short-term were the freehold properties at Griffiths Street and the foreshore reserve.

The properties on Griffiths Street are currently not vulnerable and only have a rare likelihood of being impacted by 2030. However, once impacted these assets have a significant financial and social consequence and also have a very low adaptive capacity, resulting in an extreme vulnerability by 2030. This indicates the need for early adaptation planning. Griffiths Street is on the seaward side of the properties and in addition to providing access, utilities are located within the road reserve. Consequently, the properties will be impacted as soon as the road is impacted.

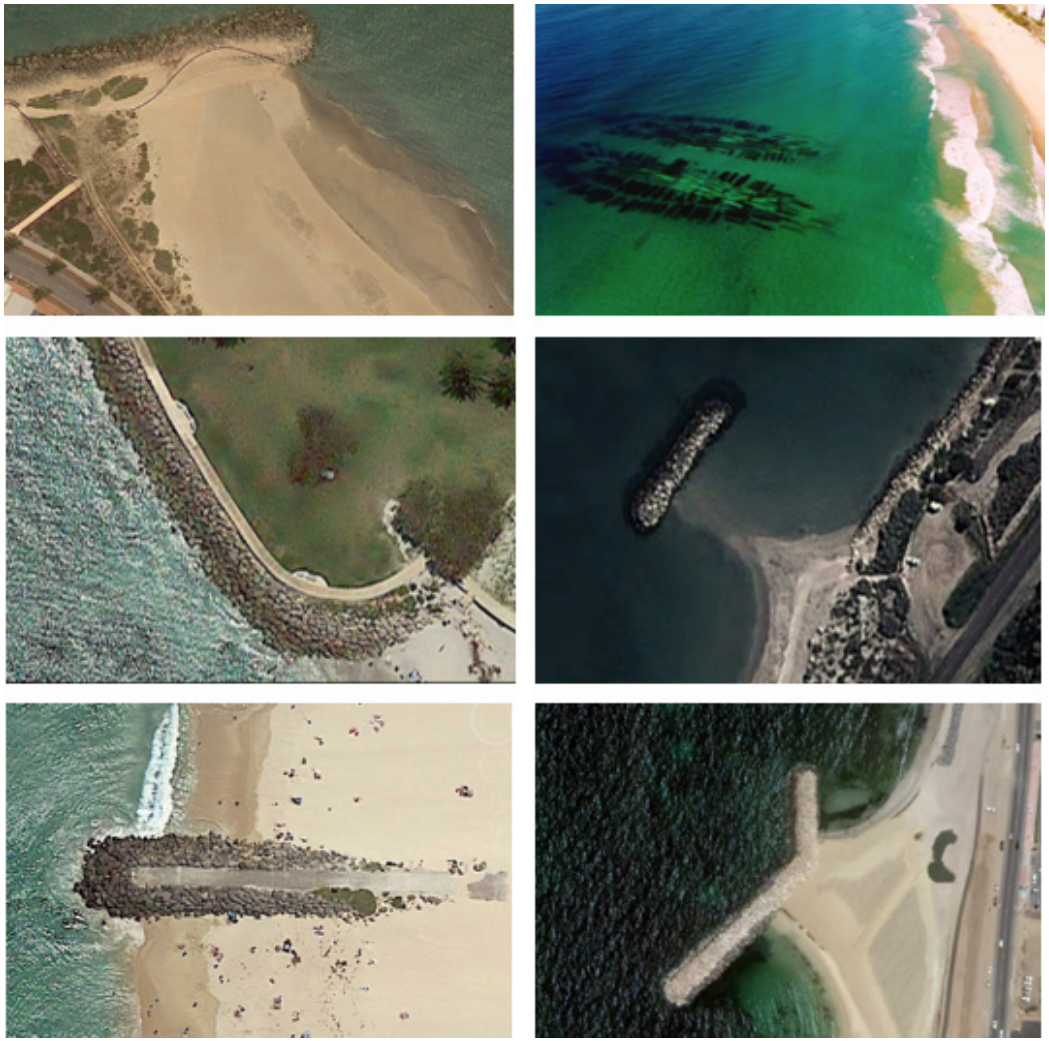
The foreshore reserve transitions from a stable accreting shoreline in the southern end of the management unit, with a natural ability to recover post storm event (similar to MU2 - refer to previous section), to the area adjacent to the eroded foreshore reserve at the end of the Emu Point revetment. Given the interconnectedness of the sea wall and the foreshore to the south, options are considered as part of the management of the Emu Point southwest foreshore reserve – please see Table 7.6. Figures 7.10 and 7.11 present the shortlisted options.

NB: It should be noted that Table 7.6 does not recommend Option AV2 be shortlisted. This is specific to this collection of 'at-risk assets' as the actions associated with AV2 would be incorporated within any other managed retreat option (MR) and potentially within some of the accommodate (AC) options to manage residual risk. However, it is relevant to note that avoidance of any further development within the at-risk areas is a desirable outcome.

Figure 7.10 - MU3 Properties On Griffiths Street – Shortlisted Option MR2. Relocate Assets

Above: Relocation of houses in the United Kingdom (Source: EADT, 2013).

Figure 7.11 - MU3 Properties On Griffiths Street – Shortlisted Options PR1, PR2, PR3, PR4, PR5, PR7



Right: Clockwise from top left: PR1 Sand nourishment; PR2 artificial reef; PR3 detached offshore breakwaters; PR4 Attached onshore breakwaters/ headlands; PR5 beach groynes and PR7 seawall.

Source: Unknown

Table 7.6 - MU3 Properties On Griffiths Street Short-Term (0-10 Years) Adaptation Options

Option	Description Of Application To Asset - MU3: Properties On Griffiths Street	Shortlist
AV2. Avoid further development in existing developed areas impacted by coastal hazards	This option applies to all developed sections of the study area shown to be vulnerable to the impacts of coastal hazards over the planning timeframe. It could complement several other options but does not address coastal hazard risk in its own right. Requires appropriate legislative controls through the planning system; may include Special Control Areas and/or Foreshore Management Plans that do not enhance land use rights, such as rezoning land for increased development density. Requires ongoing funding arrangements linked to rates and other sources. Restrict the development of further infrastructure, particularly infrastructure which is parallel to the coast. Ensure landowner and prospective future buyers are made aware of the risk through restrictive covenants or notifications on titles. Trade-offs: • Provides for ongoing use of existing assets until hazards are imminent. • May require urgent monitoring and action during or after a severe event. • May require preparation of emergency plans. • Requires strong commitment to collaborating with landowners and providing alternatives including buy-back schemes and compensation.	No
MR1. Leave assets unprotected	'Do nothing' option. Accept losses during/following a hazard event. Requires emergency management to maintain public safety pre/post event. Not considered applicable because: Requires assets to be removed when they are no longer safe to use – this can be part of MR2. First row of properties likely to be condemned and require removal when erosion reaches Griffiths Street. But implementation likely to be a slow process – more appropriate under MR2. Allows for the natural recession and realignment of the shoreline – this can be incorporated in MR2.	No

Option	Description Of Application To Asset - MU3: Properties On Griffiths Street	Shortlist
MR2. Relocate assets	Plan to progressively remove assets as they become at risk from coastal hazards. In the first instance this would require the removal of the seaward portion of Griffiths Street and buy-back of the first row of properties. Requires appropriate legislative controls through the planning system to enforce relocation in private property; may include Special Control Areas and/or Foreshore Management Plans developed in conjunction with the lessee, with ongoing funding arrangement agreed. Allows for the progressive recession of the beach and foreshore. As land is freehold it is important to start planning as early as possible. Trade-offs: • Provides for ongoing use of existing assets until coastal hazard risk becomes unacceptable. • Provides for time to coordinate removal of assets – allowing deconstruction, not removal of damaged assets. • Requires ongoing funding to ensure care, control and maintenance.	Yes
AC1. Design assets to withstand impacts	Not possible to design land parcels against erosion.	No
AC2. Maintain and enhance beach system	Not possible to be undertaken at large enough scale to address erosion risk to properties.	No
AC3. Maintain and enhance dune system	Not possible to be undertaken at large enough scale to address erosion risk to properties.	No
AC4. Maintain and enhance nearshore system – Seagrass regeneration	N/A for MU3 - seagrass system not identified as key sediment control.	No

Option	Description Of Application To Asset - MU3: Properties On Griffiths Street	Shortlist
PR1, PR2, PR3, PR4, PR5, PR7 Coastal protection structures	Construction of protection structures. A variety of different options exist for protecting the shoreline including nearshore and off-shore headlands, groynes and seawalls. Structures are likely to have a negative impact on the shoreline to the south. Does not allow for the natural recession of the beach and foreshore. Implementation needs to consider if protection would be undertaken early to ensure a large width of foreshore reserve is also protected; or undertaken later so that only a narrow width of foreshore reserve is provided into the future. Trade-offs: • Provides for ongoing use of existing assets. • Very expensive to install and maintain – raises issue of who pays. • Option PR7 likely to result in loss of sandy beach in front of the wall – resulting in no accessible beach. • Option PR5 may limit beach amenity by interrupting pedestrian access between groynes. • Often considered to interrupt natural vista of beach and ocean setting and creates barriers along the beach for walkers etc. • Requires ongoing funding to ensure care, control and maintenance. Depending on the grouped options, may require ongoing costs of plant and equipment mobilisation and demobilisation (and requires relevant plant to be available in a timely manner). • Depending on the grouped options, may require a number of additional truck movements through the area. • Some options may result in a negative visual impact. • Potential negative impacts on the adjacent environment.	Yes
PR9. Upgrade of existing protection structures	N/A – no protection structures exist within management unit.	No

7.3.4 MU4 Emu Point

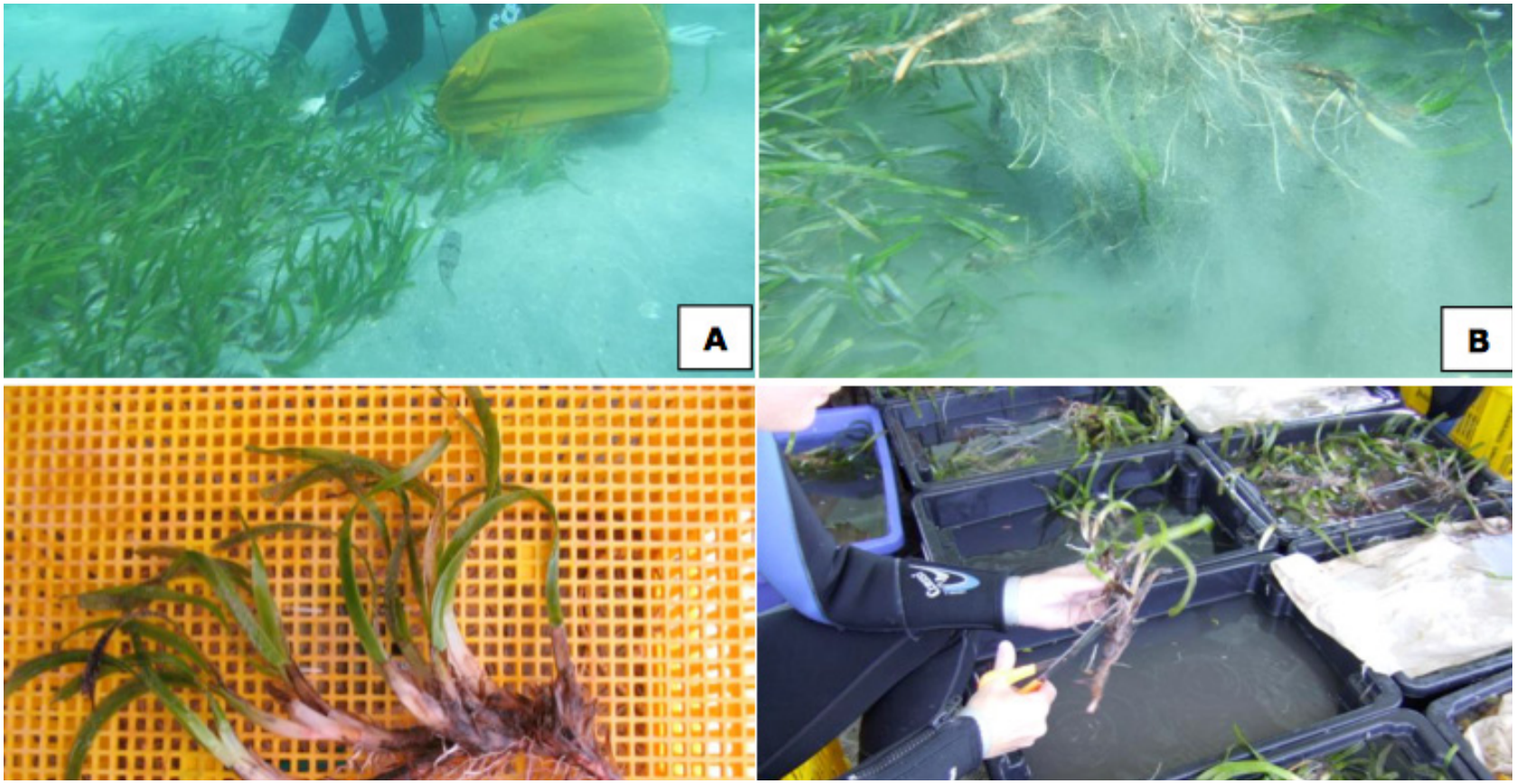
The southwest foreshore reserve and toilet block (near the end of Firth Street) within the Emu Point management unit have been identified as extremely vulnerable in the short term. Adaptation options for this section of coast are known to directly impact the adjacent foreshore reserve in the Emu Point Beach management unit to the south west. As such, the influence of options on the **MU3 foreshore** is also considered.

