10.5 Director Infrastructure

10.5.1 City of Bunbury Coastal Hazard Risk Management and Adaptation Plan (CHRMAP)

File Ref:	DOC/1279042
Applicant/Proponent:	Internal
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Executive:	Gavin Harris, Director Infrastructure Services
Authority/Discretion	☐ Advocacy ☐ Quasi-Judicial ☒ Executive/Strategic ☒ Information Purposes ☐ Legislative
Attachments:	Appendix 10.5.1-A Final City of Bunbury CHRMAP Appendix 10.5.1-B Short-term Coastal Action Plan Appendix 10.5.1-C DRAFT CHRMAP Summary Report

Summary

The purpose of this report is to request Council to endorse the City of Bunbury Coastal Hazard Risk Management and Adaptation Plan (CHRMAP), support the implementation of the Short-term Coastal Action Plan, and support the promotion of the CHRMAP Summary Report in the community.

Executive Recommendation

That Council resolves to:

1. Endorse the final City of Bunbury Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) as presented at appendix 10.5.1-A as a guide for future coastal planning and management.

2. Commence investigations and actions to confirm the assumptions made in the CHRMAP, as outlined in the Short-term Coastal Action Plan, as presented at appendix 10.5.1-B, noting that groynes are a protective option that will be investigated but not constructed in the short-term (0 – 15 years).

3. Prepare and implement an engagement plan to communicate the CHRMAP recommendations and next steps to the community, including the promotion of the CHRMAP Summary Report, as presented at appendix 10.5.1-C.

4. Request the Chief Executive Officer to investigate opportunities to share a Coastal Engineering resource with adjoining local governments to provide a holistic approach to managing the adjoining coastline.

Voting Requirement: Simple Majority

Strategic Relevance

Pillar	Planet
Aspiration	A healthy and sustainable ecosystem
Outcome 6.1	Minimise risks and impacts from fires, floods, heat waves, and other natural disasters.
Objective 6.1.1	Develop and implement a Coastal Hazard Risk Management Adaptation Plan (CHRMAP)

Regional Impact Statement

Endorsement of the CHRMAP means the City will be eligible for grant funding to implement the Short-term Coastal Action Plan. Coastal actions and investigations will be undertaken to investigate the recommended adaptation pathways, including more engagement with the community about the CHRMAP.

Background

The City is a member of the Peron Naturaliste Partnership (PNP), which comprises the membership of nine local government authorities between Cape Peron and Cape Naturaliste in the southwest of Western Australia – Bunbury, Busselton, Capel, Dardanup, Harvey, Mandurah, Murray, Rockingham, Waroona. Through the City's PNP membership, the City joined a Steering Group with the Shires of Capel, Harvey and Dardanup, the Southern Ports Authority and the Department of Biodiversity, Conservation and Attractions to commission consultants to produce the Capel to Leschenault CHRMAP. The City of Bunbury CHRMAP was developed as part of the Capel to Leschenault CHRMAP.

The 2019 CHRMAP prepared for the Koombana Bay area has been considered in the Capel to Leschenault CHRMAP. Outside of Koombana Bay, there has been no prior CHRMAPs prepared for the remainder of the project area.

Coastal engineering consultancy Water Technology along with community planning consultancy Shape Urban were appointed in March 2021 to produce the CHRMAP. The final CHRMAP was presented to the Steering Group in November 2023 and the CHRMAP was finalised in December 2023.

In March 2024, a Short-term Coastal Action Plan was developed to assist City staff and Elected Members in prioritising, budgeting, scoping and implementing the various coastal management actions that were recommended in the CHRMAP, over the next five years. The City also sought the assistance of a consultant to summarise and re-frame the CHRMAP for a public audience (the CHRMAP Summary Report).

Council Policy Compliance

The following Council Policies apply:
- Asset Management
- Climate Change
- Sustainability

Legislative Compliance

State governments across Australia have introduced obligations that require local governments to consider and plan for coastal hazards (inundation and erosion). In Western Australia, the governing policy is the Western Australian Planning Commission's State Planning Policy No. 2.6: State Coastal

Planning Policy ("SPP2.6"). SPP2.6 recommends management authorities develop a CHRMAP for land use or development that is vulnerable to coastal hazards.

Officer Comments

The City's coastline is exposed to a significant level of coastal hazard risk (specifically coastal erosion and inundation), which will place pressure on public and private assets along the coast as the sea level rises over time. Rising sea levels and intensifying storm activity will increase the risk of coastal inundation (temporary coastal flooding), storm erosion and long-term shoreline recession. The purpose of the City of Bunbury CHRMAP is to provide strategic guidance for coordinated, integrated, and sustainable decision making for future coastal land use planning, including management or, and adaptation to, these coastal hazard risks.

The City of Bunbury CHRMAP describes risk management actions to be undertaken to achieve preferred risk treatments, considering the short-term (0-15 years), medium-term (15-30 years) and long-term (up to 100 years). Coastal hazard vulnerabilities were addressed by dividing the City's shoreline into five Management Units, recommending adaptation pathways and options to manage the coastal erosion and inundation risk, to give preliminary direction for future investigations and funding opportunities.

<u>CHRMAP Endorsement (Appendix 10.5.1-A)</u>

Four Management Units recommend a short-term option to "investigate and prepare for groynes" to address beach erosion. This means that the City would need to undertake further investigations and studies to determine whether this option is suitable. There is no recommendation to build groynes in the short-term (0 – 15 years).

The CHRMAP recommends that groynes be constructed in the medium to long-term (15 – 100 years). However, this recommendation would depend on the outcomes of the short-term investigations. In endorsing the CHRMAP, Council would not be committing to building groynes. Council would be acknowledging the CHRMAP actions and recommendations to use as a guide for future coastal planning and management. It is important to note that endorsement of the CHRMAP means the City will be eligible for grant funding to implement the Short-term Coastal Action Plan.

The CHRMAP notes that the proposed options should be the subject of further investigations, surveys, policy review, impact investigations (environmental, visual and social), development approval and authorities' endorsement, local stakeholder and community engagement, preliminary design, detailed design, costing and any other applicable preparation work required prior to being implemented. Following this work, the intent is for the CHRMAP to be reviewed, and the recommended options will be updated to take the new information into consideration.

<u>Short-term Coastal Action Plan (Appendix 10.5.1-B)</u>

The Short-term Coastal Action Plan was developed to help prioritise, budget, scope and implement the various coastal management actions that were recommended in the CHRMAP, over the next five years (2024/2025 to 2028/2029 inclusive). Actions include (but are not limited to) storm impact monitoring, sand and rock source feasibility studies, the development of foreshore management plans, foreshore asset and coastal protection structure audits, and the development of an emergency evacuation plan. The Short-term Coastal Action Plan does not include the construction of protective structures such as groynes or seawalls.

Importantly, State and Federal coastal grant opportunities outline that an 'endorsed' CHRMAP is required to be eligible for funding to implement recommended actions. Once the CHRMAP is endorsed, City officers will systematically work through the actions in the Short-term Coastal Action Plan, accessing grant funding where possible.

CHRMAP Summary Report (Appendix 10.5.1-C)

Community and stakeholder involvement is a critical component of the CHRMAP process, as it defines what and how much value is placed on assets within the coastal management zone. It is recommended that an engagement plan is prepared and implemented to support future local stakeholder and community engagement into the implementation stage of the CHRMAP project.

However, it is important to first ensure the community are aware of and understand what a CHRMAP is and what the recommendations mean. While the final CHRMAP was released for public consultation, the City received limited interest and submissions, which is likely to be in part because the CHRMAP is a highly technical report that is very long (101 pages, plus eight appendices) and structured in accordance with SPP2.6 guidance which is rigid and hard to digest.

A CHRMAP Summary Report is being developed to distil the technical CHRMAP information, to put it simply, and to include frequently asked questions and a description of how the community may be affected. The CHRMAP Summary Report was prepared by a consultant and is currently in draft form, with the intent being to reduce the content further to create a shorter and more streamlined document for public release. The Draft CHRMAP Summary Report, in its current form, gives a comprehensive and detailed overview of the CHRMAP process that is helpful to read and understand.

Shared Coastal Engineering Resource

The CEO and Director of Infrastructure have had preliminary discussions with adjoining local governments including Busselton, Capel and Harvey in regard to identifying key resources required to investigate and implement the outcomes identified in the individual CHRMAP's. There is a need for the local governments to work together and to pool resources and ensure that the coastline and associated investigations and implementations are considered across more than one local government. Consideration should be given to secure Coastal Engineering resources that can work across several local governments and ensure economies of scale, particularly when securing investigations that may be wider ranging than one local government.

Analysis of Financial and Budget Implications

Endorsement of the CHRMAP will enable the City to apply for grant funding, such as the Western Australian State Government, Coastal Adaptation and Protection (CAP) Grant, Coastal Management Plan Assistance Program (CMPAP), Coastwest Grants Program and the Australian Federal Government, Disaster Ready Fund (DRF).

There is an existing budget for CHRMAP preparation and implementation (*PR-4286 – Prepare City of Bunbury CHRMAP*). Identified in the current Long Term Financial Plan are allocations of $220,000 in FY 23/24, increasing to $440,000 in FY 24/25, $660,000 in FY 25/26, $880,000 in FY 26/27 and $1,100,000 in future years. It is understood that unspent funds from each financial year will be transferred to a reserve fund.

There is likely to be unspent funds in the short-term, as the implementation of the Short-term Coastal Action Plan is estimated to cost $868,000 over the next five years. The majority of the costs are likely to be encountered in the medium to long-term, when investigations are complete, and the relevant protection measures are being constructed or implemented.

Community Consultation

Consultation with community, residents, businesses and users of the City of Bunbury coastal zone was undertaken as part of the CHRMAP development. Consultation was undertaken in accordance with a Community and Stakeholder Engagement Plan, which included a Community Assets and Values survey, a community workshop, a briefing session and public advertisement of the CHRMAP. The draft CHRMAP was publicly advertised for 12 weeks (ending 16th June 2023) and five comments were received. A summary of the public review comments and associated responses are included in Appendix H of the final CHRMAP.

Councillor/Officer Consultation

A presentation was delivered to Council on 7 February 2023 by the consultant (Water Technology) and the PNP, which outlined the CHRMAP process and draft CHRMAP recommendations ahead of the public advertisement period. Elected Members were also invited to the community engagement session on 3 May 2023.

Councillor Tresslyn Smith sits on the PNP Board and has received updates for the duration of the CHRMAP project during quarterly board meetings.

The CHRMAP was mentioned at the 1 February 2022 OCM concerning a City of Bunbury Declaration on Climate Change (Council Decision 019/22).

Applicant Consultation

Nil.

Timeline: Council Decision Implementation

On 20 March 2024, the City in partnership with the Department of Transportation Maritime has submitted a grant application requesting $3.77M from Round 2 of the Australian Federal Government Disaster Ready Fund for repair works to the Leschenault Inlet training walls and channel revetment rock protection structures. These works will increase the height of the channel revetment walls to help protect against the medium term predicted sea level rise identified within the CHRMAP.

The City will submit one or more grant applications (CAP and/or CMPAP) on 17 April 2024, to secure funding to proceed with relevant items as outlined in the Short-term Coastal Action Plan.

The grant applications will be subject to Council endorsement of the CHRMAP prior to grant award.

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Capel to Leschenault CHRMAP

City of Bunbury CHRMAP

Peron Naturaliste Partnership

4 December 2023

Document Status

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Project Details

Project Name	City of Bunbury CHRMAP
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ACKNOWLEDGEMENT OF COUNTRY

In the spirit of reconciliation, the Board, Directors and employees of Water Technology acknowledge and respect the Aboriginal and Torres Strait Islander Peoples as the Traditional Custodians of Country throughout Australia.

We acknowledge the Traditional Custodians of the land on which our offices reside and where we undertake our work. We specifically acknowledge the Wardandi Noongar people as the Traditional Custodians of the land our work relates to for this report.