The main existing control structure is the rock revetment, which provides immediate protection but is in poor condition and requires significant repairs. It has been assumed there is no “do nothing” option as that would result in the progressive failure of the revetment.

A review of protection options was completed by URS (2012) and this work is still considered a valid representation of the range of protection options. As the toilet block is publicly owned and within the foreshore reserve, options for the assets have been jointly considered.

Adaptation options for MU4 Emu Point are shown in Table 7.7 and presented in Figures 7.13, 7.14 and 7.15.

Figure 7.12 - MU3 Foreshore Reserve, MU4 Southwest Foreshore Reserve And Toilet Block – Shortlisted Option AC4: Maintain And Enhance Nearshore System



Seagrass regeneration (BMT, Oceanica 2013).

Figure 7.13 - MU3 Foreshore Reserve, MU4 Southwest Foreshore Reserve And Toilet Block – Shortlisted Option MR2: Relocate Assets

Erosion hazard lines from RHDHV (2017) depicting potential future erosion if the existing coastal protection structures were removed. Foreshore assets would need to be relocated in accordance with triggers before they are impacted.

Figure 7.14 - MU3 Foreshore Reserve, MU4 Southwest Foreshore Reserve And Toilet Block – Shortlisted Options PR1, PR3, PR4, PR7, PR9.

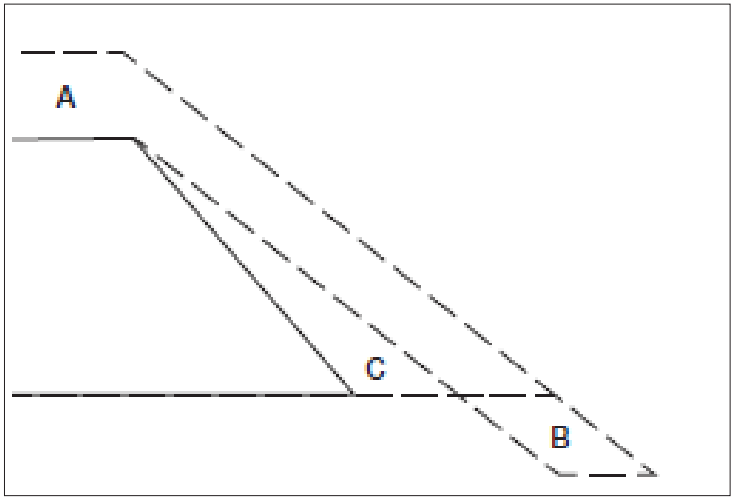
Above: PR1 Sand nourishment - Concept scheme (URS, 2012d)

Left: PR3 Offshore Structures/breakwaters - Concept scheme (URS, 2012d)

Figure 7.15 - MU3 Foreshore Reserve, Mu4 Southwest Foreshore Reserve And Toilet Block – Shortlisted Options PR1, PR3, PR4, PR7, PR9.

Right: PR4 Nearshore Breakwaters - Concept scheme (URS, 2012d)

Below Left: PR7 Seawall Revetments with landscaped park (Landscape Australia, 2018)



Right: PR9 (EAC/change adaptation guidelines, 2012) Potential design changes for seawall revetment to provide a design life for the medium to long term – (A) raising crest; (B) increased toe protection; (C) slope modifications.

Table 7.7 - MU3 Foreshore Reserve And MU4 Southwest Foreshore Reserve And Toilet Block Short-Term (0-10 Years) Adaptation Options

Option	Description Of Application To Asset - MU3: Foreshore Reserve, And MU4: Southwest Foreshore Reserve And Toilet Block	Shortlist
AV2. Avoid further development in existing developed areas impacted by coastal hazards	This option applies to all developed sections of the study area shown to be vulnerable to the impacts of coastal hazards over the planning timeframe. It could complement several other options but does not address coastal hazard risk in its own right. Requires appropriate legislative controls through the planning system and may include Special Control Areas or Foreshore Management Plans with ongoing funding arrangements linked to rates and other sources. Could be linked to responses under MR1 and MR2 for asset replacement. Trade-offs: • Minimises value at risk. • Provides for ongoing use of low-value assets until impacted. • Provides for ongoing use of existing assets until hazards are imminent. • May require urgent monitoring and action during or after a severe event. • May require preparation of emergency plans for some public assets. • Requires strong commitment to retaining existing natural areas and deterring incremental redevelopment	No
MR1. Leave assets unprotected	N/A assets already protected by structures. The option for removing the existing structures is considered as part of MR2 below.	No

Option	Description Of Application To Asset - MU3: Foreshore Reserve, And MU4: Southwest Foreshore Reserve And Toilet Block	Shortlist
MR2. Relocate assets	Feasible for toilet block. More difficult for Foreshore Reserve. Could include removal of existing revetment, but revetment could not be removed without relocating several assets. Requires ongoing funding to ensure care, control and maintenance. Alternatively, this option could be combined with the installation of protection options. Allow shoreline to naturally retreat. Requires appropriate legislative controls through the planning system; may include Special Control Areas and/or Foreshore Management Plans. Trade-offs: • Minimises value at risk. • Provides for ongoing use of existing assets until coastal hazard risk becomes unacceptable, or low-value assets are impacted. • Provides for time to coordinate removal of assets – allowing deconstruction, not removal of damaged assets. • Requires development of a staging and design strategy that reduces longer term risk. • Requires ongoing funding to ensure care, control and maintenance.	Yes
AC1. Design assets to withstand impacts	Not possible to design land parcels against erosion. Not feasible to design toilet block against erosion. Existing revetment design cannot be easily changed – modifications would be part of a significant upgrade – see PR9.	No
AC2. Maintain and enhance beach system	N/A revetment has replaced beach system.	No
AC3. Maintain and enhance dune system	N/A revetment has replaced dune system.	No

Option	Description Of Application To Asset - MU3: Foreshore Reserve, And MU4: Southwest Foreshore Reserve And Toilet Block	Shortlist
AC4. Maintain and enhance nearshore system – Seagrass regeneration	Preserve and enhance the natural off-shore system to assist in absorbing the impact of storm events and post storm recovery. May include seagrass regeneration and/or placement of sand off-shore to enhance natural bars. Lockyer Shoal would be rebuilt after significant storm events as required. Acts to increase the resilience of the beach and nearshore system by damping storm waves. Trade-offs: • Reinforces natural coastal processes. • Maintains existing ocean vista and natural setting. • May allow for continued provision of accessible foreshore reserve. • Has medium to high uncertainty in effectiveness.	Yes
PR1. Sand nourishment	Bulk sand nourishment of the beach in front of existing revetment. Alternatively, could be undertaken in combination with removal of revetment. Requires a compatible sand source. Unlikely to be sufficient volumes available within study area - likely to need an external source. This may be inland, marine or other areas of the beach which are experiencing accretion. Trade-offs: • Accessible dry sandy beach maintained. • Access to water provided by beach. • Suits a preference for a natural vista. • Requires suitable source with significant quantities. • Due to large volumes required, costs are likely to be significant.	Yes
PR1. Sand nourishment	Requires ongoing costs of plant and equipment mobilisation and demobilisation (and requires relevant plant to be available in a timely manner). Results in additional truck movements in and out of the area.	Yes

Option	Description Of Application To Asset - MU3: Foreshore Reserve, And MU4: Southwest Foreshore Reserve And Toilet Block	Shortlist
PR2. Offshore structures – artificial reefs/shoals	Unlikely to maintain shoreline position during all types of significant storm events. Less confidence than with non-submerged structures i.e. PR3.	No
PR3. Offshore structures – detached breakwaters/ headlands	Structures limit wave energy able to reach shoreline, minimising potential for erosion. Design could consider area of influence to address risk to MU2 foreshore. Trade-offs: • Stabilises section of coast and maintains dry sandy beach presence and access. • Provides for ongoing use of existing assets. • Very expensive to install and maintain. Requires ongoing funding to ensure care, control and maintenance. • Often considered to interrupt natural vista of beach and ocean setting. • May have a negative visual impact. • Potential negative impacts on the adjacent environment.	Yes

Option	Description Of Application To Asset - MU3: Foreshore Reserve, And MU4: Southwest Foreshore Reserve And Toilet Block	Shortlist
PR4. Nearshore structures – breakwaters/ head-lands	Similar to existing structure – limits wave energy able to impact beach. Forms small sheltered pocket beaches, which could be smoothly integrated with foreshore. Could be part of a staged strategy with revetment option PR9 to stabilise this section of coast, but minimise upfront capital costs. Trade-offs: • Stabilises section of coast and maintains dry sandy beach presence and access. • Provides small sheltered pocket beaches. • Provides for ongoing use of existing assets. • Expensive to install and maintain. Requires ongoing funding to ensure care, control and maintenance. • Often considered to interrupt natural vista of beach and ocean setting. • May have a negative visual impact • Potential negative impacts on the adjacent environment.	Yes
PR5. Nearshore structures – groynes	New groyne field could replace revetment to stabilise this section of coast. Would require removal/relocation of some assets be-hind, and/or bulk sand nourishment to move shoreline further into ocean to maintain a suitable buffer. Would form small pocket beach which hold a buffer of sand, protecting land and assets behind. Design could consider area of influence to address risk to MU2 foreshore. Trade-offs: • Stabilises section of coast and maintains dry sandy beach presence and access. • Provides small sheltered pocket beaches. • Provides for ongoing use of existing assets. • Expensive to install and maintain. Requires ongoing funding to ensure care, control and maintenance.	Yes

Option	Description Of Application To Asset - MU3: Foreshore Reserve, And MU4: Southwest Foreshore Reserve And Toilet Block	Shortlist
PR5. Nearshore structures – groynes	Often considered to interrupt natural vista of beach and ocean setting and creates barriers along the beach for walkers etc. May have a negative visual impact. Potential negative impacts on the adjacent environment.	Yes
PR7. Seawalls/ revetments	Replace existing revetment with specially designed structure that integrates with a foreshore redevelopment. New revetment could be multi-level to allow different access by users, have better connection with ocean, reduced wave reflection and increased amenity value (crest treatments etc.) Likely to cost up to twice as much as a standard rebuild of what is already there. Will result in loss of sandy beach in front of structure. Will continue negative impact on adjoining shoreline, forcing an erosion hotspot on MU2 foreshore. Trade-offs: • Provides for ongoing use of existing assets. • Will continue to have no beach in front of the wall. • Very expensive to install and maintain. Requires ongoing funding to ensure care, control and maintenance. • Likely to continue to have an erosion problem at end of wall which may affect MU3 foreshore in future. • Can design features of wall to integrate into foreshore and provide increased amenity. • May have a negative visual impact. • Potential negative impacts on the adjacent environment.	Yes

7.3.5 MU5 Oyster Harbour

Due to the existing protection structures (training wall, northern groyne and vertical wall), the **southeast beach** is the only physical asset identified as vulnerable in the short-term (refer to Section 6). The beach is sheltered from ocean forces and subsequently slower to evolve and change. However, due to the presence of the vertical wall it has a reduced adaptive capacity and limited ability to recover following a storm event.

The southern portion of the beach is strongly influenced by the presence of the swimming pontoons which act as an offshore breakwater causing the formation of a bulge (cusp) in the beach directly in the lee of the structure and narrowing of the beach either side (refer to Figure 7.16). The narrowing of the beach to the south of the cusp in 2012 caused undermining of the seawall, and more recently has resulted in slumping of the rock revetment adjacent to the northern groyne. To manage this localised erosion the City has previously undertaken small volumes of sand nourishment.

Oyster Harbour as a whole was also identified as a cultural asset. For the purpose of assessing the vulnerability of this asset it was assumed that the asset's integrity is tied to that of the beach and shoreline. Although specific management options have not been identified to preserve the Oyster Harbour asset, each adaptation option for the beach has considered potential cultural impact, as part of the multi-criteria evaluation undertaken in Section 8.