We respect the knowledge, skills and lived experiences of Aboriginal and Torres Strait Islander Peoples and we will continue to strive to learn from them and work with them.

We also extend our respect to all First Nations Peoples, their cultures and to their Elders, past and present.

EXECUTIVE SUMMARY

It is internationally recognised that the mean sea level has been rising globally since the nineteenth century and is predicted to rise at an increasing rate in the future (IPCC 2014). Rising sea levels and intensifying storm activity will increase the risk of coastal inundation (temporary coastal flooding), storm erosion and long-term shoreline recession. State governments across Australia have introduced obligations that require local governments to consider and plan for these hazards. In Western Australia (WA), the governing policy is the

Western Australian Planning Commission's State Planning Policy No. 2.6: State Coastal Planning Policy (WAPC, 2013, herein referred to as "SPP2.6"). SPP2.6 recommends management authorities develop a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for land use or development that is vulnerable to coastal hazards. Specific guidelines have been developed to assist in this process (WAPC, 2019).

One of the key objectives of SPP2.6 is to establish coastal foreshore reserves including allowances for the protection, conservation and enhancement of coastal values across the state. Risk assessment processes are then utilised to identify risks that are intolerable to the community, and other stakeholders such as local governments, indigenous and cultural interests, and private enterprise. Adaptation measures are then developed according to the preferential adaptation hierarchy outlined in SPP2.6.

The Peron Naturaliste Partnership (PNP) comprises the membership of nine local government authorities. The PNP's Coastal Adaptation Pathways Project identified the coastal areas of Capel, Leschenault and Greater Bunbury as being particularly exposed to coastal hazards and climate change, which triggered the need for this CHRMAP. The project has investigated and planned for coastal hazards which are likely to affect these regions from Capel to Leschenault.

The project identifies the strategic direction for coastal adaptation scenarios and details an implementation plan describing risk management measures to be undertaken to achieve preferred risk treatments. The CHRMAP serves as a key reference for management, planning and policy making for the short-term (0-15 years), medium-term (15-30 years), and long-term (100 years).

The broader study area covers four Local Government Areas (LGAs) namely Shire of Harvey, City of Bunbury, Shire of Dardanup, and Shire of Capel. This report addresses coastal hazard vulnerabilities for the City of Bunbury.

The City shoreline can be divided into five primary management units:

- MU4 - Bunbury South
- MU5 - Bunbury (including Five Mile Brook district, Koombana Bay, Leschenault Inlet)
- MU6 - Bunbury Port (Inner Harbour)
- MU7 - The Cut
- MU8 – Bunbury East

A Coastal Hazard Assessment has identified the coastal hazards in the study area that need to be considered in the CHRMAP. Hazard maps were produced defining the erosion and inundation extents for present day, 2035, 2050, 2120. It is acknowledged that the hazard identification component of the present study was undertaken to provide a broad understanding of exposure that can support government planning at a regional level. The hazard identification may be superseded by future site-specific studies, particularly at the estuary/inlet and along the river courses. Results derived from this study should not be over-interpreted at a micro-scale due to the assumptions applied and the limitations in resolution.

Following the Hazard Assessment, a Coastal Assets Identification investigation was undertaken to identify the assets within the coastal hazard zone. All the assets in the coastal hazard zone were identified and classified into 9 categories as listed below. The quantity of each asset category by Management Unit, category and planning horizon are presented for each hazard.

- Roads
- Residential land
- Commercial land and assets

- Public and community assets not located in the foreshore reserve e.g., car parks, recreational facilities
- Developed foreshore reserve, including coastal, estuary and river foreshore areas
- Undeveloped foreshore reserve, including coastal, estuary and river foreshore areas
- Environmental
- Agricultural / rural lands
- Aboriginal heritage

Community and stakeholder involvement is a critical component of the CHRMAP process, as it defines what and how much value is placed on assets within the study area. As such, the project contained a high level of community and stakeholder engagement. Engagement outcomes have informed the adaptation planning process and ensured all needs are considered. This provides ownership of the CHRMAP with those that it affects, and acceptance of its outcomes. A Community Values assessment using various engagement methods was used to identify key values and concerns for the study area.

Key coastal, estuarine and riverine values identified by participants across the whole study area as follows:

- Beaches and estuarine areas for activities like walking, swimming, snorkelling, exercise, views, fishing, surfing, 4WDing
- Wetlands and environmental areas for their flora and fauna diversity which participants could appreciate
- Coastal views, walks and scenery
- Coastal vegetation and the natural environment generally

The values collated from the engagement to date have been used to generate the success criteria for the vulnerability and risk assessment component of the CHRMAP.

- Conserve, enhance and maintain the natural environment and character of the study area
- Facilitate and promote public usage and enjoyment of the natural environment, coast, estuaries and rivers
- Protection of the cultural values of the coastline
- Manage impacts to the existing residential areas from erosion and inundation
- Maintain critical infrastructure supporting the community (roads, utilities).
- Manage and maintain coastal infrastructure that provides access to the water and supports the lifestyle enjoyed by people in the region
- Retain the widest possible range of risk management options for future users of the coast

A Vulnerability Analysis, which constitutes the second stage of the risk identification process, was undertaken to develop likelihood, consequence, level of risk, adaptive capacity and vulnerability ratings for the nine asset categories.

All identified at-risk assets within the 11 management units are presented for the planning horizons of present day, 2035, 2050 and 2120, for each hazard. Extreme vulnerability has been identified from the present day onwards. Most of this extreme vulnerability is predicted to be from erosion, except for residential and commercial inundation.

The enormous number of at-risk assets, a total of approximately 48,000 in the broader study area, means grouping and summarising is the only meaningful method of assessing the risk at this stage of the planning process.

Recommended adaptation options to manage the coastal erosion and inundation risk in the City are presented to give direction for future investigations and funding opportunities. The recommendations are preliminary as they are based on currently available information. Future investigations are required to confirm they are suitable, including further consultation with stakeholders and the community. Subsequently a likely outcome is that a combination of options may be the preferred approach in some locations. The recommendations are based on the analysis presented in this report. Additional considerations may be incorporated into future analyses.

The proposed Options should be the subject of further investigations, surveys, policy review, impact investigations (environmental, visual and social), development approval and authorities endorsement, local stakeholder and community engagement, preliminary design, detailed design, costing and any other applicable preparation work required prior to be implemented. The Options should be optimised and modified following such additional investigations.

To address erosion for the City's coastline in the short-term a combination of Planned / Managed Retreat (MU4) and Protection with Groynes (MU5, MU6, M& and MU8) has been shown to the preferred approach as a result of this analysis. To address inundation in the short-term it is recommended investigations are undertaken to plan for the Storm Surge Barrier to be replaced with an upgraded structure (MU5); and for confirmation of suitable levee design (MU6) as well as further design and investigations (MU7 and MU8)

A number of additional general investigations are recommended:

1. Prepare an Asset Management Plan for each Management Unit
2. Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat.
3. Sand source feasibility study
4. Rock source feasibility study
5. Emergency evacuation planning
6. Update Foreshore Management Plans (FMPs) - Updated foreshore management plans for the study areas may increase the protective capacity of the natural dune system.
7. Coastal Hazard Mapping Study

The CHRMAP is a strategic planning document that considers long timeframes. While the CHRMAP provides a rationale for coastal hazard management a substantial amount of preparatory work, detailed in the CHRMAP recommendations, is required before "on-the-ground implementation" can proceed. The next phase of research and studies would consider priority items in more detail, including:

- Community and stakeholder engagement
- Data collection and analysis
- Preliminary and detailed design investigations
- Environmental investigations to mitigate potential impacts
- Economic and budgeting analysis to determine accurate costs, once detailed designs are available

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1 INTRODUCTION

1.1 Background

It is internationally recognised that the mean sea level has been rising globally since the nineteenth century and is predicted to rise at an increasing rate in the future (IPCC 2021). Rising sea levels and intensifying storm activity will increase the risk of coastal inundation (temporary coastal flooding), storm erosion and long-term shoreline recession. State governments across Australia have introduced obligations that require local governments to consider and plan for these hazards. In Western Australia (WA), the governing policy is the Western Australian Planning Commission's (WAPC) State Planning Policy No. 2.6: State Coastal Planning Policy (WAPC, 2013, herein referred to as "SPP2.6"). SPP2.6 recommends that management authorities develop a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for land use or development potentially vulnerable to coastal hazards. Specific guidelines have been developed to assist in this process (WAPC, 2019).

SPP2.6 requires adequate risk management planning is undertaken where the existing or proposed development is in an area at risk of being affected by coastal hazards over the 100-years planning timeframe. SPP2.6 and the CHRMAP Guidelines provide the risk assessment framework to be applied to identify risks that are intolerable to the community, and other stakeholders such as local governments, indigenous and cultural interests, and private enterprise. Risk management measures are then developed according to the adaptation hierarchy outlined in SPP2.6.

The Peron Naturaliste Partnership (PNP) comprises membership of nine local government authorities. The PNP's Coastal Adaptation Pathways Project identified the coastal areas of Capel, Leschenault and Greater Bunbury as being particularly exposed to coastal hazards and climate change, which triggered the need for this CHRMAP. Therefore, the present study aims to investigate the nature and severity of coastal hazards that are likely to affect these regions from metre over future planning horizons. Refer Figure 1-2 for locality, study area extent and management units. This report addresses coastal hazard vulnerabilities for the City of Bunbury (City).

This CHRMAP project aims to increase knowledge and understanding of coastal hazard risks and identify risk management and adaptation measures for implementation. The outcomes will be used to inform local and state government policies, strategies and plans, including (but not limited to), planning strategies, community strategic plans, drainage strategies, asset management plans, emergency management plans, and foreshore management plans. The project adheres to the WAPC (2019) guidelines with scope and deliverables consistent with the objectives identified by these guidelines and SPP2.6. In addition, the project determines the strategic direction for coastal adaptation scenarios from the present-day to 2120 (100 yrs. management time frame) and identifies an implementation plan to achieve this direction. Overall, this CHRMAP will serve as a key reference for management, planning and policymaking for the short-term (0-15 years), medium-term (15-30 years), and long-term (100 years).

Delivery of this project has occurred over 9 stages (as summarised in Figure 1-1), each of which represented a key hold point. The staged approached was developed according to the PNP's scope and is in line with the CHRMAP Guidelines (WAPC, 2019).

This report presents one of four Stage I Final CHRMAP Reports, which summarise the project and makes recommendations to address erosion and inundation vulnerabilities. The red bubble displayed in Figure 1-1, outlines Stage I in the context of the CHRMAP.