Adaptation options for MU5 Southeast Beach are discussed in Table 7.8 and short-listed adaptation options are presented in the Figure 7.16. For MU5 Southeast beach – shortlisted option AC2: Maintain and enhance beach system please see Figure 7.12.

Figure 7.16 - MU5 Southeast Beach – Shortlisted Options Pr1, Pr3, Pr4

PR1 (Source: URS, 2012d scheme report)

Top: PR3 (Source: Sand Sea Salt, 2010)

Bottom: PR4

Table 7.8 - MU5 Southeast Beach Short-Term (0-10 Years) Adaptation Options

Option	Description Of Application To Asset – MU5: South-East Beach	Shortlist
AV2. Avoid further development in existing developed areas impacted by coastal hazards	N/A for beach as an asset – will always be within active coastal zone.	No
MR1. Leave assets unprotected	Based on results of stakeholder engagement it is not considered an acceptable option for there to be no accessible beach, because: • It is a 'Do nothing' option, leaving beach unprotected. • It would cause the progressive reduction in beach width and height. Over the short-term portions of the beach would be expected to narrow and/or be lost in front of the vertical wall. In the long-term most of the dry sandy beach would be lost. • Likely to require future upgrade of protection structures to account for increased risk of undermining when beach is eroded.	No
MR2. Relocate as-sets	Based on results of stakeholder engagement it is not considered an acceptable option for there to be no accessible beach at this location.	No
AC1. Design assets to withstand impacts	Not feasible to design beach to resist erosion.	No
AC2. Maintain and enhance beach system	Assist in post storm recovery, may include beach scraping nearshore back onto the beach to enhance post storm recovery. May include locally transferring sand from the beach cusp to narrow sections of beach. Trade-offs: • Accessible dry sandy beach maintained. • Access to water provided by beach. • Suits a preference for a natural vista. • Limited to smaller volumes of sand. • Requires ongoing costs of plant and equipment mobilisation and demobilisation (and requires relevant plant to be available in a timely manner).	Yes

Option	Description Of Application To Asset – MU5: South-East Beach	Shortlist
AC3. Maintain and enhance dune system	N/A vertical wall has replaced dune system.	No
AC4. Maintain and enhance nearshore system – Seagrass regeneration	N/A for MU5 - seagrass system not identified as key sediment control.	No
PR1. Sand nourishment	Placement of a large volume of sand on the beach to reinstate the beach profile. Typically triggered by erosion following a severe storm event(s) but could also be done proactively. Requires a compatible sand source. This may be inland, marine or other areas of the beach which are experiencing accretion May require the extension of the Northern Groyne to hold sand in place and prevent loss to the channel, depending on the scale of nourishment. Initially sufficient volumes may be available within study area but in medium to longer-term likely to need an external source. Trade-offs: • Accessible dry sandy beach maintained. • Access to water provided by beach. • Suits a preference for a natural vista. • Requires suitable source with significant quantities. • Depending on location of source, can be expensive. • Requires ongoing costs of plant and equipment mobilisation and demobilisation (and requires relevant plant to be available in a timely manner).	Yes
PR2. Offshore structures – artificial reefs/shoals	Unlikely to maintain shoreline position during all types of significant storm events. Less confidence than with non-submerged structures i.e. PR3.	No

Option	Description Of Application To Asset – MU5: South-East Beach	Shortlist
PR3. Offshore structures – detached breakwaters/ headlands	The swimming ponton currently acts as an offshore structure. It could be removed and 'smoothing' of the beach profile undertaken. This may cause an overall reduction in the narrowing of the beach but would only be acceptable if the beach was more highly valued that the functionality of the pontoon. Alternatively, additional offshore headlands could be installed to protect the other sections of the beach. Trade-offs: • Stabilises section of coast and maintains dry sandy beach presence and access. • Expensive to install and maintain. • Often considered to interrupt natural vista of beach and ocean setting. • May have a negative visual impact. • Potential negative impacts on the adjacent environment.	Yes
PR4. Nearshore structures – breakwaters/ head-lands	Similar (but much smaller) to existing structure in ocean at Emu Point – limits wave energy able to impact beach. Forms small sheltered pocket beaches, which could be smoothly integrated with foreshore, and meets community expectation for usable sandy beach. Trade-offs: • Stabilises section of coast and maintains dry sandy beach presence and access. • Provides small sheltered pocket beaches. • Moderately expensive to install and maintain. • Often considered to interrupt natural vista of beach and ocean setting. • May have a negative visual impact. • Potential negative impacts on the adjacent environment.	Yes

Option	Description Of Application To Asset – MU5: South-East Beach	Shortlist
PR5. Nearshore structures – groynes	Not considered effective for this beach as community highly values beach access and groynes create barriers along the beach.	No
PR7. Seawalls/ revetments	Vertical wall already implemented which restricts ability of the beach to behave naturally.	No
PR9. Upgrade of existing protection structures	N/A Modifications to the vertical wall would not assist the beach.	No

7.4 LONG-TERM ADAPTATION PATHWAYS

The identification of detailed options for implementation at longer term timeframes is not appropriate due to the uncertain nature of coastal hazards and the need to ensure that a wide range of future options are available. The focus for longer-term timeframes is to identify broad pathways for future adaptation. Simplistically the four broad pathways are the four option categories from the hierarchy of controls: avoid, managed retreat, accommodate and protect. These four pathways are discussed below and characteristics are presented in Section 8. The State preferences Avoid and Retreat, and short term adaptation should be considered in this context.

Triggers for the implementation of monitoring and the development of future adaptation actions are identified in the Implementation Plan.

Avoid

This long-term adaptation pathway is relevant to areas within the study area that currently appear 'under-developed' and may be under investigation by various stakeholders for development. Deterrents to development should be implemented through strategic planning and then legislative frameworks. As all of study area includes land considered vulnerable to coastal hazards over the planning timeframe this pathway should be applied by using hazard information to confirm areas unsuitable for future development.

As this plan considers risk and adaptation for existing assets rather than future assets, this pathway is not considered further in the CHRMAP as a pathway independent of other measures. However, the identified hazard information (from Section 2) can be used to inform other planning decisions in the Emu Point Middleton Beach area outside the study area. Further discussion regarding deterrents through legislation and strategic planning can be found in Section 9 – Implementation.

Managed Retreat

This pathway allows for the removal of 'at-risk' development or assets outside the area of risk when the coastal hazard risk level is no longer acceptable, to allow land at risk to naturally experience erosion and/or inundation. A key aim of this planning approach is to ensure the ongoing provision of a coastal foreshore reserve and beach amenity and public access (Retreat Guidelines, WAPC 2017).

Managed retreat can include small scale activities of staged retreat for lower-cost assets such as bollards, seating, bins and shelters as they reach the end of their normal design life (so as to reduce the cost burden). Over the longer term managed retreat can include substantial activities such as the removal of infrastructure or even buildings. Longer term managed retreat is likely to require adequate planning, time and funding to ensure all stakeholders are treated equitably in accordance with the impact to their activities and their existing rights and entitlements.

Managed retreat is possibly the most challenging of the options available for the community and private landowners. The impacts of erosion and inundation occur over long periods and the stakeholders of today (and their values) may be different to the stakeholders in 10 years time. The threats of coastal impacts are also quite often dismissed as 'not in my lifetime' type events. Thus, managed retreat needs to be planned carefully to consider the relevant triggers, the cost implications and to allow adequate time to communicate, coordinate and partner with landowners, leaseholders and other stakeholders.

Long term managed retreat plans require ongoing monitoring, establishment of triggers, emergency management plans and a strong commitment to ensuring the activities of the current day do not commit the local government to costly and expensive future activities unless all other options are exhausted.

Managed retreat can be supported by appropriate legislative control through the planning system and options include provisions in the planning scheme, Special Control Areas, Foreshore Management Plans, restrictive covenants and notifications on titles within the planning framework. Funding can be sourced through special area rates, rates levies, land swaps and acquisition of private land within the property portfolio of local government, or through grants and funding at State and Commonwealth levels.

A significant number of assets within the study area may be considered suitable for a managed retreat response.

Accommodate

The accommodate pathway is primarily appropriate for assets identified as vulnerable to inundation. There are only four assets/groups identified as having high or extreme inundation vulnerability at 2120 (see Section 6) and three of these are at Ellen Cove and have been addressed in the associated Foreshore Management Plan. The remaining asset is the toilet block in MU5 and this is considered to have extreme erosion vulnerability by 2070.

There are some elements of the accommodate pathway which could be incorporated to an adaptation strategy to address erosion vulnerability. The preparation of emergency plans (particularly emergency access), location of development within certain areas of a lot, temporary development only or sacrificial development, application of easements or zones to allow for rolling change of land-use are relevant and have been considered under the managed retreat pathway. In general terms the accommodate pathway is only relevant to address erosion vulnerability for a limited time when the erosion vulnerability is low or medium before the managed retreat or protect pathways must be considered.

Protect

The protect pathway is the last pathway to be considered under the hierarchy of controls as it limits future risk management options. It is only appropriate for assets and land that is defendable long-term and where there is a commitment to a high level of development which justifies the significant and ongoing cost. A key consideration for this pathway is when high value public land is vulnerable to erosion (e.g. foreshore reserve) before built assets. The width of land that is desired to maintain future functionality needs to be determined e.g. half of the original width or a minimum distance.

Due to the cost and ongoing maintenance obligations, there should be compelling reasons why a protective measure in one area is more suitable than relocating the at-risk assets to a less vulnerable location. It should also be clear why the ongoing development of the area cannot be undertaken in a way that reduces or removes the risk (i.e. location and design solutions for the asset (building) that protect the asset rather than creating secondary protective measures.

Where managed retreat is challenging to justify to the community and landowners because of its long term and uncertain nature, the absence of protection measures can be challenging to explain to stakeholders; particularly where private interests are held. Assets that have a significant benefit for a large number of stakeholders such as essential service infrastructure would still preferentially be relocated through appropriate maintenance programs. In the alternative, it would be challenging to justify significant public expenditure to protect assets which benefit private individuals only.

It should also be noted that there is no legal obligation for Government's of any level to protect private property.

Protection measures can be supplemented by appropriate legislative control through the planning system and options include provisions in the planning scheme, Special Control Areas, Foreshore Management Plans, restrictive covenants and notifications on titles within the planning framework. Funding can be sourced through special area rates or rates levies within the property portfolio of local government or through grants and funding at State and Commonwealth levels.

It should be noted that the 'protect' pathway carries inherent risks associated with establishing and expectation that land will be protected in perpetuity, which may not always be achievable or appropriate (e.g. spending public funds to protect individual properties). Where land is protected in the short term, measures should be taken to clarify the future obligation of Government to maintain protection. Protective measures are time limited, and therefore should only be considered themselves as an interim protection, albeit usually of longer term consequence.


Photo Source: City of Albany

8. Assessment of Adaption Options

The assessment of adaptation options comprises 4 key steps;

1. Developing preliminary cost estimates;
2. Establishing a multi-criteria analysis (MCA) framework and then assessing options through that framework with the community;
3. Utilising the multi-criteria analysis framework to cross-check the assessment based on rigorous technical analysis; and
4. Determining implementation timeframes.

Step 2 in the assessment of adaptation options was a critical stage in developing this CHRMAP and is a departure from the normal CHRMAP process. This is because community values are often intrinsic and experience based, and whilst the technical costs and suitability of certain measures from an engineering or scientific perspective can be quantified by technical consultants (as in Step 3), the intrinsic values of the community cannot be so easily measured.

The City of Albany committed to a testing of community values with stakeholders of the study area in delivering the typical CHRMAP MCA process, which included the establishment of a Community Advisory Panel (CAP) to provide a community led analysis of the multiple criteria that are considered in developing a suitable CHRMAP.

Options considered for each management unit are shown within Appendix F.

8.1 PRELIMINARY COST ESTIMATES

Preliminary cost estimates were prepared specifically to inform the rating of Capital and Maintenance Cost criteria in the options assessment. The method used is described below and incorporates aspects of Class 3 and 4 cost estimation techniques in accordance with Association for the Advancement of Cost Engineering (AACE, 2005, see Table 8.1). Following the identification of preferred options for each asset a more detailed Cost Benefit Analysis (CBA) differentiated between potential options (See Section 8.6).

Table 8.1 - Description of Different Classes of Cost Estimation

	Primary Characteristic	Secondary Characteristic			
ESTIMATE CLASS	**LEVEL OF PROJECT DEFINITION** **Expressed as % of complete definition**	**END USAGE** **Typical purpose of estimate**	**METHODOLOGY** **Typical estimating method**	**EXPECTED ACCURACY RANGE** **Typical variation in low and high ranges [a]**	**PREPARATION EFFORT** **Typical degree of effort relative to least cost index of 1 [b]**
Class 5	0% to 2%	Concept Screening	Capacity Factored, Parametric Models, Judgement, or Analogy	L: -20% to -50% H: +30% to +100%	1
Class 4	1% to 15%	Study or Feasibility	Equipment Factored or Parametric Models	L: -15% to -30% H: +20% to +500%	2 to 4
Class 3	10% to 40%	Budget, Authorisation, or Control	Semi-Detailed Unit Costs with Assembly Level Line Items	L: -10% to -20% H: +10% to +30%	3 to 10
Class 2	30% to 70%	Control or Bid / Tender	Detailed Unit Cost with Forced Detailed Take-Off	L: -5% to -15% H: +5% to +20%	4 to 20
Class 1	50% to 100%	Check Estimate or Bid / Tender	Detailed Unit Cost with Detailed Take-Off	L: -23 to -10% H: +3% to +15%	5 to 100

Source: AACE, 2005

Preliminary cost estimates are sufficiently detailed for the purpose of screening options and use unit rates for typical options, factored to the management unit they are being applied to. Any available concept design information and drawings were sourced from the City and previous consultancy reports where available. Adaptation option costs are summarised in Table 8.2 by asset. Allowances have been included for design, project management, preliminary investigations, mobilisation and demobilisation (as a factor of 25%) with contingency of 30%. Relative maintenance costs are indicated and have been considered by assuming a nominal implementation year for each option and estimating ongoing costs in 2018 dollars to 2120. To allow for comparison between treatment options costs have been grouped:

1. Low - indicates less than $2 million.
2. Medium - $2million to $12 million.
3. High - $12 million to $25 million.
4. Very high - $25 million and above.

Table 8.2 - Preliminary Cost Estimates for Adaptation Options for Assets Vulnerable in the Short-Term (0-10 years)

Asset	Option	Approximate Capital Cost	Assumed Year to Implement	Indicative Maintenance Cost	Notes
MU1 Beach	AC2. Maintain and enhance beach system	N/A	2018	Low	Assumes ongoing annual campaign of sand scraping etc. of several thousand dollars per year.
	PR1. Sand nourishment	$0.5M	2030	Medium	
MU2 Foreshore	AV2. Avoid further development in existing developed areas impacted by coastal hazards	$0.25M	2018	Low	Capital cost reflects the potential need to undertake planning studies, prepare management plans and amend planning documents etc.
	MR1. Leave assets unprotected	$1.25M	2030	Medium	Capital cost reflects the potential need to undertake further planning studies, prepare management plans and amend planning documents etc. and to remove some built infrastructure within foreshore.
	AC3. Maintain and enhance dune system	N/A	2018	Low	Assumes that this is covered under general foreshore park management works.

Asset	Option	Approximate Capital Cost	Assumed Year to Implement	Indicative Maintenance Cost	Notes
MU2 Big 4 Holiday Park	AV2. Avoid further development in existing developed areas impacted by coastal hazards	$0.5M	2030	Low	Capital cost reflects the potential need to undertake planning studies, prepare management plans and amend planning documents etc.
	MR1. Leave assets unprotected	$3.75M	2030	Medium	Capital cost reflects the potential need to undertake further planning studies, prepare management plans and amend planning documents etc. and to remove some built infrastructure within holiday park.
	MR2. Relocate assets	$8.0M	2030	Medium	Capital cost primarily for removing buildings and infrastructure and refurbishing land as foreshore reserve.
	PR7. Seawalls/Rock revetments	$1.75M	2020	Medium	
	PR7. Seawalls/revetments/ GSC Sandbags	$2.75M	2020	High	
MU3 Griffiths St. properties	MR2. Relocate assets	$14.0M	2030	High	Capital cost primarily for purchasing private property and removing buildings and infrastructure.
	PR1. Sand nourishment	$1.0M	2020	Medium	
	PR2 & PR3 Offshore structures (Breakwaters)	$4.5M	2020	Medium	
	PR4 & PR5 Nearshore structures (Breakwaters)	$3.25M	2020	Medium	
	PR7. Seawalls/revetments	$1.75M	2020	Medium	

Asset	Option	Approximate Capital Cost	Assumed Year to Implement	Indicative Maintenance Cost	Notes
MU3 & MU4 Foreshore	MR2. Relocate assets	$26.75M	2030	High	Capital cost primarily purchasing and removing private property assets and removing buildings and infrastructure from leasehold land.
	AC4. Maintain and enhance nearshore system – Seagrass regeneration	$6.0M	2020	Very high	
	PR1. Sand nourishment	$4.5M	2020	Very high	
	PR3. Offshore structures – detached breakwaters/ headlands	$15.0M	2020	Very high	
	PR4. Nearshore structures – breakwaters/ headlands	$8.75M	2020	High	
	PR5. Nearshore structures – groynes	$3.0M	2020	Medium	
	PR7. Seawalls/revetments	$6.5M	2020	High	
	PR9. Upgrade of existing protection structures	$4.75	2020	Medium	
MU5 Southeast beach	AC2. Maintain and enhance beach system	N/A	2018	Low	Assumes ongoing annual campaign of sand scraping etc. of several thousand dollars per year.
	PR1. Sand nourishment	$0.25M	2020	Low	
	PR3. Offshore structures – detached breakwaters/ headlands	$0.5M	2020	Low	
	PR4. Nearshore structures – breakwaters/ headlands	$0.5M	2020	Low	

8.2 MULTI-CRITERIA ANALYSIS

Multi criteria analysis (MCA) is a decision making tool used across the world to consider complex decision making where a number of criteria are important and the best case scenario requires making a number of trade-offs. MCA is the method used to help to identify and rank the important factors associated with choosing a particular option for at-risk assets in the Emu Point to Middleton Beach area.

The MCA for this CHRMAP was undertaken in two parts. The first part was the establishment of criteria with the Community Advisory Panel (CAP) and their assessment of the adaptation options. The second was a technical assessment of the CAP criteria and measurements.

Community Advisory Panel MCA Process

The CAP was convened to develop the scoring and measurement values for an MCA to assess the positive and negative aspects of the shortlisted adaptation options (see Section 7) for each asset with high or extreme vulnerability at 2030. The multi-criteria assessment framework (refer to Table 8.3) was developed with this group and in consultation with the City and incorporates the key community and stakeholder values/priorities identified from stakeholder engagement.

The seven broad criteria considered were:

- Capital cost - intended to identify the City's financial capability to implement the adaptation option. In particular, whether the City has the capacity to undertake the works independently or if it will require external funding/ support (e.g. by state or federal government).
- Maintenance costs - are intended to broadly identify the financial liability to maintain the adaptation option. Maintenance considers the full life of the option.
- Environmental impact - considers impacts on natural assets and the potential for subsequent environmental impact, (e.g. the generation of down-drift erosion from the construction of a revetment). This takes into consideration the work undertaken by RHDHV (2017) to identify the underlying coastal processes within the study area.
- Social/amenity impact - community - is intended to take into consideration the community values identified by the stakeholder engagement activities (see Sections 1 and 3), in particular the valued assets survey and targeted stakeholder engagement workshops.
- Social/amenity impact – property – is intended to take into consideration the community values associated with the possible impact, loss or damage to private property or privately operated leasehold land.
- Reversibility - is intended to identify the flexibility of an action to allow a broad range of future options in the context of the hierarchy of controls identified in SPP 2.6 (refer to Section 7).
- Effectiveness - is intended to identify the likelihood of the option in reducing the impact of coastal hazards.

CAP participants were provided an opportunity to first discuss the measurement values in small groups, and the summary feedback was collated and an agreed measurement value was set for each criteria. In some cases, the group did not fully achieve consensus. However, the final scoring criteria provides both a greater insight into community values and a logical/measurable basis for assessing each adaptation option.

The final output of this part of the CAP was a measurement matrix for each of the criteria. The matrix defines a numerical value between 1 and 5 for different outcomes associated with each option. A score of '1' would be an option which results in a low negative impact (or a positive impact) against that criteria, whilst a score of '5' would be an option which results in a high negative impact against that criteria.

Notes on Measurement Values

The final decision for the 'Capital Cost' criteria was that cost should not be a determinant. The CAP noted that if all other criteria scores are equal, cost would be the determining factor and a cheaper option would be preferred.

The 'Social Impact – Property' category was divided into three sub-categories as each was considered to have differentiated value. CAP participants identified that private property with existing protective structures would have a greater expectation of having protection maintained, whilst conversely noting that other waterfront property without existing protections should be classified as 'at owners' risk'.

Participants considered business properties as a third sub-category, noting that there are multiple beneficiaries of business activity in Albany, including economic benefits that should be protected if possible.

For scoring purposes, if more than one property class is included in a single area, the total will be combined and a single score agreed to ensure this criterion does not over-influence the final preference (e.g. if against residential property the score would be 4, and against business impact the score would be 3, only a single worst-case scenario score of 4 would be applied rather than a combined score of 7).

The results of the scoring and measurement values developed by the CAP are presented in Table 8.3.

Table 8.3 - Multi-Criteria Analysis Criteria Measurement Values

Criteria	1	2	3	4	5
Capital Cost	A less expensive option is preferred if all other criteria are equal.				
Maintenance Cost	<5 million	$5 - $15 million	$15m - $30 million	$30 - $50 million	>$50 million
Environmental Impact	Preserves and repairs	Maintains Status Quo	May result in impact & damage	Likely to result in impact & damage	Will result in impact & damage
Social Impact - Residential property not currently protected	No loss is preferable but this asset class is at owners risk.		Protection for current assets only		
Social Impact - Residential property already protected	0 houses lost	1-10 houses lost	11-19 houses lost	20-40 houses lost	> 40 houses lost
Social Impact - Business property	No loss of existing businesses		Protects or maintains for as long as possible		Loss of existing businesses
Social Impact (community)	Does not affect any community values and/or improves access	Minor impact to community values and/or access	Loss of access to some community assets that doesn't effect overall intrinsic community value	Loss of access to certain assets Improve man made facilities	Will definitely affect key values of area
Reversibility	Easily reversible	Reversible	Reversible but with some cost	Difficult to reverse	Irreversible
Effectiveness	Effective, long-term mitigation	Effective, mid-term mitigation	Effective, short-term mitigation	Limited effectiveness	Ineffective and/ or suitable only for minor events

After developing the MCA criteria measurement values, the CAP produced a final score for each of the adaptation options per at-risk asset. A detailed summary of this process is included in Appendix F. Tables 8.2 – 8.6 present the outcomes of the CAP MCA process.

TECHNICAL MCA PROCESS

Subsequent to the CAP analysis, the consultant team undertook a testing process comparing the CAP scoring with the criteria values provided by the CAP. It is clear from this analysis that when undertaking the scoring process, individual preferences often overrode the agreed scoring criteria. This provides an insight into strongly held values associated with the natural coastline experience, skewing most adaptation preferences away from any man-made structures.

After reviewing the variation across scores, which regularly saw individuals score against their own criteria measurement values, the project team completed a second MCA using the CAP criteria and measurement values. The main observation of the technical analysis of the options is that effectiveness and reversibility were often scored incorrectly, compared to the CAP criteria and measurement values.

The scoring of the consultant team differs on a number of the adaptation options as shown in Tables 8.4 – 8.9. Each table shows the CAP scores and the technical scores, and highlights the preferred adaptation option in the final scores.

It should be noted that the CHRMAP process preferences the most flexible adaptation pathways; the pathways that provide for the broadest possible decision making at the time when a decision becomes necessary. For this reason, recommended options favour Avoid and Planned Retreat where these are available. Notwithstanding, when an avoid or retreat option is recommended, many other options remain valid, and planning should continue to be undertaken on all valid options until the point a decision is to be made.

Ellen Cove Beach (Management Unit 1)

As part of the Middleton Beach Activity Centre development, a buried seawall has been proposed and is now funded. To maintain a sandy beach in front of the wall, the supporting adaptation option chosen is sand nourishment.

It is recommended to maintain and enhance the beach system in front of the proposed MBAC seawall after storm events. There may be a need to bring sand in from other sources if sufficient sand is not available in close proximity.

It was noted by participants of the MCA process that at the end of the construction life of the revetment, an alternative option may need to be considered. Assets such as the foreshore, the cafe and the Surf Club were identified as' very high value' and important to the community of Albany, as well as significant to tourism activity.

Middleton Beach Foreshore (Management Unit 2)

The Middleton Beach foreshore (Surfers and Golf Course area) comprises mostly natural foreshore area, with several coastal access points with Flinders Parade outside of the 100 year risk area.