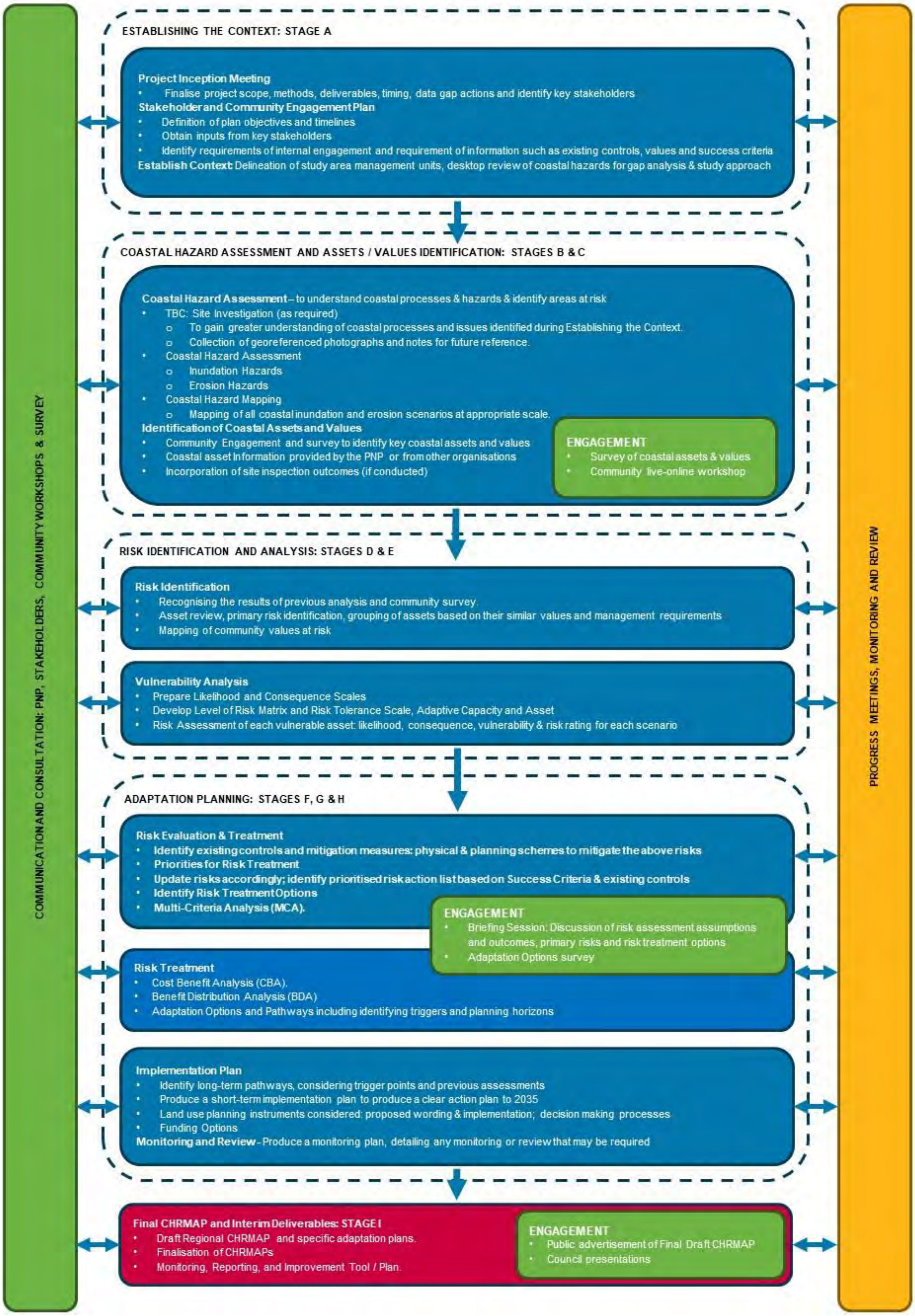


Figure 1-1 Methodology

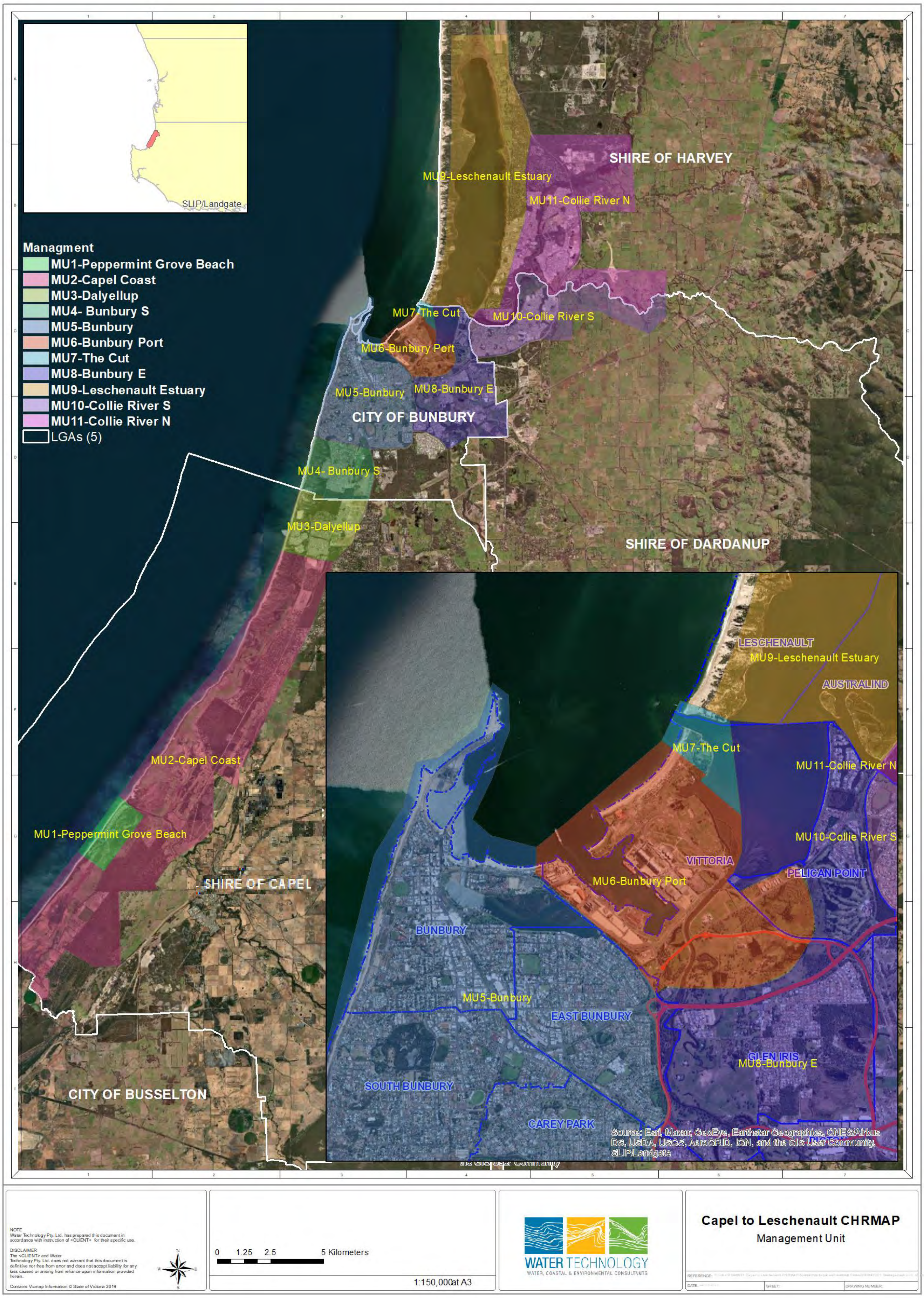


Figure 1-2 Study Area and Management Units

1.2 Structure of this report

This report is a summary document outlining the CHRMAP project and presenting content from the previous project stages and technical reports. It has been written to provide an overview that is more accessible to a wider audience. This report addresses coastal hazard vulnerabilities for the City and should be considered in combination with the more detailed technical reports which are provided as appendices. References are provided throughout this document and refer to the documents listed in the reference section of the relevant technical reports.

To facilitate the coastal hazard assessment and development of adaptation options, the study area was delineated into several management units which are determined according to a set of factors:

- Jurisdiction boundaries
- Presence of coastal assets and relevant stakeholders
- Coastal processes and potential hazard types.

The City shoreline can be divided into five primary management units:

- MU4 - Bunbury South
- MU5 - Bunbury (including Five Mile Brook district, Koombana Bay, Leschenault Inlet)
- MU6 - Bunbury Port (Inner Harbour)
- MU7 - The Cut
- MU8 – Bunbury East

2 STAGE A – ESTABLISH THE CONTEXT

An Establish the Context Chapter Report was prepared (Appendix A). This report outlines in detail the key management and adaptation issues that need to be considered in the CHRMAP, summarised below.

2.1 Purpose

The purpose of this project was for the PNP to work with the Steering Group and consultant(s) to develop a CHRMAP. The Steering Group included the City of Bunbury, the Shires of Capel, Dardanup and Harvey, WA Department of Biodiversity, Conservation and Attractions (DBCA), and the Southern Ports Authority (SPA), with support and technical advice from Department of Water Environment and Regulation (DWER), Department of Planning Lands and Heritage (DPLH), and Department of Transport (DoT).

The purpose of the CHRMAP was to provide strategic guidance for coordinated, integrated, and sustainable decision making for future coastal land use planning, including management of, and adaptation to, coastal hazard risks (coastal erosion and inundation). Management of risks to the study area's land adjacent to the ocean coast, estuaries and rivers is very important for the social, environmental, infrastructure and economic assets and values of the local communities. Although some work on coastal hazards had been undertaken across the study area in the past, a coordinated approach which identifies areas likely to be affected to erosion and/or inundation and requiring management and adaptation to mitigate the risks will provide increased resilience to these communities.

2.2 Objectives

The overall objectives of this CHRMAP were:

- Summarise the existing policies and planning controls, existing physical controls, and jurisdiction boundaries
- Improve understanding of existing coastal processes, features, and hazards within the study domain
- Identify coastal assets and values through stakeholder and community engagement
- Identify coastal hazard risks in terms of both coastal erosion and inundation, as well as potential vulnerability trigger points
- Improve understanding of asset risk and vulnerability to coastal hazards
- Determine the consequence, likelihood, and tolerance of assets to the identified risks
- Identify effective risk management measures through Multicriteria Analysis and Cost Benefit Analysis
- Identify short, medium, and long-term risk management actions
- Engage with stakeholders and the community to inform local values, adaptation pathway selection, and the implementation plan.

2.3 Scope

This CHRMAP identifies values and assets with intolerable risk levels to the coastal erosion and inundation hazards within the study area. Risk management measures were considered to reduce risks to tolerable levels. Tasks to implement the measures are summarised to provide strategic guidance on medium and longer-term risk management but provide more focus on short-term (<25 years) management measures. The CHRMAP has focussed on preserving assets and values which provide public benefit, although private at-risk assets are also identified.

2.4 Local Context

Goomburrup (Bunbury) is located in the Gnarla Karla Boodja region of WA and the traditional owner of this land is the Noongar nation. The City is located approximately 180 km south of Perth covering about 65 km area of coast. The area was first established as Municipality of Bunbury in 1871. In 1961, it became the Town of Bunbury under the Local Government Act 1960 and assumed its current name in Oct 1979. The 2016 census figures indicate the City has an established population of almost 32,000.

The study area within the City comprises of many different sections of coastline with variable shore types and degrees of development (Figure 2-1). Low-lying land is present along Five Mile Brook (e.g., the Big Swamp Wetland), surrounding Leschenault Inlet, and along Preston River. These areas are susceptible to coastal inundation. The City is a regional hub and has undertaken numerous developments along its coast. Infrastructure located within Koombana Bay includes shops, restaurants, Koombana Beach foreshore playground, Bunbury Port, Koombana Bay Sailing Club, Casuarina Harbour, Dolphin Discovery Centre, breakwaters, jetties, groynes, seawalls, bridges, roads, the storm surge barrier, as well as foreshore reserves etc. Consideration of the coastal hazards and adaptation constraints of these assets will be crucial for successful risk management and implementation plans.

The current shoreline of Bunbury is a result of combined effects of coastal processes and human intervention. The City is subject to coastal erosion and inundation, despite the numerous physical controls that have been implemented.

- Koombana Beach (one of the erosion hotspots identified by DoT (2019) study) has experienced a westwards littoral drift and progressive erosion on the eastern end. The issue has been studied previously to develop a feasible adaptation option. A seawall structure has been constructed to prevent further erosion.
- A breach of the northern training wall occurred at the Cut channel into Leschenault Estuary (one of the erosion hotspots identified by DoT (2019) study) in 2012 causing erosion of a sand bar along the northern bank. Emergency remedial work (such as minor excavation of the sand bar, landward extension of the northern training wall, tie-in of the extension with existing training wall) was undertaken in 2014, however it was not built to specification due to erosion of the site access point.
- Bunbury Ocean Drive (on the watchlist of coastal erosion by DoT (2019) study). Rock outcrops are present north of Wellington St along Bunbury Ocean Drive and Baudin Terrace. These rocks in general have a low elevation backed by sandy soil. The shoreline further north is protected by the Outer Harbour breakwater and spur groyne.
- Shorelines within Koombana Bay are either modified by engineering controls e.g., breakwaters and seawall, or within the scope of large-scale developments (such as the Port). All beaches in Koombana Bay are heavily modified due to the construction of the Port's inner harbour and river diversion. Sandy beaches are also present inside the bay, e.g., within Casuarina Harbour, Koombana Beach, and near Turkey Point.
- Leschenault Inlet and surroundings have a low-lying nature and are vulnerable to present and future inundation hazards. A tidal gate (Bunbury storm surge barrier) was installed near the entrance to prevent coastal flooding.
- Five Mile Brook is one of the main drainage paths of the City. The surrounding areas, including the Big Swamp Reserve, have a low ground elevation. There is a physical control at the outfall location, but it is unclear how it will function during extreme ocean water levels. Water Technology recommend including this site in the (yet to be confirmed) site inspection.
- Flood plain along Preston River. Riverbank protections were built to restrict the spreading of river flood.

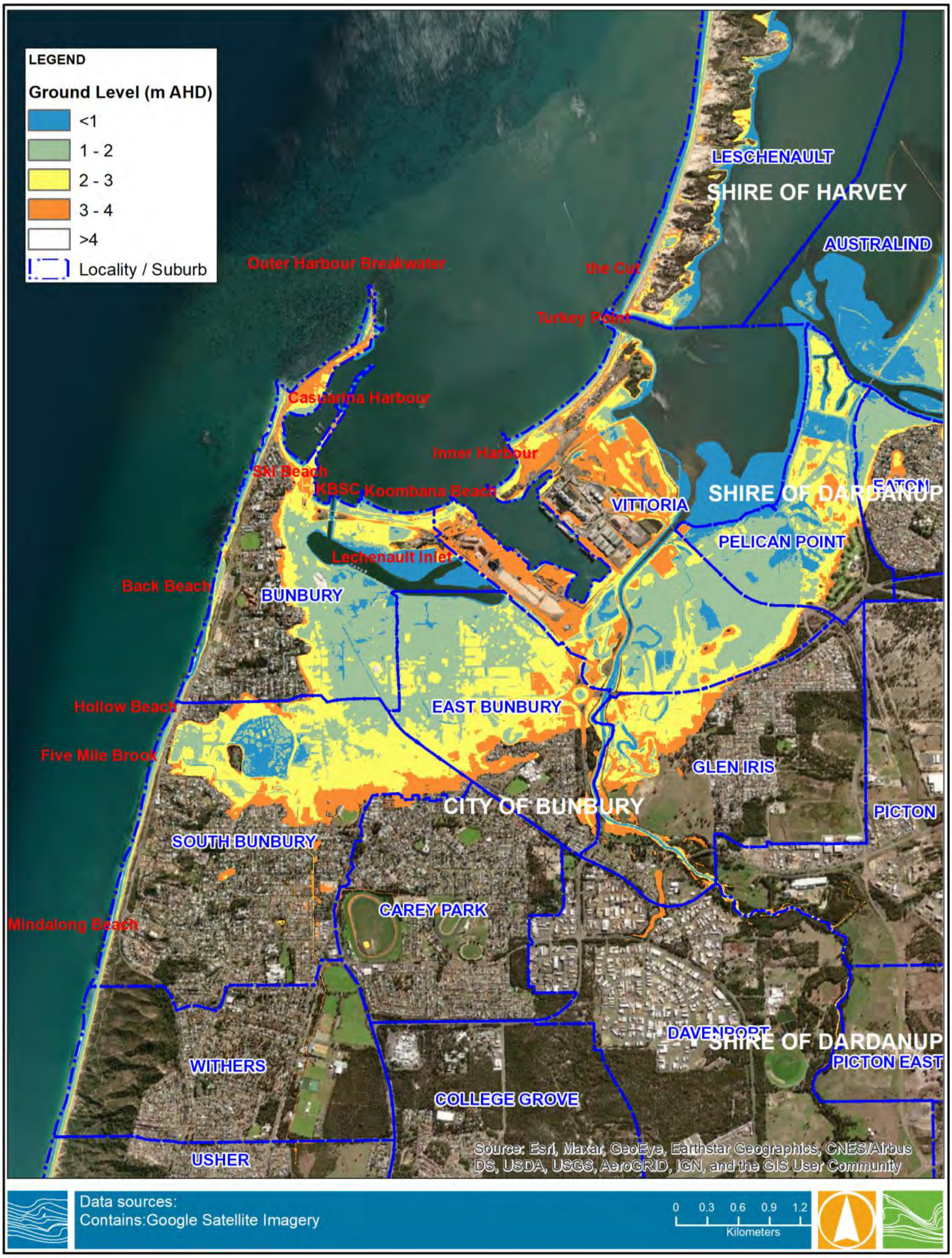


Figure 2-1 Bunbury Project Area (Overlayed are Suburbs & Roads)

2.4.1 Developments in Koombana Bay

Koombana Bay has experienced significant development since the 1900s (see Figure 2-2). The outer harbour breakwater was constructed in the early 1900s which formed the current layout of Koombana Bay. Since then, numerous coastal infrastructure projects have been implemented, including the construction of the Inner Harbour and various groynes, breakwaters, and jetties to stabilise the shoreline (e.g., the Plug in 1970s, Inner Harbour in 1970s, the Cut in 1950s-1970s, Northern Breakwater Arm in 1980s). Investment in Bunbury's coastline has increased in recent years, including:

- Planned, yet to be implemented, Inner Harbour expansion by Southern Ports Authority (SPA). The expansion of the inner harbour has been in discussion for at least three decades. In 2009, Bunbury Port drafted a structure plan as a policy document to guide the development and decision making of the Inner Harbour. More recently, a draft master plan has been prepared.
- Bunbury waterfront development (Figure 2-3) by the Department of Transport and South West Development Commission. This development includes multiple stages:
  - Koombana Foreshore Revitalisation and Dolphin Discovery Centre Redevelopment (completed)
  - Jetty Road Causeway upgrade (completed)
  - Casuarina Drive Redevelopment (underway)
  - Construction of new breakwaters for Casuarina Harbour (planning in progress – subject to approvals, including environmental approvals)
  - Koombana Sailing Club Marina, (planning in progress - progress – subject to approvals, including environmental approvals)

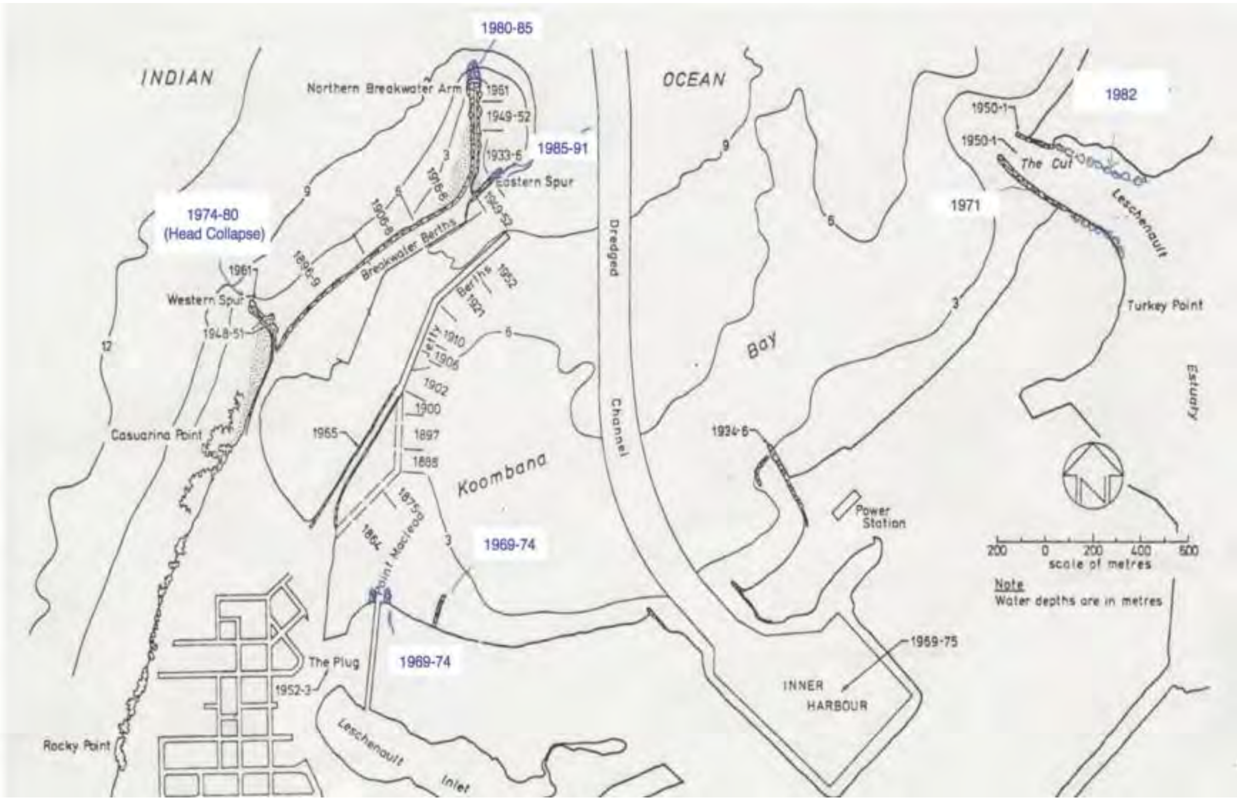


Figure 2-2 Historic Developments in Koombana Bay (until 1990s)

Figure 2-3 Bunbury Waterfront transformation - Marina Structures (Taken from RPS 2015)

2.4.2 Developments in Leschenault Inlet

Leschenault Inlet is a remnant of the lower section of the Leschenault Estuary, which was separated from the main water body by the construction of the Inner Harbour in the 1970s. The inlet has an area of approximately 70 hectares and is now one of Bunbury's most important recreational waterfronts. Since the 1980s, the inlet has undergone significant development including construction of foreshore protection (seawalls), boat ramps, jetties, boat clubs, discovery park, car parks, foreshore reserves, and boardwalks.

In 2013, the City prepared a Leschenault Inlet Master Plan to guide future development and planning for the area (Figure 2-4). The plan provided an overview of existing planning frameworks and land usage, and prioritised land developments for the future. Currently, the inlet comprises a mangrove reserve, and segments of engineered shoreline protecting the foreshore area. The foreshore is backed by paved roads and urban development and has limited setback for shoreline management or additional development beyond its present extent. In addition, the Bunbury storm surge barrier limits high ocean water levels impacting the inlet and surrounding lands.