The foreshore is primarily a public asset and has limited opportunity for any form of development. The overall MCA score preferenced 'Avoid Further Development' (see Table 8.4), which implies a longer term management option of avoiding further development for the assets at-risk in the longer term, such as Flinders Parade, the toilets, car parks and parts of the Golf Course.

As these assets are primarily owned by the City of Albany, it is possible that over time when these assets are replaced, in line with normal asset replacement timeframes, that assets could be relocated outside of the vulnerable area, allowing for extended use of the coastline over time with limited (or less) impact to community access.

Table 8.4 - Middleton Beach Foreshore MCA *Note: the lowest score is the best score.*

	Community Advisory Panel Scores		Technical Scores	
Criteria	**Avoid Further Development**	**Leave Assets Unprotected**	**Avoid Further Development**	**Leave Assets Unprotected**
Maintenance Cost	1	1	1	1
Environmental Impact	1.7	3	2	4
Social Impact - Residential not protected	1.9	3.2	1	2
Social Impact - Residential protected already				
Social Impact - Business property				
Social Impact (community)	2	3.5	2	2
Reversibility	1.8	3.3	1	1
Effectiveness	2.4	3.5	3	4
TOTAL COMBINED	**10.8**	**17.6**	**10**	**14**

Big 4 Caravan Park (Management Unit 2)

The Big 4 Middleton Beach Caravan Park is a popular tourism destination in Albany. The site is leased by the City of Albany to a private organisation.

Throughout the MCA CAP scoring, participants noted how significant tourism is to the City of Albany economy, local employment as well as general local amenity. The asset is also adjacent to an established park area to the north of the Surf Club and car park.

Whilst the community preferenced 'avoid further development' in this location, this option has implications in the future if the asset is significantly damaged by coastal events and this option is unlikely to maintain longer term community values without an additional management option.

The CAP score has suggested that the alternative would be a seawall. However, when using the measurement values developed by the community, it is not possible to ignore the long term implications of a revetment, which would essentially result in the loss of beach in front of the wall. This would have an irreversible impact on the coastal amenity of the beach, which was identified as one of the most valued assets in the study area. Figure 3.1 illustrates how many respondents valued access to the beach, coastal scenery, and the wide sandy beach. The scoring varied greatly between the CAP and the project team for this reason, and 'Managed Retreat' is considered the next most suitable option (See Table 8.5).

It is currently predicted that the asset will face high risk by 2030, but it is only 'likely' that erosion will be experienced within the site by 2050. It is recommended that the City and the leaseholder work together to plan for staged retreat of assets and work toward an agreed level of risk and exit timeframe.

It is acknowledged that this adaptation option may impact on a local business, which is also valued by the community. It is recommended that nearby locations be considered as soon as possible for relocation of the assets to make for an easier transition whilst providing for continuity of business activities. Specifically, there is an opportunity to use land adjacent to the golf course or for a redesign within the golf course to enable those assets most at risk to be relocated.

There is also an opportunity to continue to allow for accommodation within the current site through the siting of less permanent uses such as unpowered camp sites and parklands on the seaward area of the site, provided there is an appropriate emergency management plan for responding to extreme storm activity.

Notwithstanding the recommended option, the City acknowledges that planning for, and preliminary design of, a buried seawall in this location is being completed independently by the leaseholder of the Big 4 Caravan Park. Combined with the work being undertaken by the City of potential relocation sites, the work being undertaken to support this design will better enable to City and the leaseholder to make decisions about the use of the land until such time as the asset is facing immediate risk.

It is also recognised that the coast has been very stable in the MU2 area with a strong accretion trend and a beach that recovers well after severe storms. Both factors should be considered in the implementation of the preferred adaptation option at the relevant time.

Table 8.5 - Big 4 Middleton Beach Caravan Park MCA *Note: the lowest score is the best score.*

	Community Advisory Panel Scores					Technical Scores				
Criteria	Avoid Further Development	Leave Assets Unprotected	Relocate Assets	Seawall (rock)	Seawall (sandbags)	Avoid Further Development	Leave Assets Unprotected	Relocate Assets	Seawall (rock)	Seawall (sandbags)
Maintenance Cost	1	3	3	1	2	1	3	3	1	2
Environmental Impact	2.3	3.6	2.3	3.4	3.5	2	4	2	4	4
Social Impact - Residential not protected	2.9	3.7	3.1	2.1	2.3	3	3	4	1	1
Social Impact - Residential protected already										
Social Impact - Business property										
Social Impact (community)	2.4	3.7	3.1	2.9	3.1	1	3	1	4	4
Reversibility	2.7	3.4	3.4	4.1	3.3	1	1	1	4	3
Effectiveness	2.9	3.5	2.2	2.8	2.8	3	3	2	1	1
TOTAL COMBINED	**14.2**	**20.8**	**17.3**	**16.3**	**17.1**	**11**	**17**	**13**	**15**	**15**

Properties on Griffiths Street (Management Unit 3)

A number of privately owned properties exist within Management Unit 3. However, it is the first row of houses on Griffiths Street that are the most immediately vulnerable. This is due to the access road itself being at risk; when the road and services are damaged, legal access to the lots will be affected and the properties will be impacted.

The Griffiths Street properties (front row), are only marginally more impacted than adjacent properties on Barry Court and Dillon Close. However, these properties have longer term access and short term alternatives are available. Notwithstanding, the option preferred for the Griffiths Street asset, implies that same option would also be implemented for the adjacent private properties over the longer term.

The overall score preferenced during the MCA was 'Sand Nourishment'. It is noted that in the case of this asset, the 'Sand nourishment' option may be suitable in the short term, but is recognised as ineffective for longer term protection. This option may not maintain longer term community values without an additional management option being considered.

The next most preferred option in the CAP MCA was the offshore breakwaters, however, when using the measurement values developed by the community, the project team noted that scoring in the CAP did not adhere to the measurement values on almost every criteria. The technical assessment recommends 'Managed Retreat' as the next most suitable option (See Table 8.5), being both highly effective and providing for substantial flexibility over the long term. Adequate time is available to coordinate strategic planning for the retreat (Table 8.6).

Table 8.6 - Griffiths Street Properties MCA *Note: the lowest score is the best score.*

	Community Advisory Panel Scores					Technical Scores				
Criteria	**Relocate Assets**	**Sand Nourishment**	**Offshore breakwaters**	**Nearshore breakwaters**	**Seawall (rock)**	**Relocate Assets**	**Sand Nourishment**	**Offshore breakwaters**	**Nearshore breakwaters**	**Seawall (rock)**
Maintenance Cost	3	2	2	2	1	3	2	2	2	1
Environmental Impact	2.7	2.6	3.1	3.3	3.6	1	2	3	4	5
Social Impact - Residential not protected	3.5	2.4	2.2	2.6	2.7	3	2	1	1	1
Social Impact - Residential protected already										
Social Impact - Business property										
Social Impact (community)	3.4	2.3	2.5	2.7	3.3	1	2	3	3	4
Reversibility	3.8	1.6	4.6	4.2	4.1	1	1	5	4	4
Effectiveness	2.6	3.5	2.8	2.9	2.9	1	5	2	1	1
TOTAL COMBINED	**19.2**	**14.7**	**17.2**	**17.8**	**17.4**	**10**	**14**	**16**	**15**	**16**

Emu Point Holiday Park (Management Unit 3)

The Emu Point Holiday Park has had partial revetment protection for some time, which provides a highly undesirable waterfront experience and ongoing risk to assets. The asset was originally considered as a part of a larger foreshore area, but its location slightly away from the existing revetment and its' leasehold status implies that it is unlikely to achieve State or Federal funding support for an extension of the revetment. In addition, its current layout, as well as the period at which is becomes most at risk (beyond 2050), suggest that there are numerous options in the existing site within which to utilise the available site whilst also improving the coastline and coastal experience of the park.

This option was not originally considered by the CAP. To resolve this and ensure fairness in the process, the CAP members were provided an opportunity to provide feedback at a later time, and 11 of the original CAP members provided a response. The CAP preferenced 'nearshore structures/groynes' by a relatively slim margin.

However, when using the measurement values developed by the community, it is not possible to ignore the long term implications of revetments and groynes which have a substantial negative impact on the beach environment. Technically, it is also unclear whether groynes in this location will have the desired outcome or will have a negative impact on Lockyer Shoal, and as such they cannot be considered to be completely effective. Groynes would have an irreversible impact on the coastal amenity of this beach, where alternative options could significantly improve the current amenity.

The scoring varied greatly between the CAP and the project team for this reason, and 'Managed Retreat' is considered the next most suitable option, being both highly effective and providing for substantial flexibility over the long term (See Table 8.7). The technical assessment also considered that the expansion of the existing low-profile sandbag trial groynes could be beneficial in this location, and this is included in the recommendation.

The removal of the failing sandbag revetment will most likely result in much improved amenity of the foreshore and far greater beachfront accessibility for the park.

It is currently predicted that the asset will face high risk by 2030, but it is only 'likely' that erosion will be experienced within the site before 2050. It is acknowledged that this adaptation option may impact on a local business, which is also valued by the community and as such it is recommended that the City and the leaseholder work together to plan for staged retreat of assets and work toward an agreed level of risk and exit timeframe.

There is an opportunity to continue to allow for accommodation within the current site through the siting of less permanent uses such as unpowered camp sites and parklands on the seaward area of the site, provided there is an appropriate emergency management plan for responding to extreme storm activity.

Table 8.7 - Emu Point Holiday Park MCA *Note: the lowest score is the best score.*

	Community Advisory Panel Scores					Technical Scores				
Criteria	**Relocate Assets/ Sandbag Trial**	**Sand Nourishment**	**Nearshore Structures Breakwaters**	**Nearshore Structures - Groynes**	**Seawalls/ revetments**	**Relocate Assets/ Sandbag Trial**	**Sand Nourishment**	**Nearshore Structures Break- waters**	**Nearshore Structures - Groynes**	**Seawalls/ revetments**
Maintenance Cost	4	5	3	2	2	4	5	3	2	2
Environmental Impact	3.4	2.8	3.0	3.2	3.7	2	2	4	4	4
Social Impact - Residential not protected	4.2	3.4	2.8	2.8	2.8	4	2	1	1	1
Social Impact - Residential protected already										
Social Impact - Business property										
Social Impact (community)	3.3	3.2	3.1	3.1	3.2	1	2	3	4	2
Reversibility	3.1	1.9	3.4	3.7	3.4	1	1	4	4	4
Effectiveness	3.6	4.0	2.9	3.1	3.1	1	4	1	4	1
TOTAL COMBINED	**23.9**	**21.3**	**22.1**	**20.9**	**21.3**	**13**	**16**	**16**	**19**	**14**

Emu Point Foreshore Reserve (Management Unit 4)

The Emu Point Foreshore Reserve comprises a number of man made and natural assets. Past adaptation actions have resulted in structures that are widely acknowledged as having a negative impact, whilst the foreshore parkland that is protected by those structures is highly valued by the community.

A large number of adaptation options are available for this asset. Due to the significant number of assets included (and behind) the immediate vulnerability line, there is an ongoing implication that protection in this location will lock the City of Albany in to ongoing protection in the area. Participants noted this, and also noted how much past decisions had impacted the current coastline, identifying a preference not to repeat 'old mistakes'.

The overall score preferenced 'Maintain and Enhance the Nearshore System' (seagrass rehabilitation). It is noted that in the case of this asset, the preferred option alone is not sufficient to control the shore line and reduce the risk to the landwards assets.

This has implications in the future if the seagrass is repeatedly damaged - rendering the coastline behind it vulnerable and without back-up protection. Any seagrass rehabilitation should be supported by ongoing investigations into methods to enhance the capacity of the system to naturally rejuvenate following storms, noting that the system takes some 50 years to naturally recover. Ideally, investigations would consider ways to shortcut the natural recovery process. This option is recommended, but only if considered as one part of the solution.

The technical MCA considered 'Protection – Seawall and Parklands' as the next most suitable option, being both highly effective and providing the necessary maintenance of community values (Table 8.8). This option effectively maintains the status quo, although it does require a detailed design process to be undertaken for the entire length of the wall, to ensure that the new design has greater effectiveness for the coastal environment than the current wall. The southern end of the revetment requires detailed design to improve the tail of the wall and mitigate against substantial scouring.

Table 8.8 - Emu Point Foreshore MCA *Note: the lowest score is the best score.*

	Community Advisory Panel Scores								Technical Scores							
Criteria	**Relocate Assets**	**Maintain/ Enhance seagrass**	**Sand Nourish-ment**	**Offshore break-waters**	**Nearshore break-waters**	**Groynes**	**Seawall and parkland**	**Seawall upgrade (basic)**	**Relocate Assets**	**Maintain/ Enhance seagrass**	**Sand Nourish-ment**	**Offshore break-waters**	**Nearshore break-waters**	**Groynes**	**Seawall and parkland**	**Seawall upgrade (basic)**
Maintenance Cost	4	4	5	3	3	2	2	2	4	4	5	3	3	2	2	2
Environmental Impact	2.6	1.5	2.6	2.9	3.2	3.6	3.6	3.1	1	1	3	3	4	4	4	4
Social Impact - Residential not protected	3.3	2	2.5	2.2	2.4	2.4	2.5	2.4	5	3	2	1	1	1	1	1
Social Impact - Residential protected already																
Social Impact - Business property																
Social Impact (community)	2.9	2.1	2.2	2.4	2.4	3	3	3	3	1	2	3	3	4	2	3
Reversibility	3.2	2.2	2.3	4.2	3.9	4	4.2	3.6	3	1	1	5	4	4	4	4
Effectiveness	2.8	2.7	3.8	2.6	2.6	3.3	2.9	3.3	1	5	4	2	1	4	1	1
TOTAL COMBINED	**18.9**	**14.5**	**18.7**	**17.2**	**17.6**	**18.5**	**18.5**	**17.1**	**17**	**15**	**17**	**17**	**16**	**19**	**14**	**15**

Oyster Harbour Beach (Management Unit 5)

The Oyster Harbour Beach Management Unit is markedly different from the balance of the study area as it is an estuarine environment with shallower water depths and lower energy coastal processes. The shoreline is already managed by seawall structures and swimming pontoon infrastructure behaves somewhat like an offshore breakwater without the requisite reliable effectiveness.

The overall score preferenced 'Sand Nourishment'. Table 8.9 shows the combined scores across criteria. It is noted that in the case of this asset, the 'Sand Nourishment' option may be suitable in the short term, but is also recognised as ineffective for longer term protection.

Table 8.9 - Oyster Harbour Beach MCA *Note: the lowest score is the best score.*

	Community Advisory Panel Scores			Technical Scores		
Criteria	**Sand Nourishment**	**Nearshore breakwaters**	**Nearshore breakwaters submerged**	**Sand Nourishment**	**Nearshore breakwaters**	**Nearshore breakwaters submerged**
Maintenance Cost	1	1	1	1	1	1
Environmental Impact	2.6	2.7	2.7	1	1	1
Social Impact - Residential not protected	1.8	2.3	1.8	1	1	1
Social Impact - Residential protected already						
Social Impact - Business property						
Social Impact (community)	1.9	2.3	1.9	1	3	2
Reversibility	2.2	3.3	3.9	1	3	3
Effectiveness	3.2	2.5	2.8	1	2	2
TOTAL COMBINED	**12.5**	**14.4**	**14.2**	**6**	**12**	**11**

8.3 RECOMMENDED ADAPTATION OPTIONS

The recommended adaptation options for the assets requiring short term (10 year) management are as follows:

- MU1 Ellen Cove: Sand nourishment.
- MU2 Surfers and Golf Course: Avoid further development in existing developed areas impacted by coastal hazards.
- MU2 Big4 Middleton Beach Holiday Park: Staged relocation of assets.
- MU3 Griffiths Street Properties: Relocate assets.
- MU3 Emu Beach Holiday Park and Dual Use Path: Staged relocation of assets.
- MU4 Emu Point: Maintain and enhance nearshore system – seagrass regeneration.
- MU4 Emu Point: Seawalls/ revetments and parkland development.
- MU5 Oyster Harbour - Southeast Beach: Sand nourishment.

8.4 OVERARCHING ADAPTATION OPTIONS

It should be noted that all assets within the study are vulnerable over time (100 years). This requires consideration of other management and adaptation planning options that may be relevant to all assets. This section summarises the key strategic planning, statutory planning, and policy or governance interventions that the City of Albany will need to implement regardless of the proposed adaptation option chosen per asset.

Recommendation 1: Local Planning Strategy – Investigation Area

The City is currently preparing its Local Planning Strategy, which provides an excellent opportunity to identify the vulnerability in this study area in the strategic planning framework. This will help to guide ongoing planning and development in the area, and provide an important signal to landowners and developers that the land in the study area has associated risks. This is an important first step to including known vulnerability in the statutory planning framework.

The study area should be identified as a Coastal Erosion Investigation Area in the Local Planning Strategy.

Recommendation 2: Local Planning Scheme Special Control Area

It is recommended that the City of Albany undertake a planning scheme amendment to include the vulnerable zone (up to the modelled area to 2120) in a Special Control Area. This special control area will provide a signal to landowners when buying the land if they seek information from the City, and will also enable notification to landowners if they seek a development approval.

It is recognised that such a recommendation has the potential to cause concern amongst the community, especially landowners, which is a natural response from citizens trying to protect property values. However, it must be noted that there is no obligation on Government to compensate for land lost due to erosion, and it is much more proactive for the City to identify the possibility of land at risk in the future and take appropriate action. For landowners who may be considering purchasing or developing lands, it is important to note that they should not assume any funds will be forthcoming to compensate for future retreat.

Recommendation 3: City Infrastructure Asset Planning

It is recommended that the City ensure that all future infrastructure assets placed in the vulnerable zone either be sacrificial or have a design life that ensures the asset will be redundant before the risk becomes 'likely to almost certain'.

The City's current spatial database is a logical location for such a management tool as it can be spatially referenced to respond to include the vulnerable zone (up to the modelled area to 2120), or the same area as shown in the Special Control Area. This will ensure that hard assets such as seating, pathways, toilets, playgrounds etc, as well as soft assets such as landscaping, be developed in such a way as to allow for continued enjoyment of the coastal zone for as long as possible whilst also reducing or removing the risk associated with assets.

Recommendation 4: Resilience Planning and Monitoring

A number of the 'at-risk' assets include possible management options that are ongoing City of Albany management tools. These options were 'Maintain and Enhance Beach System'; a beach scraping and sand nourishment option, and 'Maintain and Enhance Dune System'; a dune rehabilitation and protection option.

The City of Albany has committed to ongoing resilience management of the coastal system which would include both of these options at appropriate times. The ongoing dune rehabilitation is subject to a number of grants, which the City will continue to apply for, support and manage.

The two options were scored comparatively with 'Maintain and Enhance Dune System' the preferred option with lower scores across all criteria. This aligns with community preferences for more natural options.

It is recommended that the City develop a system of assessment for priority resilience planning, which may include an ongoing schedule, as well as event response criteria and action plan. The plan should include details of monitoring required across the study area. It is also recommended that the City use this plan to support ongoing grant applications through grant bodies such as Coastwest. The development of this plan may be supported by the Federal Coastal Management Plan Assistance Program or the State Coastal Management Plan Assistance Program.

Recommendation 5: Sand Nourishment Investigation

A number of the 'at-risk' assets include possible sand nourishment as a management option. However, it is acknowledged that the availability of sand for nourishment is not well understood. The plan recommends that the City undertake a sand availability analysis to determine the capacity of local sand supplies.

It should be noted that costings in this plan have assumed a reliable source of sand in proximity to Albany, and if this is not the case the costs associated with sand nourishment could be greatly increased.

Recommendation 6: Rates Levy Investigation

Where proposed management options have the potential to protect private interests, notably as Middleton Beach and Emu Point, it is recommended that the City investigate the establishment of a Specified Area Rate to support the ongoing maintenance and future replacement of protection structures. This rate should be applied only to those properties who will directly benefit from the proposed or existing management option and is thus an equitable method of funding for protection options.

Recommendation 7: Lease Land Management

The City is responsible for a number of leased lands within the study area, some of which are identified as vulnerable in the short term.

As and when these leases come up for renewal, the City will need to consider the current day likelihood of vulnerability and carefully determine both the length of time and the suitability of granting lease extensions.

It is noted that there are a number of developments that can continue for many years in their current form. However, it may be necessary to reconsider design outcomes if renovation is proposed, relocate assets outside of the vulnerable zone if the asset is considered to be beyond its suitable design life, or include conditions on the lease to require removal of infrastructure or relocation dependant on specific and agreed events or catalysts (triggers).

Recommendation 8: Purchase of Property Investigation

As noted in Recommendation 2, it is suitable to begin contemplating the gradual increase of the foreshore reserve in the vulnerable zone in the medium term. Such a decision could potentially result in an obligation on the City to acquire lands under current legislation (Injurious Affection).

It is recommended that the City investigate, as an alternative, the opportunity to acquire land as it become available on the public market. Such property could then be converted to a leasable asset and continue to be utilised up to the time when the risk becomes 'likely/very likely'. Lease clauses may include immediate relocation of tenants. This option would result in a more flexible approach to adaptation over time, with assets being the long term responsibility of the City rather than private landowners.

Recommendation 9: Emergency Management Plan

Notwithstanding any of the above recommendations, it is also recommended that the City prepare an emergency management plan to cover unexpected events, significant coastal erosion and resulting emergency asset repair or removal. This plan could be undertaken in line with Recommendation 4 and include resilience planning and monitoring activities.

The development of this plan may be supported by the Federal Coastal Management Plan Assistance Program or the State Coastal Management Plan Assistance Program.

8.5 COST BENEFIT ANALYSIS

A cost-benefit assessment was undertaken by Jeremy Benn Pacific (JBP) (Appendix G). It describes a coastal erosion damages assessment and Cost-Benefit Analysis (CBA) of several coastal adaptation options. The methodology provides a quantitative, economic assessment of a range of adaptation options to address erosion vulnerability. It provides information on the whole life costs of each option devised to mitigate erosion, the damages avoided due to the option's implementation, and the economic benefits received within the study area. It does not include intangible, environmental or social values, which have been considered in the MCA (Section 8.1).

The CBA uses the available erosion mapping for 2017, 2030, 2070 and 2120 (Royal Haskoning DHV, 2017) to estimate the economic damages likely to be experienced to 2120. A landuse map based on the City of Albany (CoA) Local Planning Scheme and a CoA asset register have been compiled based on datasets supplied for this project. Three broad categories have been used for asset classification:

1. assets delineated by area (e.g. landuse and groundcover);
2. Assets delineated by length (e.g. linear infrastructure); and
3. Assets located on a point (e.g. single assets).

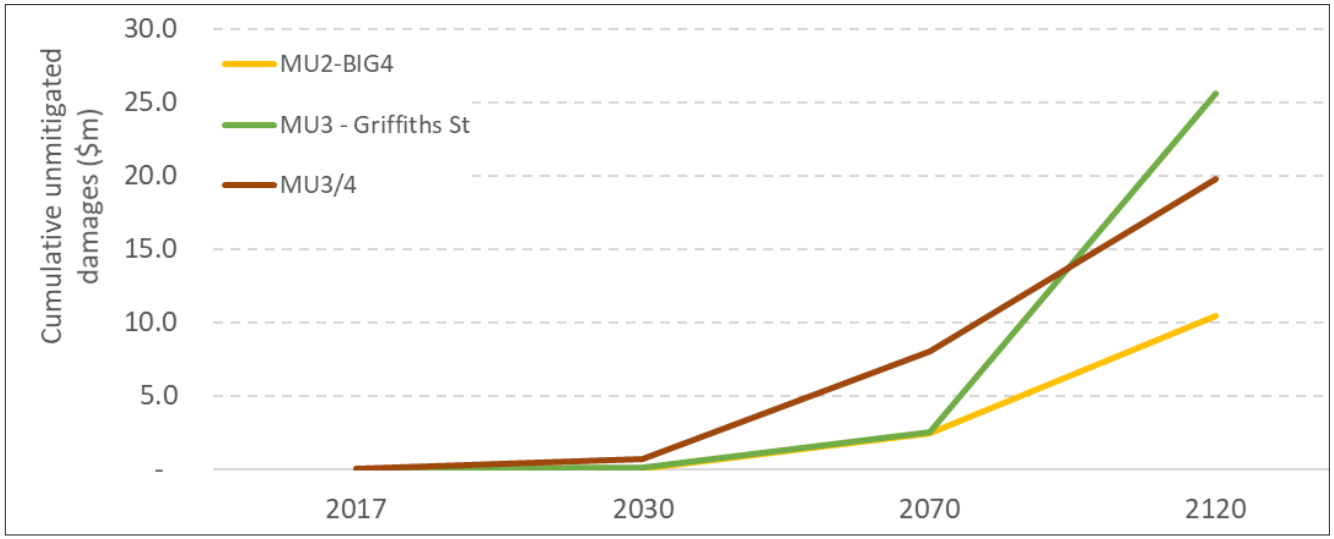
All areas, infrastructure or assets within the mapped erosion zones have been identified within their expected year of loss. A set of unit rates have been developed for each category, based on a range of techniques, including market rates, state-wide estimates and replacement costs.