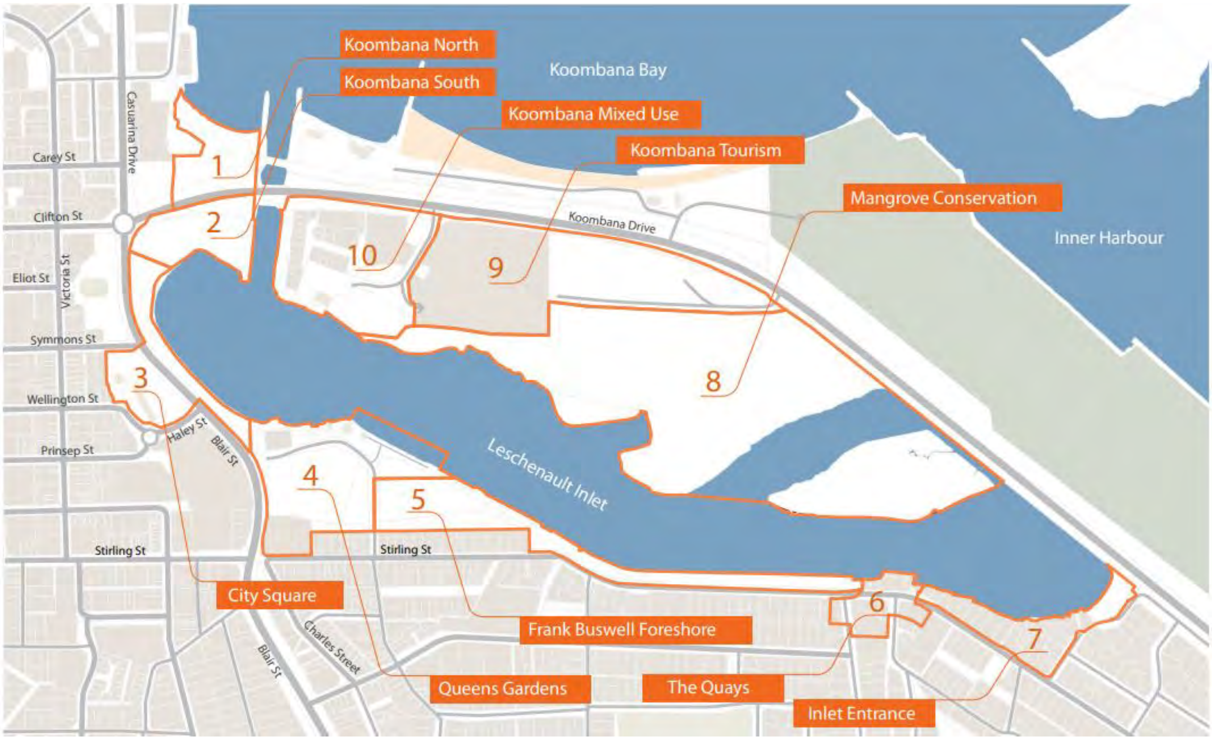


Figure 2-4 Leschenault Inlet Master Plan (City of Bunbury, 2013)

2.5 Existing Planning Controls

Planning in Western Australia is guided and regulated by the State Planning Framework, which ranges from overarching strategic planning strategies, to specific planning policies and supportive guidelines. Figure 2-5 explains the framework, which includes planning at the state, regional, and local levels and demonstrates how strategic planning is implemented through statutory planning controls (e.g., local planning schemes) and local planning policies. This Framework sits within the Planning and Development Act 2005. The relationships of the various policies are presented in Figure 2-6.

The planning documents within this Framework were reviewed to determine which are relevant to coastal hazard planning in the project area. This review helped to: assess the adequacy of the existing planning documents for addressing coastal hazards; identify gaps that needed to be addressed through the CHRMAP process (such as planning controls that are required, or need amending to enable implementation of CHRMAP recommendations); identify any potential planning issues that may constrain the CHRMAP process; and ensured that the adaptation plan aligns with state, regional and local planning frameworks.

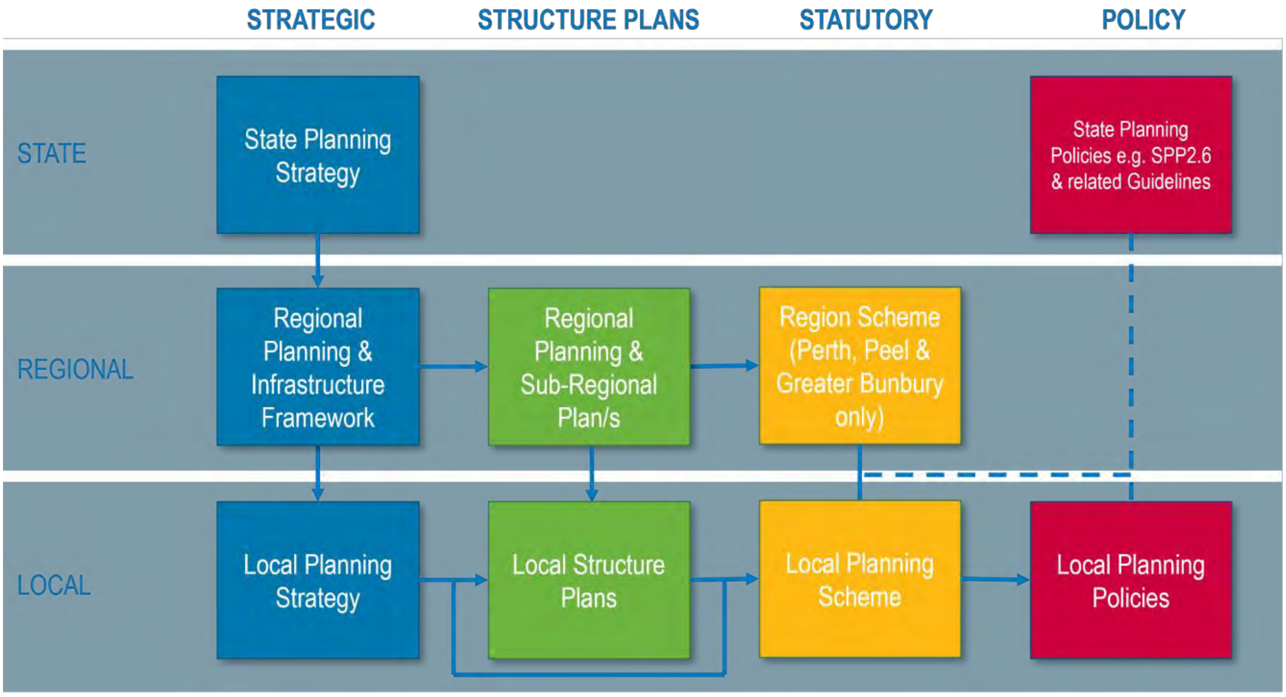


Figure 2-5 State Planning Framework for Western Australia

2.6 State Planning Policies and Strategies

The following state documents have been reviewed. Information relevant to the CHRMAP has been included below:

- State Planning Strategy 2050
- The WA Coastal Zone Strategy 2017
- State Planning Policy 2.6 – State Coastal Planning Policy, and associated Guidelines
- State Planning Policy 2.9 – Water Resources
- Coastal Hazard Risk Management and Adaptation Planning Guidelines 2019
- State Planning Policy 3.4: Natural Hazards and Disasters

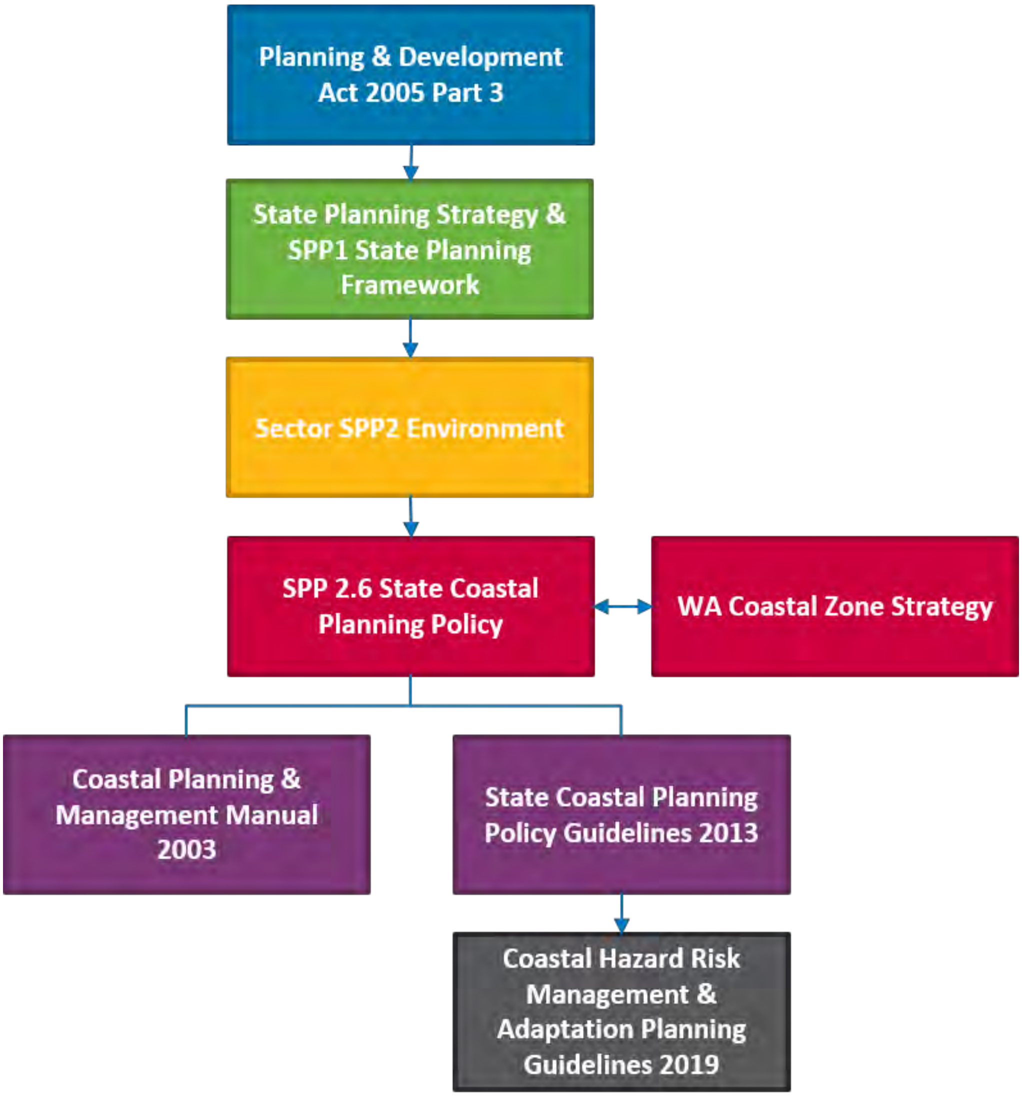


Figure 2-6 Policy Relationships

Regional and local planning documents were also reviewed for study area and discussed further in the Establish the Context Report.

2.7 Community and Stakeholder Engagement

Key to the success of the CHRMAP project was to ensure that the plan is underpinned by community and stakeholder values and knowledge. To this end, a Community and Stakeholder Engagement Plan was developed in order to identify relevant stakeholders and determine the structure and pathways for their engagement throughout the CHRMAP process. The plan was intended to be tailored, and commensurate with the size and scope of the CHRMAP –to avoid consultation fatigue within the community.

This plan was prepared in accordance with the requirements of, and for consistency with, the following documents:

- Capel to Leschenault Communications Framework (PNP, 2020)
- The International Association of Public Participation (IAP2) documentation

The overarching objectives of the community and stakeholder engagement plan for the CHRMAP are:

- Establish strong working relationships with community networks and stakeholders which are built on mutual trust and respect.
- To ensure all stakeholders have up to date information about the CHRMAP, and the broader coastal management framework that supports the project.
- To provide the community and relevant stakeholders the opportunity to have direct input into the development and delivery of the CHRMAP.
- To understand community goals and aspirations for the coastal zone and community views on values, assets, opportunities and priorities.
- To aid in identifying key issues and selecting site-specific CHRMAP management actions to address them. Stakeholders on the ground will have knowledge of the site developed over years of interaction. This provides invaluable information that can be applied to generate innovative CHRMAP measures.
- Increased community and stakeholder understanding of, and support for, actions and priorities in the CHRMAP.

The engagement plan activities undertaken for the CHRMAP are outlined below in Table 2-1.

Table 2-1 Summary of Engagement Activities

CHRMAP Stage	Engagement Activity	Description
Stage C: Coastal Assets and Community Values	Prepare for launch of project	Established Social Pinpoint mapping page for integration with PNP website portal - Social Pinpoint is a customisable community engagement platform which will be used to create a space to share information and keep the community engaged and informed. Provided tailored information for project communications (website content, media release, project information sheet, letter/email content, FAQs) Project launch – live project webpage, social media posts, launch of Coastal Assets and Values Survey to commence engagement phase of the project
Stage C: Coastal Assets and Community Values	Coastal Assets & Values Survey	Digital survey for PNP's use, to provide the community, and stakeholders with the opportunity to identify areas / assets of value. Values will be categorised to aid the identification process.
Stage C: Coastal Assets and Community Values	Community live-online workshop	Confirmation local community's values and perceptions of the key issues facing the study area. In this session, community members had an opportunity to provide information regarding: ▪ Community uses, and areas of high social, environment and cultural value; and/or ▪ Community concerns regarding potential issues (including their priorities) to be addressed in the CHRMAP. This can also ascertain feedback regarding the current management plans and opportunities for improvement.