The results indicate Big 4 Middleton Beach Caravan Park (MU2-Big4) and Griffiths St Properties (MU3-Griffiths Street) will incur relatively minor damages until 2070 (Figure 8.1). After this planning horizon, the impacts at MU3-Griffiths Street will increase steadily as residential properties are affected. The foreshore reserves in MU3 and MU4 (MU3/4 foreshores) experience higher impacts earlier, as modelling indicates that land and assets located close to the foreshore are affected in the shorter term.

This economic assessment considered adaptation options for the following assets/ asset-groups:

- Big 4 Middleton Beach Caravan Park in Management Unit 2
- Griffiths Street properties in Management Unit 3
- Emu Beach and Emu Point foreshore reserves including toilet block on Boongarrie Street in Management Units 3 and 4

Figure 8.1 - Cumulative Damages Due to Erosion ($ millions) with No Discounting



Treatments for MU1 and MU5 were not considered in detail as costs for the implementation of options in these locations was significantly less than the rest of the study area. Some options have been combined for some management units as they complement each other and provide improved confidence to address erosion vulnerability. Some options were not considered in the CBA because the capital and maintenance costs associated with their implementation were not considered likely to be key criteria in determining if they would be selected as preferred options. The implementation year for options is typically proposed between 2030-2040, with whole life costs estimated throughout their lifespan to 2120. Costs have included construction, intervention, training, maintenance, repairs, and upgrade fees. Purchase and demolition costs are also included where required.

The CBA considered some of the economic merits of the potential adaptation options. The Benefit-Cost Ratio (BCR) is the value of benefits divided by the value of operating costs (benefit/costs). An option is considered beneficial for BCR values over 1 (i.e. benefits outweigh costs). The higher the BCR the greater the economic return. As currently proposed, no option has a positive economic return (Table 8.15). The options proposed are expensive while the present erosion risk is economically low in comparison. This translates to relatively low BCRs which indicates that costs outweigh benefits.

The following options have the highest Benefit-Cost Ratio (BCR) for each asset group, where a value of over 1 is considered economically viable:

- MU2-Big4: PR7, Rock Seawall. BCR: 0.5
- MU3-Griffiths Street. PR7, Rock Seawall. BCR: 0.5
- MU3/4 foreshores: PR5, Nearshore structures - groynes. BCR: 0.5

For these options to be economically viable, consideration could be given to a staged response. Testing of a delayed implementation date at MU2-Big 4 Middleton Beach Caravan Park and MU3-Griffiths Street indicates a delayed construction of the rock seawalls could be economically viable. Simply delaying the implementation date of the nearshore groynes at MU3/4 foreshore does not produce a positive BCR and further design optimisation could be considered. The economic analysis supports a multi-stage development of options for each management unit to initially focus on mitigating current risks. Beach and dune maintenance and sand nourishment may allow investment in more costly options to be delayed, so funding can be sourced.

Overall the CBA results provide economic information complementary to that provided by the MCA. Combined with the outcomes from stakeholder engagement, the CBA results may help differentiate between options that are approximately equivalent against the MCA criteria and stakeholder preferences.

Table 8.10 - Cumulative Lifecycle Costs, Benefits and BCR for Adaptation Options *** nominates option with the highest BCR for each management unit*

Option	Total Costs (PV, $, millions)	Total Benefits (PV, $, millions)	BCR
MU2 - Big4			
1MR1 & AV2. Leave assets unprotected and avoid further development	1.1	0.2	0.2
2MR2 & AV2. Relocate assets and avoid further development	1.2	0.3	0.2
PR7 Seawall - Rock **	0.4	0.2	0.5
MU3 - Griffiths Street			
MR2. Relocate assets	3.2	0.2	0.1
PR1. Sand nourishment	0.4	0.2	0.4
PR4 Nearshore breakwaters	0.8	0.2	0.3
PR7 Seawall **	0.5	0.2	0.5
MU3/4 foreshores			
MR2. Relocate assets	8.5	0.7	0.1
AC4. Maintain and enhance near-shore system	2.9	0.4	0.2
PR4. Nearshore structures - breakwaters/headlands	3.2	0.7	0.2
PR5 Nearshore structures - groynes**	1.1	0.5	0.5
PR7 Seawall	2.5	0.5	0.2

Photo Source: City of Albany

9. IMPLEMENTATION PLAN

A separate, standalone Implementation Plan has been prepared to provide an easier to read and more accessible document for the community, referring back to this more detailed technical report.

The plan provides both an indication of costs of all recommended options as well as a timeframe within which each should be prioritised.

Photo Source: City of Albany

10. MONITORING PLAN

10.1 MONITORING PLAN

This chapter outlines a framework for coastal monitoring within the study area based on the CHRMAP implementation recommendations, while providing a better knowledge base to inform longer term management strategies.

The City has a long history of coastal monitoring and an established coastal monitoring and management program. The updated monitoring framework takes into consideration the already extensive body of information collected for the study area (refer to EvoCoast, 2017) to ensure a consistent long term record is maintained.

10.2 MONITORING INTENSITY

The level of monitoring recommended for each asset is based on its risk of being impacted by coastal hazards and the likely requirement for management actions to be required over the next 10 years. The CHRMAP has identified a number of individual assets which are vulnerable in the short-term and require specific attention. For these assets, specific management triggers were identified in the Implementation Plan (Section 9), which when reached, flag the requirement for immediate management actions. For beaches and dunes, the trigger points are reference lines or buffer widths, for structures they relate to the condition of the structure (refer to Table 10.1).

In addition to monitoring at specific locations, to inform management triggers, monitoring across the wider study area is recommended for a broader understanding of the coastal system. This is necessary to inform future coastal processes studies and (where required) the future design of coastal structures.

Table 10.1 - Management Triggers

MU/Asset	Trigger	Management Actions	Monitoring Required
MU1: Beach	Beach width of less than 20m at high water. Measured from the mean water level (MWL).	Minor erosion - beach scraping from the local beaches to reinstate the beach profile. Erosion beyond trigger – sand nourishment likely using sand from outside the local beaches to reinstate the beach profile.	• Beach survey profiles collected 6 monthly (pre/post winter). • 3D beach scan and hydrographic survey collected periodically (every 2-4 years) or after a severe storm event
MU2: Foreshore	Offset of 35m from the back of the beach. Measured from the 1.15m AHD* contour or the vegetation line identified in aerial photographs.	Within the buffer area, construction of new assets should be avoided and planning should be undertaken to relocate or remove existing assets.	• 3D beach scan and hydrographic survey collected periodically (every 2-4 years) or after a severe storm event. • Aerial photography and digitalisation of the coastline position. Collected every 5 years. • Beach survey profiles collected 6 monthly (pre/post winter) (Optional). Note: Beach profiles are optional as although they will provide an early indication of change they will not be sufficient to cover the large area required.
MU2: Big4 Holiday Park Middleton Beach	Offset of 35m from the back of the beach. Measured from the 1.15m AHD* contour.	Within the buffer area, construction of new assets should be avoided and planning should be undertaken to relocate or remove existing assets.	• Beach survey profiles collected 6 monthly (pre/post winter) and post a significant erosion event. Note: Three (3) new survey profiles have been recommended for this location. • 3D beach scan and hydrographic survey collected periodically (every 2-4 years) or after a severe storm event.

MU/Asset	Trigger	Management Actions	Monitoring Required
MU3: Griffiths St Properties	Offset of 35m from the back of the beach. Measured from the 1.15m AHD* contour or the vegetation line identified in aerial photographs.	Within the buffer area, planning should be undertaken to relocate or remove existing assets.	• 3D beach scan and hydrographic survey collected periodically (every 2-4 years) or after a severe storm event. • Aerial photography and digitalisation of the coastline position. Collected every 5 years. Note: Monitoring intensity and frequency
MU3: Big4 Holiday Park Emu Beach	Offset of 35m from the back of the beach. Measured from the 1.15m AHD* contour.	Within the buffer area construction of new assets should be avoided and existing assets should be planned relocated or removed.	• Beach survey profiles collected 6 monthly (pre/post winter) and post a significant erosion event. Note: Three (3) new survey profiles have been recommended for this location. • 3D beach scan and hydrographic survey collected periodically (every 2-4 years) or after a severe storm event.
MU4: Foreshore Reserve	Revetment condition poor or very poor. Required repairs exceed routine maintenance.	Reconstruction of revetment	• Condition inspection by coastal engineer collected annually (post winter).
MU5: Southeast Beach	Maximum beach width of less than 20m at high water. Measured from the mean water level (MWL) at peak of beach profile, behind swimming structure.	Minor erosion - beach scraping from the local beaches to reinstate the beach profile. Erosion beyond trigger – sand nourishment likely using sand from outside the local beaches to reinstate the beach profile.	• Beach survey profiles collected 6 monthly (pre/post winter).

Note: The 1.15m AHD level is based on the work by RHDHV (2017a). It is the estimated peak steady water level (PSWL) expected to occur offshore during a 500 year ARI storm event. (Note: during a storm event, wave breaking may cause the water levels at the beach to increase higher/beyond this level.) On an eroding shoreline this is expected to be approximately the toe of the dune, or the back of the beach.

10.3 MONITORING REQUIREMENTS

The recommended monitoring activities are summarised in Table 10.2, which lists:

- Monitoring type
- Spatial extent
- Description
- Collection frequency
- Collected by
- Data review schedule

Although recommendation for data collection by organisations other than the City (e.g. Southern Ports Authority, Bureau of Meteorology and DoT) is based on existing monitoring programs, it is acknowledged that these organisations are only able to collect and share coastal information and data, when and where resources permit.

A summary of the key monitoring actions, including details of any recommended changes to the existing monitoring program, is as follows:

Metocean

a. Continue acoustic wave and current (AWAC) meter deployment. The continued deployment of a single AWAC instrument (or similar) to record waves and currents is recommended. It is recommended that the position at Lockyer Shoal be maintained to ensure a recording length of 2 years in order to improve the understanding of wave driven currents on the formation of the shoal. Following completion of monitoring at Lockyer Shoal, the benefits of monitoring in the vicinity of Ellen Cove should be considered to evaluate the off-shore sediment transport budget.

b. Continue wind recordings at Emu Point. The continuation of wind recordings at Emu Point is recommended to establish a local dataset. It is recommended that a minimum of 5 to 6 years of continuous recordings be collected. Following which a comparison be undertaken to the global wind models to determine the benefit for ongoing data collection.

Structures

a. Condition inspections. Given the current fair or poor condition of some structures within the study area, an annual condition inspection by consultant engineers is recommended. It is recommended that this be complimented by post storm event inspections by City officers. As repairs/upgrades are undertaken and condition improves, monitoring frequency can be reduced accordingly. Annual condition inspections should identify: condition rating, remaining life, and replacement cost with information added to the City's asset database. For consistency the simple methodology and rating scales detailed in letter report EVO-AL-002-L-001-A, 21 June 2017 is recommended. This details a structure condition rating consistent with the rating scale used for all asset management across the City.

Storm events

a. In the event a significant storm event is to occur the following monitoring items are recommended:
    a. If there is sufficient time available undertake pre-storm beach profiles and beach photos.
    b. Post storm beach profiles and beach photos. If there is a significant change it the profiles, consideration should be given to undertaking full hydrographic survey and 3D beach scan.

c. Post storm coastal structures inspection. This can be undertaken initially by a City officer, if any significant damage is evident a full condition inspect by a coastal engineer is recommended.

Beach

a. Beach profiles. It is recommended beach profile surveys continue every 6-months, with the objective of capturing pre and post winter profiles. These are required to inform a number of short-term triggers. The following additional profiles are recommended to be added to the existing monitoring program (also shown in Figure 10.1):

   a. Two (2) additional beach profiles MB-01 A & B in front of the Big 4 Middleton Beach Caravan Park (MB-01 A - Easting 583552.7m, Northing 6124094m & MB-01 B - Easting 583580., Northing E 6124321.1m).

   b. Relocation of MB-05 profile south to be directly in front of Griffiths Street (Easting 584926.0m, Northing 6125965.8m).

   c. One (1) additional profile MB-10 at the southern end of the Emu Point revetment (Easting 585777m, Northing 6126430m).

b. Hydrographic survey. It is recommended that the City continues to obtain nearshore surveys to ~10m water depth, currently undertaken by DoT, as and when undertaken. A nominal frequency of 2-3 years would be desirable. The priority survey area remains Lockyer Shoal. CoA to liaise with DoT.

c. Scanning beach survey. It is recommended that the City continue to obtain detailed 3D scanning beach surveys undertaken by DoT when available, nominally on a 2 - 3 year frequency, to fill in the gaps between the more regular beach profiles. Consideration should be given to the use of drone surveys as they become more readily available. These can be a cost-effective option and can provide a more detailed coverage of both the dunes and beach.

d. Aerial photography. Vertical aerial photography, captured by Landgate, and associated photogrammetry to plot shoreline change is recommended as an important tool for evaluating long-term changes in the position of the coast. It is recommended that the minimum collection frequency of 5 years be continued with the next collection scheduled for 2020.

e. Aerial photography (water penetrating). Water penetrating aerial photography and associated seagrass surveys are recommend to continue nominally every 3 years in order to record and understand the regrowth of seagrass through the study area.

f. Beach Photos. The continued use of the fixed camera to monitor the beach and structures at Emu Point is recommended, but with a reduced collection frequency of 3 hours. It is recommended that staff/volunteer field photo monitoring continue.