CHRMAP Stage	Engagement Activity	Description
Stage F: Risk Treatment and Stage H: Implementation	Coastal Community Advisory Group	Two workshops with community members to calibrate the evaluation of options and consult on planned implementation measure.
Stage I: Draft CHRMAP	Public Advertisements of CHRMAP Reports	Draft CHRMAP will be placed on the CHRMAP website for public comment. The document will be emailed / mailed to stakeholders identified as not having access to the CHRMAP website.

3 STAGE B - COASTAL HAZARD ASSESSMENT

A Coastal Hazard Assessment Chapter Report (Appendix B) was prepared to identify the coastal hazards in the study area that need to be considered in the CHRMAP. Hazard maps are produced defining the erosion and inundation extents for present day, 2035, 2050, 2120.

The study area covers a complex shoreline with various types of coastal hazards present in this region. The presence of rivers, an estuary and inlet has increased the complexity of the broader study area, in particular the assessment of inundation hazards where river flood plays a more dominant role than the intrusion of ocean water. **It is acknowledged that the hazard identification component of the present study was undertaken to provide a broad understanding of exposure that can support government planning at a regional level - and will be superseded once site-specific studies become available, particularly at the estuary/inlet and along the river courses**. Results derived from this study should not be over-interpreted at a micro-scale due to the assumptions applied and the limitations in model resolution. More detailed risk assessments and analysis may be required for the development of detailed engineering measures for specific sites. No geophysical or geotechnical assessments have been undertaken across the study to date. Erosion response across the study area may differ in reality to the predictions of this study due to the lack of data. Further geophysical/geotechnical assessment will be a recommendation of this CHRMAP.

3.1 Erosion Hazard Assessment Method

3.1.1 Summary

The erosion hazard study was carried out by the following steps:

- Simulate storm erosion for the 100 years ARI storm (S1).
- Evaluate historic shoreline movement trends based on DoT vegetation lines (S2).
- Evaluate sea level rise impacts for present day, 2035, 2050 and 2120 (S3).
- Apply corrections for controlled shoreline segments.
- Evaluate total erosion values for each coastal management zones and for four different planning periods i.e., present day, 2035 (short term), 2050 (medium term) and 2120 (long term).
- Establish an erosion matrix considering both exposure levels and planning periods.
- Mapping of erosion hazard lines.

3.1.2 Method

A desktop review of available information was undertaken, including:

- Metocean conditions
- Coastal processes
- Existing coastal monitoring and management
- Existing coastal hazard information

The coastal hazard identification approach has been developed based on the following policies and guidelines:

- State Planning Policy 2.6 State Coastal Planning Policy (SPP2.6)
- Coastal Hazard Risk Management and Adaptation Planning Guidelines (CHRMAP Guidelines)
- State Planning Policy 2.9 Water Resources (SPP2.9)

SPP2.6 (WAPC, 2013) has provided a clear guideline for the evaluation of erosion hazards in tidal areas. It stipulates the following components be considered when evaluating the coastal erosion risk:

- Storm erosion in response to storm waves and loss of beach material.
- Historic shoreline movement that highlights the chronic/long-term evolution of the coast. This could be contributed by littoral drift processes, larger scale morphological movements, long-term water level/wave dynamic variations (~18.6 yrs. tidal cycle, interannual climate oscillations e.g., La Niña effects, Pacific Ocean decadal Oscillation etc.) and climate change impacts (SLR, more intense storms and rainfalls etc.).
- Direct response to future sea level rise.

SPP2.6 indicates the methods for determining the allowance for erosion for a sandy coast are derived principally for open coastlines. For erosion on tidal reaches of inland waters, allowance should be assessed in a site-specific context, with the methodology to be developed appropriately for each site.

The horizontal shoreline datum (HSD) is defined as the active limit of the shoreline under storm activity. It is the line from which the erosion hazard allowance will be applied from. In this assessment HSD has been determined by:

- Present day vegetation lines which often characterise the upper limit of seasonal storm impacts. The vegetation line can be difficult to establish within a reach where there are seasonal beach variations.
- Elevation of the 100-year ARI Peak Steady Water Level (about 1.7m AHD for 100-year ARI storm). A 2 m AHD elevation for open coast is generally appropriate to outline the potential unimpacted area for typical winter storms if vegetation lines are deemed too conservative for hazard mapping.
- For estuary environments with the presence of large tidal flats and vegetation growth, a conservative approach is used to define the HSD as the limit of storm inundation or riparian boundary as the HSD boundary.

The HSD line is included in the erosion hazard maps.

A summary of the erosion assessment approach is provided in Table 3-1.

Table 3-1 Summary of Erosion Hazard Assessment Method

Shoreline Type	Erosion Assessment
Open Coast	Standard method as per SPP2.6. This considers erosion allowances relative to the present Horizontal Shoreline Datum. ▪ HSD is defined by topographic contours, ground-truthed by vegetation lines. ▪ Allowance for the current risk of storm erosion (S1) estimated by SBEACH model. ▪ Allowance for historic shoreline movement trends (S2) estimated by analysis of historic vegetation lines. ▪ Allowance for erosion caused by sea level rise (S3) through the application of Bruun Rule ▪ Uncertainty allowance as per SPP2.6 ▪ Hazard lines are defined by HSD+S1+S2+S3+uncertainty Consideration of erosion controls: ▪ Physical controls such as Groynes, Port facilities, Outer breakwater and jetty road breakwater are considered as permanent structures assuming ongoing maintenance and management. These are key facilities that determines the overall landscape of Bunbury coast. ▪ Seawall (erosion control works) that are designed with large armour rocks and proper toe protection are considered as effective for their design life e.g., buried seawalls along Ocean Drive, Ski Beach and Koombana Beach. The recorded extent of the existing seawalls along the ocean coast may be incomplete. During the CHRMAP the City identified that there are more seawalls in place along Ocean Drive than previously documented, with final details yet to be confirmed. ▪ Temporary works, such as thin layers of revetment, are not considered as erosion controls. Consideration of landform stability in accordance with sediment cells and geomorphological features wherever appropriate. Rocky shoreline definition requires a continuous rocky surface extending above the reach of storm waves plus SLR. If the rocky surface is lower than the active limit of waves, the shoreline should be defined as a mixed or sandy type. Our analysis shows no continuous rock cliff above the reach of storm impact. Unless otherwise notified by geotechnical assessments, the shoreline within the study domain is categorised as 'sandy' (i.e. erodible) for the purpose of coastal planning and management.
Estuary	For shallow foreshore with/without riparian boundary, hazard lines defined by HSD+S1+S2+S3+uncertainty with fine scale adjustment to define the HSD: ▪ HSD defined by the location of riparian boundary / inundation line (HAT level, 0.6m AHD, as boundary of tidal inundation) / physical controls. ▪ Allowance for the current risk of storm erosion (S1). SBEACH model used to evaluate the extent of erosion generated by the strongest possible waves in the Estuary. ▪ Allowance for historic shoreline movement trends (S2) estimated by review of historic vegetation lines/satellite images/historic reports. ▪ A fixed allowance of 50 m is assumed as a response to SLR (or S3) by 2120, as per SPP2.9 recommendations. The estimated erosion hazard lines are compared against the permanent inundation extent (HAT water level +SLR) in 2121. Both are reported to facilitate erosion hazard assessment. Tidal flats and dynamic river deltas are excluded from current shoreline.

Shoreline Type	Erosion Assessment
Leschenault Inlet	Leschenault Inlet has a very limited impact from storm waves. Erosion of shoreline is largely contributed by increasing sea level and overflow of flood water. Shoreline movement is determined in context with tidal inundation from SLR and operation of the storm barrier. Total erosion allowance is estimated at 0.6m + SLR (e.g., 1.5 m AHD in 2120)
Riverbank	For riverbanks, methods derived for open coast by SPP2.6 are not applicable. SPP2.9 is used to guide the development of erosion hazard lines. ▪ a 'foreshore reserve' width of 30 m by 2120 for main waterways (Preston, Collie River, Capel River) ▪ a 'foreshore reserve' width of 15 m by 2120 for secondary channels (Branches of Collie River, Miller River, Henty River Brunswick River, Wellesley River etc.) We have noted several breaches through the coastal barrier near the Capel River mouth. This erosion is investigated at a broader scale by historic shoreline movement and also in the context of open coast erosion. Detailed analysis of breach activation is beyond the scope of current study. This study does not investigate riverine flooding through rainfall run-off within the river catchment, instead coastal flooding was assumed to be coincident with catchment flooding. Additionally, DWER has an existing Operational Policy 4.3, which requires a more comprehensive site-specific assessment based on biological and physical features.

3.2 Inundation Hazard Method

Inundation is one of the primary coastal hazards of the region. Historical studies have identified multiple mechanisms contributing to the high-water levels along the coast and in the estuary and inlet of the broader study area.

SPP2.6 requires the allowance for inundation to be the maximum extent of inundation calculated as the sum of S4 Inundation plus the predicted extent of sea level rise. Being a coastal Policy, it does not apply to areas where inland processes dominate the inundation/flooding process.

A detailed numerical modelling approach has been used to assess coastal inundation with calibration to existing studies and information. Several MU's required case-by-case consideration and adjusted methodologies – please refer to the Coastal Hazard Assessment Chapter Report for a detailed description of the modelling tools utilised in this assessment.

The DHI MIKE storm surge model has been used to simulate the inundation extent in the study area coastal zone from Capel to Leschenault Estuary. The approach was proposed to account for the complexity of inundation processes in Leschenault Estuary, along river channels, and in the land depression of Capel which cannot be accurately assessed by a simple bathtub model approach, particularly with the inclusion of catchment flood impacts. A set of coincident ARI storm and cyclone events with river discharge events have been simulated to assess coastal inundation hazards.

Inundation along the open coast is evaluated by Water Technology's Danish Hydraulic Institute's MIKE storm tide model, calibrated to hindcast the storm tide conditions during TC Alby. The model simulates the combined effects of peak steady water level and wave setup through a coupled Hydrodynamic and Spectral Wave model.

For the 500-year ARI event, the inundation level is modelled through the simulation of a representative cyclone based on the existing TC Alby track, with adjustments to locate the cyclone eye near the Bunbury region (peak surge lasts for up to 4 hours). Overall, a physically realistic storm tide was modelled using this methodology.

3.3 Erosion Hazard Results

The total erosion hazard allowance for all MU's is presented in Table 3-2 to allow comparison. Detailed mapping of erosion extents is available in the Coastal Hazard Assessment Chapter Report. Summary mapping is provided in Section 3.5.