Data management and sharing

a. Data storage – It is recommended that GIS metadata summaries of collected coastal zone data be created to ensure information is well-archived. There is also the opportunity for increased coordination with DoT regarding the collection of coastal photography and hydrographic survey to seek synergies with Southern Ports, DoT and the City's spatial data team where data sets are shared. The GIS metadata summaries should be updated annual with any additional information collected.

Figure 10.1 - Beach transects Ellen Cove to Oyster Harbour Beach

Source: John Kinnear and Associates

CO-ORDINATE LISTING

NAME	EASTING	NORTHING	ELEV
ALB-15	583111.33	6124053.53	1.84
MB-01	583576.96	6123888.70	2.33
MB-02	583715.43	6124582.15	4.48
MB-03	584196.40	6125278.10	4.23
MB-04	584559.34	6125668.99	4.25
ALB-10	584803.57	6126002.91	5.11
MB-05	585042.89	6126053.95	2.91
MB-06	585263.26	6126184.26	2.97
MB-07	585515.39	6126304.69	4.13
MB-08	585720.55	6126435.83	3.63
MB-09	585636.48	6126410.54	4.17
EP-01	586172.30	6126623.93	3.78
EP-03	586338.69	6126635.83	2.09
OH-01	586536.06	6126723.48	1.35
OH-02	586396.94	6126806.69	1.54
OH-04	586161.75	6127020.15	1.61
OH-06	586075.51	6127326.29	1.16

Table 10.2 - Recommended Monitoring Activities for Ellen Cove to Oyster Harbour Beach

ITEM	MONITORING TYPE	SPATIAL EXTENT	DESCRIPTION	COLLECTION FREQUENCY	COLLECTED BY	DATA REVIEW SCHEDULE
1	Offshore Wave Buoy	Outside study area, ~60m water depth 35°11'53" S 117°43'19" E	Offshore wave height, period & direction. Baseline metocean information for future investigations.	Hourly, ongoing	DoT	No regular review required by City
2	AWAC	M/Unit 3/4 Lockyer Shoal	Nearshore wave height, period direction; and current speed, direction. Local baseline metocean information for future investigations.	Hourly, ongoing	Consultant organised by CoA	No regular review required by City
3	Water levels at Port	Outside study area 35°02'02"S 117°53'41"E	Tide gauge recording ocean water levels. Baseline metocean information for future investigations.	5 mins, ongoing	Southern Ports Authority/DoT	No regular review required by City
4	Water levels at Emu Point Boat Harbour	M/Unit 5 34°59'38"S 117°56'39"E	Tide gauge recording water levels within Oyster Harbour. Local baseline information to link Oyster Harbour water levels with ocean levels.	5 mins, ongoing	DoT	No regular review required by City
5	Wind data - Airport	Outside study area 34°56'24"S 117°49'10"E	Anemometer recording wind speed & direction. Baseline metocean information for future investigations.	Half-hourly, ongoing	BOM	No regular review required by City
6	Wind data – Emu Point	M/Unit 4 - Located on Port navigation aid 34°59'56"S 117°56'45"E	Anemometer recording wind speed & direction. Local baseline metocean to characterise study area wind climate; and link to long-term datasets.	10 mins, ongoing	CoA with assistance by consultant Ecotech	Weekly quality control check by City or consultant to ensure data is being collected/ received intact

ITEM	MONITORING TYPE	SPATIAL EXTENT	DESCRIPTION	COLLECTION FREQUENCY	COLLECTED BY	DATA REVIEW SCHEDULE
7	Hydrographic Survey	Whole study area Ellen Cove to Oyster Harbour through Emu Point channel, and out to ~10m water depth	Water depths collected by boat. To provide a broad understanding of changes in offshore morphology. Identify whole scale reductions in seabed/ sediment movement.	Every two years (same time as 3D beach survey)	CoA	No regular review required by City
8	3D scanning beach survey	Whole study area, will vary. Generally, beach and foredune from Ellen Cove to Emu Point	Beach topography collected by different methods. To identify volumetric rates of beach change, and; assist with identification of erosion hazard to assets.	Every two years (same time as hydrographic survey)	DoT & CoA	No regular review required by City
9	Beach survey profiles	Whole study area 22 historic profile lines between Ellen Cove and the north side of the Emu Point Boat Harbour (4 new profile lines)	Beach topography collected along single lines by traditional survey methods. Early detection of reduction in buffer widths; to assist in linking coastal change to storm events, and; detection of shoreline trends.	6-monthly ongoing; AND Triggered by significant storm forecast; OR Post-storm erosion scarp over 1.5m	CoA / local contractor	Post collection review against triggers. Data to be provided to City and plotted into x, y overlay plots for each transect against previous survey data.
10	Aerial Photo	Whole study area Variable, generally whole study area covered	Vertical aerial photographs. Identify shoreline change and larger scale changes in coastal features, primarily by informing photogrammetry process.	5-yearly ongoing Last capture 2016. Next capture in 2021	Landgate	Consultation in 2020 by City with Landgate and possibly DoT/WALIS Marine Group to confirm their capture scheduled for coastal photography

ITEM	MONITORING TYPE	SPATIAL EXTENT	DESCRIPTION	COLLECTION FREQUENCY	COLLECTED BY	DATA REVIEW SCHEDULE
11	Digitisation of Coastline Positions	Whole study area	Digitisation of State Government aerial photography vegetation lines using photogrammetry. To identify shoreline change, reduction in buffer widths and larger scale changes in coastal features.	Occasional – approximately every 5 years.	DoT	After aerial photo collection, consultation by City with DoT to confirm photogrammetry completed
12	Aerial Photo - Water penetrating	Whole study area	Collected using local aeroplane and contractor. To identify changes to seagrass distribution and density to inform relationship with sediment transport.	Approximately every 3 years in Autumn. Next collection Autumn 2020	Sampling organised by CoA and Geoff Bastyan.	Post collection review Changes in seagrass distribution
13	Beach Photos - Fixed camera	M/Unit 3 35°00'03"S 117°56'27"E	Remote camera with fixed field of view. To identify short-term changes in beach level/ width; to assist in linking coastal change to storm events.	3 hourly	Sampling organised by CoA and photos managed by BMT Oceanica	2-weekly quality control check by City or consultant to ensure data is being received intact and any review against triggers
14	Beach Photos –Staff / Volunteers	Whole study area. 23 locations from Ellen Cove to Emu Point Boat Harbour totalling 45 fields of view	Regular photos taken by City staff and community members. To identify short term changes to beach and structures. To assist in linking coastal change to storm events.	Monthly	Organised by CoA	Post collection review quality control check by City staff to ensure photos are collected and archived properly and any review against triggers

ITEM	MONITORING TYPE	SPATIAL EXTENT	DESCRIPTION	COLLECTION FREQUENCY	COLLECTED BY	DATA REVIEW SCHEDULE
15	Seagrass monitoring	Whole study area Nearshore water	Diving inspection of seagrass and comparison with aerial photo. To identify changes to seagrass distribution and density to inform relationship with sediment transport.	Approximately every 3 years in Autumn. Next collection Autumn 2020	Sampling organised by CoA and Geoff Bastyan.	Post collection review
16	Structure condition inspection	M/Unit 1, 3, 5 Various structures	Visual walk-over inspection with recorded photo locations. To assess the current condition & identify future maintenance requirements. Information to be stored in asset database and include condition rating, remaining life and replacement cost consistent with EVO-AL-002-L-001-A, 21 June 2017.	Annually before winter for key areas of concern; OR Triggered by observed structure damage Every 3 years for detailed inspections of all structures (Autumn 2019 and 2022)	Coastal engineer	Part of condition inspection
17	GIS metadata	Whole study area	Create metadata summaries which capture key coastal zone information and datasets and include details about their filing/archiving so that they can be more easily found into the future. Archive important datasets and their metadata for easy future use.	Once off	CoA or consultant	Scheduled annual update of metadata to include data collected over previous year

Photo Source: City of Albany

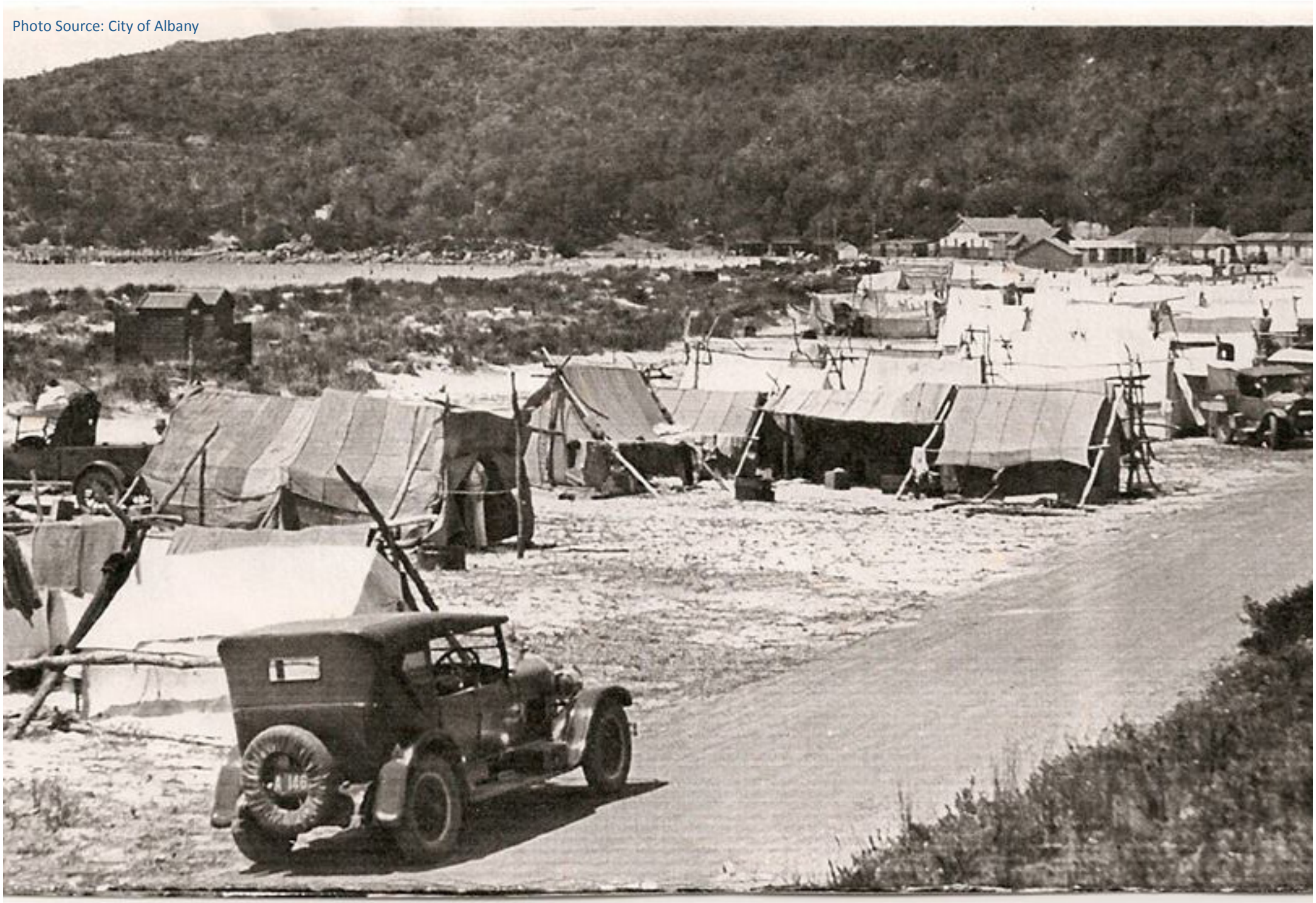


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Photo Source: City of Albany

APPENDIX A

Coastal Processes and Investigations

APPENDIX B

Key Stakeholders

APPENDIX C

Simplified Hazard and Inundation Mapping

APPENDIX D

Stakeholder Engagement Outcomes

APPENDIX E

Risk and Vulnerability Assessment Tables

APPENDIX F

Community Advisory Panel - Summary of Proceedings

APPENDIX G

Cost Benefit Analysis

APPENDIX H

Suite of Preferred Options


Photo Source: City of Albany
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