Table 3-2 Erosion Hazard Allowance Summary

Profiles	S1 m from HSD	S2 m/yr	S3 m/yr	Uncertainty m/yr	Erosion Allowance m from HSD			
					2020	2035	2050	2120
1 (MU2)	14.0	0	1	0.2	14	29	42	132
2 (MU2)	12.0	0	1	0.2	12	27	40	130
3 (MU2)	23.0	0	1	0.2	23	38	51	141
4 (MU1)	14.0	0	1	0.2	14	29	42	132
5 (MU2)	17.0	0	1	0.2	17	32	45	135
6 (MU2)	10.0	0	1	0.2	10	25	38	128
7 (MU2)	23.0	0	1	0.2	23	38	51	141
8 (MU2)	28.0	0.4	1	0.2	28	49	68	186
9 (MU3)	26.0	0.2	1	0.2	26	44	60	164
10 (MU3)	29.0	0.2	1	0.2	29	47	63	167
11 (MU3)	24.0	0.1	1	0.2	24	40.5	55	152
12 (MU4)	21.0	0	1	0.2	21	36	49	139
13 (MU5)	19.0	0	1	0.2	19	34	47	137
14 (MU5)	19.0	0	1	0.2	19	34	47	137
15 (MU5)	17.0	0	1	0.2	17	32	45	135
16 (MU5)	27.0	0	1	0.2	27	42	55	145
17 (MU5)	30.0	0	1	0.2	30	45	58	148
18 (MU5)	8.0	0	1	0.2	8	23	36	126
19 (MU5)	14.0	0	1	0.2	14	29	42	132
20 (MU5)	39.0	0	1	0.2	39	54	67	157
21 (MU5)	4.0	0	1	0.2	4	19	32	122
22 (MU5)	10.0	0.1	1	0.2	10	26.5	41	138
23 (MU5)	9.0	0.1	1	0.2	9	25.5	40	137
24 (MU5)	12.0	0.3	1	0.2	12	31.5	49	160
25 (MU6)	14.0	0	1	0.2	14	29	42	132
26 (MU6)	21.0	0	1	0.2	21	36	49	139
27 (MU6)	21.0	0	1	0.2	21	36	49	139
28 (MU7)	15.0	0	1	0.2	15	30	43	133

Profiles	S1 m from HSD	S2 m/yr	S3 m/yr	Uncertainty m/yr	Erosion Allowance m from HSD			
					2020	2035	2050	2120
29 (MU8)	3.0	0	0.5	0	3	10.5	18	53
30 (MU9)	5.0	0	0.5	0	5	12.5	20	55
31 (MU9)	3.0	0	0.5	0	3	10.5	18	53
32 (MU9)	3.0	0	0.5	0	3	10.5	18	53
33 (MU9)	3.0	0	0.5	0	3	10.5	18	53
34 (MU9)	5.0	0	0.5	0	5	12.5	20	55
35 (MU9)	5.0	0	0.5	0	5	12.5	20	55
Preston River	0.0	0	0.3	0	0	4.5	9	30
Collie River	0.0	0	0.3	0	0	4.5	9	30

3.4 Inundation Hazard Results

The modelled peak steady water levels are presented in Table 3-3. Detailed mapping of inundation extents is available in the Coastal Hazard Assessment Chapter Report. Summary mapping is provided in Section 3.5. The water level differences are smaller for 1-year, 10-year and 100-year storms as the duration of these storms were expanded to cover multiple tidal cycles. This represents the longer duration of winter storms compared to extratropical cyclones.

Table 3-3 Modelled Peak Steady Water Level (m AHD)

Locations	Peak Steady Water Level (m AHD), various ARIs (years)															
	Present				2035				2050				2120			
	1	10	100	500	1	10	100	500	1	10	100	500	1	10	100	500
Leschenault Estuary	1.1	1.5	1.9	2.1	1.2	1.6	2.1	2.3	1.3	1.7	2.2	2.9	2.1	2.4	2.9	3.1
Koombana Bay	1.1	1.4	1.9	2.8	1.2	1.5	2.0	2.9	1.3	1.6	2.1	2.9	2.1	2.4	2.9	3.7
Leschenault Inlet				1.2				1.3				1.9		0.6	1.9	2.6
Open Coast (Bunbury)	1.1	1.4	1.9	3.0	1.2	1.6	2.0	3.1	1.3	1.7	2.1	2.8	2.1	2.4	2.8	3.9
Open Coast (Capel)	1.1	1.4	1.8	2.7	1.2	1.5	1.9	2.8	1.3	1.6	2.0	2.8	2.1	2.4	2.8	3.6
Land Depression	1.0	1.2	1.5	2.3	1.1	1.2	1.5	2.4	1.1	1.2	1.6	2.4	1.2	1.5	2.4	3.4

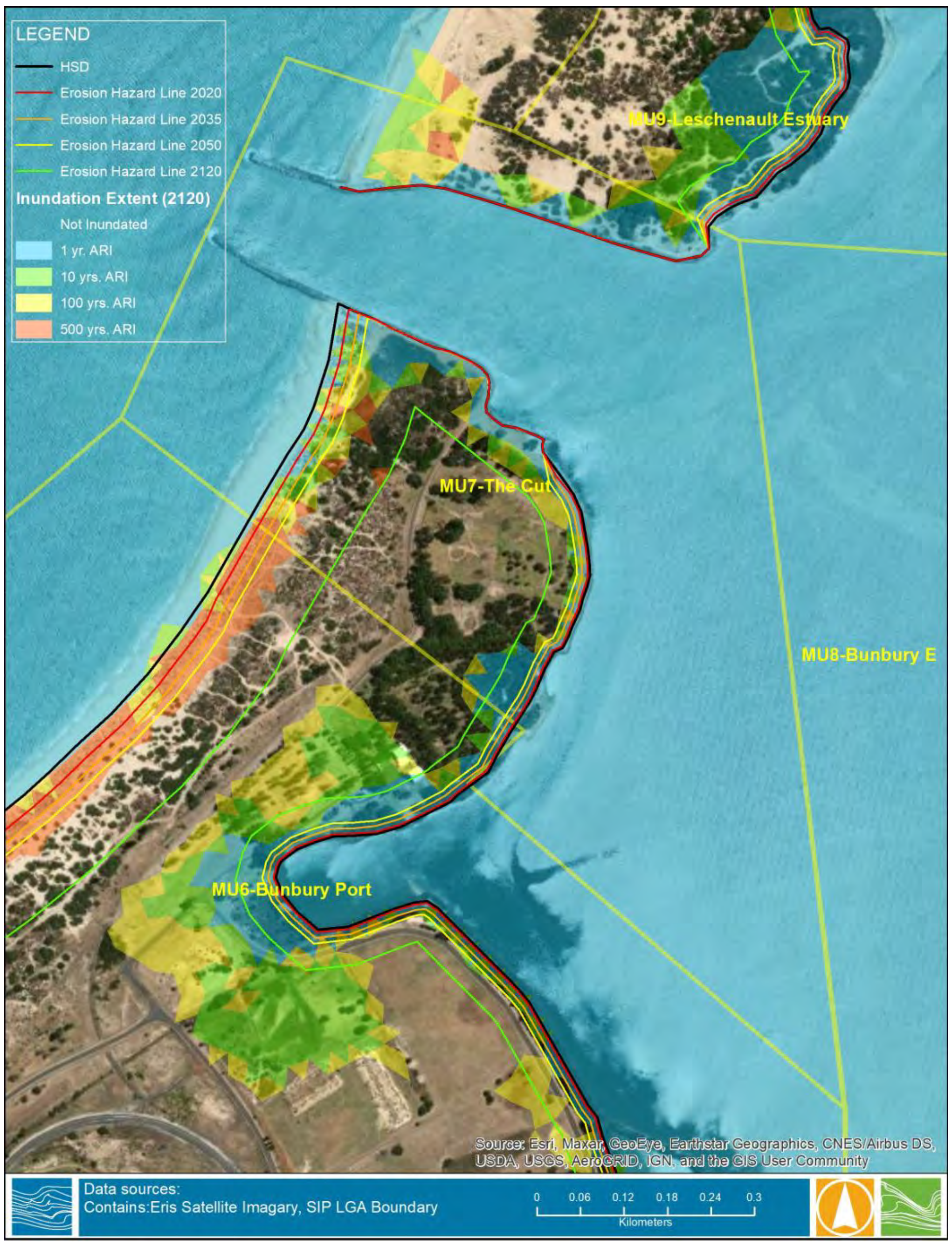
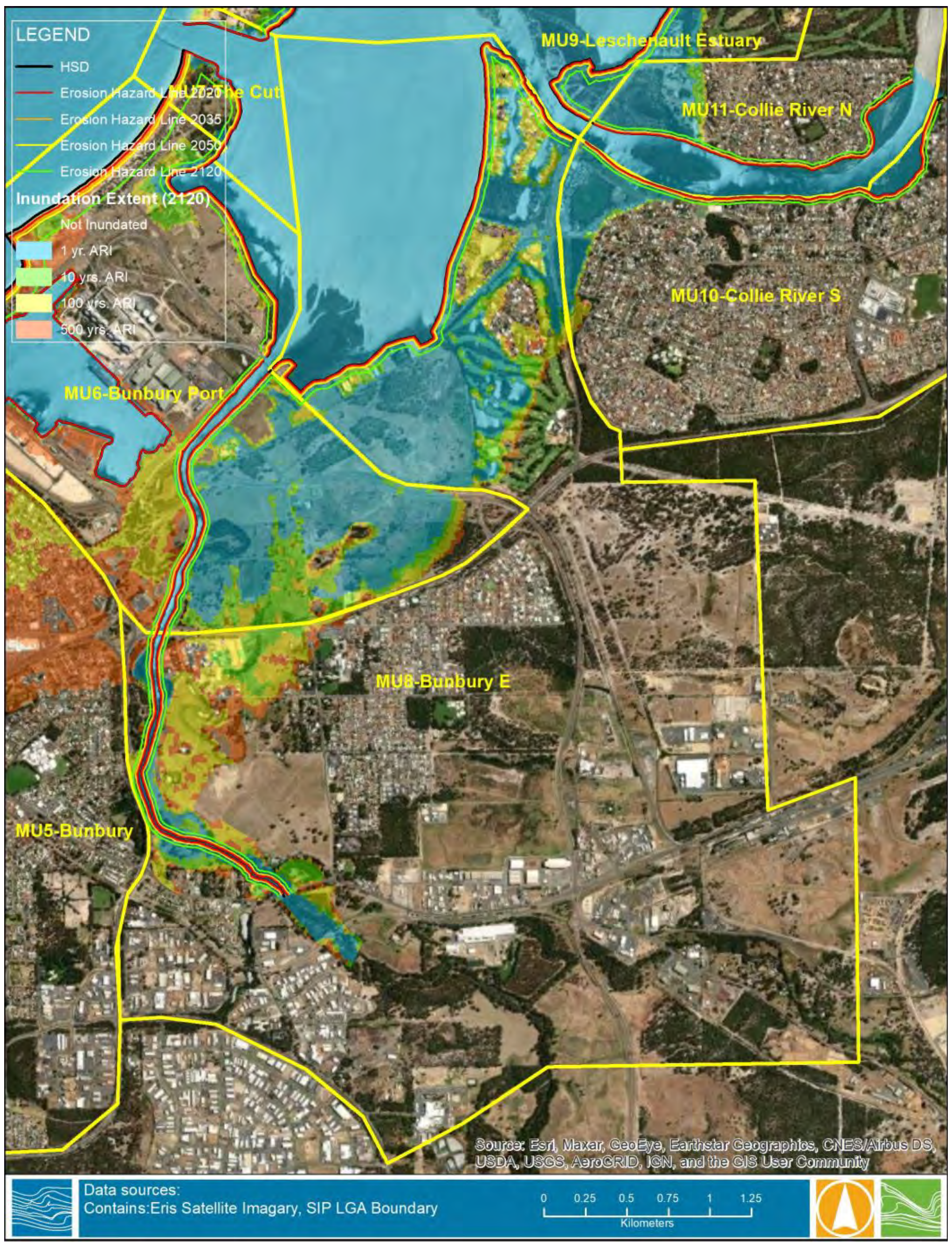
3.5 Summary of Coastal Hazard Assessment Outcomes

The outcomes of the coastal hazard assessment for each management unit are summarised and discussed in Table 3-4 below.

Table 3-4 Summary of Coastal Hazards for each Management Unit

Management Unit	Erosion & Inundation Hazard	Summary
MU4 – Bunbury South		▪ Inundation is not a high risk in this management unit. ▪ Erosion is predicted to impact natural assets only within this management unit.

Management Unit	Erosion & Inundation Hazard	Summary
MU5 – Bunbury - including open coast, Koombana Bay and Leschenault Inlet		▪ Inundation is a significant risk across much of this management unit. The inundation risk is predicted to increase from present day to 2120. By 2120, the 100-year ARI is predicted to inundate a significant residential and commercial area. ▪ The Storm barrier plays a key role in inundation control. The risk of coastal inundation would be much greater if the storm barrier was not in operation. ▪ Much of the CBD is predicted to be under water during a 100-year and 500-year ARI storm in 2120. The crest of current storm barrier is about 2.1 m AHD, which is not predicted to be high enough to withstand these storms in 2120. ▪ Erosion is a significant risk for buildings and natural assets along the western coast of the City. ▪ Koombana Bay and Leschenault Inlet are heavily engineered. Erosion may still occur along shorelines not protected by structures. ▪ Access to the outer harbour (Casuarina Drive) is at risk from 2035.
MU6 – Bunbury Port		▪ Inundation risk at the shipping yard and other lower ground areas. ▪ Main port facilities are not affected as they are located at higher ground and are protected by controlled shorelines. ▪ By 2120, the land near the entrance to the inner Port will be within the erosion hazard zone. Reinforcement may be required for shoreline segments not protected. ▪ It is noted that a high-level study using policy setbacks provides no additional value to the planning and management of lands along the Preston River (at the back end of the port). – Water Corporation levees have not been considered in the development of these lines

Management Unit	Erosion & Inundation Hazard	Summary
MU7 – the Cut		▪ The Cut entrance is at risk of erosion by 2120. Seawater may erode the sand dune behind the seawall if it is not designed and constructed to standards. Attention must be paid to the impact of overtopping and breaching of the sand dune behind the seawall. ▪ Inundation is not a key risk in this management unit.
MU8 – Bunbury East - including Vittoria Bay, Pelican Point and Districts along Preston River		▪ The areas surrounding Preston River and the Estuary are at risk of inundation from the present day. ▪ Foreshore Park and the commercial properties on Estuary Drive are predicted to be in the coastal erosion hazard zone by 2120. ▪ It is assumed the canal infrastructure will be maintained; however, the canal properties are at risk from erosion along the river and estuary fronts by 2120. This prediction however only serves the purpose of government planning and should not be used for risk assessment of individual properties.

4 STAGES C AND D – COASTAL ASSETS AND COMMUNITY VALUES IDENTIFICATION

A Coastal Values and Community Assets Chapter Report (Appendix C) was prepared which identifies the assets and community values within the coastal hazard zone. Community and stakeholder involvement is a critical component of the CHRMAP process, as it defines what and how much value is placed on assets within the study area. This informs the adaptation planning process and ensures all needs are considered. As such, the project contains a high level of community and stakeholder engagement. This provides ownership of the CHRMAP with those that it affects, and acceptance of its outcomes.

4.1 Asset Identification

Coastal assets (both natural and built) were identified in the following ways:

- Asset information was provided in excel and spatial file formats for use in this study by Steering Group members. These were imported into the GIS database developed for the project and used as the basis for the coastal asset identification.
- Landgate assets database, including for roads.
- The coastal values survey(s) and other engagement activities to identify additional assets of importance and value to the community.
- Site visit to investigate locations where information was not clear from the desktop assessment.
- Manual identification of further assets from aerial photography (e.g., developed areas of foreshore reserve)

4.2 Asset Classifications

At the time of identification, each asset was categorised into a classification. This streamlines the adaptation planning process in subsequent phases of the project. The study team grouped assets as follows:

- Roads
- Residential land, including both occupied and vacant land
- Commercial land and assets e.g., Bars, shops, markets etc.
- Public and community assets not located in the foreshore reserve e.g., car parks, recreational facilities
- Developed foreshore reserve, including coastal, estuary and river foreshore areas
  - Reserve containing public assets, e.g., car parks, public ablutions, playgrounds, walkways, access structures
- Undeveloped foreshore reserve, including coastal, estuary and river foreshore areas
- Environmental
  - Contaminated sites
  - DBCA data. This includes habitat areas potentially suitable for Matters of National Environmental Significance (such as Carnaby's Cockatoo's and Western Ringtail Possums), Threatened and Priority Ecological Communities, and known locations of threatened flora.
- Agricultural / rural lands
- Aboriginal heritage

One of the main challenges of this CHRMAP is the numerous assets and management zones. This asset classification was developed to address the main coastal adaptation issues and key locations and enable a simple yet effective method for adaptation planning.

4.3 Community Values Engagement Process

The engagement activities for this stage of the project included:

- Use of an interactive project tool (Social Pinpoint) to answer CHRMAP value survey questions and pin values and comments spatially on a project map
- Hard copy surveys mirroring the online component
- Community workshop held on 2nd September 2021 in each of the four LGAs and linked online to discuss coastal processes, map community values and understand issues and concerns of the community for the study area, attended by 28 members of the community
- Direct engagement with Traditional Owners and Indigenous representatives
- Stakeholder meetings

In the preliminary stage of engagement, stakeholders could visit an online project page with a mapping tool and survey to drop pins and comment on activities they value and their locational preferences for these activities on the map. Participants could also respond to a survey and provide any other feedback on how they use the different areas of the coastline. The survey was available online and in hard copy at the LGA administration centres. The survey and mapping tool was open from 26th July 2021 to 10th September 2021. In addition, people could provide survey responses in hard copy.

The project team received 84 CHRMAP values survey responses online, 97 hard copy survey responses (a total of 181 survey responses) and 56 ‘pins’ were placed on the map. Whilst ‘place of residence’ was not included in the survey, more than 50% of respondents visited locations in the Shire of Capel most often, and approximately 30% of respondents visited beaches in the City of Bunbury most often.

Stakeholders were further engaged through the following:

- Social media posts
- Key briefings with the Steering Group , including administrative staff from PNP, the four LGAs, the Department of Planning, Lands and Heritage, Department of Water, Environment and Regulation, Southern Ports Authority and the Department of Transport
- Briefings to key staff members and Executive Management at the LGAs.

Overall, more than 150 participants contributed to this stage of engagement, with an approximate reach of more than 445 local community members and organisations.

4.4 Coastal Assets and Community Values

A summary and brief discussion of these assets is presented in Table 4-1 for the relevant MU’s. Key coastal, estuarine and riverine values identified by participants across the whole study area as follows:

- Beaches and estuarine areas for activities like walking, swimming, snorkelling, exercise, views, fishing, surfing, 4WDing
- Wetlands and environmental areas for their flora and fauna diversity which participants could appreciate
- Coastal views, walks and scenery
- Coastal vegetation and the natural environment generally

- Opportunities for observing wildlife at various locations and protecting habitat for these communities and species

Key issues and concerns / risks to the coastal values:

- Beach erosion and its environmental, social and financial impacts
- Vegetation retention, revegetation and the need to do more to protect coastal areas from erosion came up multiple times in the different LGAs
- Environmental protection was generally very highly valued
- Sea level rise and climate change was also a key discussion point at the workshop, with participants wanting to see decision-makers actively addressing climate change impacts
- Contamination and pollution impacts on fauna and flora and the health of waterways from industrial activities along the coastline and river environment, including the port at Bunbury
- Protection of coastal wetlands that mitigate against impacts of extreme events and that are home to birds and wildlife
- Biodiversity and habitat loss
- Human impact on the coastal and estuarine natural assets and values to the community

Table 4-1 Summary of hazards to assets.

Management Unit	Summary	Snapshot of Assets at Risk
MU4 – Bunbury South	▪ Erosion is predicted to impact natural assets within this management unit. ▪ Inundation is not a high risk in this management unit.	▪ By 2120, 12 environmental assets at risk from erosion; 7 by inundation ▪ Developed and undeveloped foreshore is at risk from erosion from the present day; public and community assets are by 2120
MU5 – Bunbury - including open coast, Koombana Bay and Leschenault Inlet	▪ Erosion is a significant risk from the present day to both built and natural assets along the western coast of the City of Bunbury. ▪ Inundation is a significant risk across much of this management unit. The inundation risk is predicted to increase from present day to 2120. By 2120, the 1-year ARI is predicted to inundate a significant residential and commercial area. ▪ Environmental, public and community assets are also predicted to be significantly impacted by inundation	▪ Approximately 340 roads at risk of inundation by 2120; 57 by erosion ▪ By 2120, 141 environmental assets at risk from erosion; 277 by inundation ▪ 267 residential properties predicted to be impacted by erosion by 2120 ▪ 2106 residential properties predicted to be impacted by inundation by 2120 ▪ By 2120, 8 commercial assets at risk of erosion, 500 from inundation ▪ 4 Aboriginal Heritage assets in both hazard zones from the present day ▪ Developed and undeveloped foreshore, public and community assets are at risk from erosion and inundation from the present day
MU6 – Bunbury Port	▪ By 2120, the land at the entrance to the inner Port is completely within the erosion hazard zone ▪ Inundation is the main risk in this management unit. ▪ It is noted that a high-level study using policy setbacks provides no additional value to the planning and management of lands along the Preston River.	▪ Approximately 8 roads at risk of inundation by 2120; 3 by erosion ▪ By 2120, 90 environmental assets at risk from erosion; 78 by inundation ▪ 2 agricultural / rural lots predicted to be impacted by erosion by 2120, 4 by inundation ▪ By 2120, 13 commercial assets at risk of erosion, 7 from inundation ▪ Developed and undeveloped foreshore, public and community assets are at risk from erosion from the present day ▪ Public and community, undeveloped foreshore at risk of inundation from the present day
MU7 – the Cut	▪ The Cut entrance is at risk of erosion and inundation by 2120 (assuming seawalls are not maintained). ▪ Natural assets are at risk in this management unit	▪ By 2120, 129 environmental assets at risk from erosion; 91 by inundation ▪ The undeveloped foreshore reserve is at risk of erosion and inundation from the present day
MU8 – Bunbury East - including Vittoria Bay, Pelican Point and Districts along Preston River	▪ Inundation is the biggest risk for this management unit ▪ The areas surrounding Preston River and the Estuary are at risk of inundation from the present day. ▪ It is assumed the canal infrastructure will be maintained; however, the canal properties are at risk from erosion along the river and estuary fronts by 2120. ▪ Foreshore Park and the commercial properties on Estuary Drive are predicted to be in the coastal erosion hazard zone by 2120.	▪ Approximately 19 roads at risk of erosion by 2120; 79 by inundation ▪ By 2120, 104 environmental assets at risk from erosion; 145 by inundation ▪ 92 residential properties predicted to be impacted by erosion by 2120 ▪ 409 residential properties predicted to be impacted by inundation by 2120 ▪ By 2120, 2 commercial assets at risk of erosion, 8 from inundation ▪ By 2120, 4 Aboriginal Heritage assets at risk of erosion, 7 by inundation ▪ Public and community, developed and undeveloped foreshore at risk of erosion and inundation from the present day

4.5 Success Criteria

The values collated from the engagement were used to generate the success criteria for the vulnerability and risk assessment component of the CHRMAP. These are key to the whole CHRMAP as these criteria were used to drive the selection of adaptation options. The success criteria are reproduced in Table 4-2.

Table 4-2 Success criteria

- Conserve, enhance and maintain the natural environment and character of the study area
- Facilitate and promote public usage and enjoyment of the natural environment, coast, estuaries and rivers
- Protection of the cultural values of the coastline
- Manage impacts to the existing residential areas from erosion and inundation
- Maintain critical infrastructure supporting the community (roads, utilities).
- Manage and maintain coastal infrastructure that provides access to the water and supports the lifestyle enjoyed by people in the region
- Retain the widest possible range of risk management options for future users of the coast

5 STAGE E – VULNERABILITY ANALYSIS

A Vulnerability Analysis Chapter Report (Appendix D) was prepared which constitutes the second stage of the risk identification process. Likelihood, consequence, level of risk, adaptive capacity and vulnerability scales were developed for the nine asset categories. All identified at-risk assets within the 11 management units were then assigned vulnerability ratings, according to the various scales. The vulnerability results are presented in full in the Vulnerability Analysis Chapter Report. A summary is presented below by management unit and asset category, for the planning horizons of present day, 2035, 2050 and 2120.

5.1 Method

A vulnerability assessment defines the degree of impact coastal hazards are likely to have on coastal assets over the planning timeframe. The vulnerability of coastal assets to coastal hazards is related to its exposure to the hazard, its sensitivity to that exposure, and the ability of the asset to be modified or adapted to manage this exposure. This is displayed diagrammatically in Figure 5-1; the input components are displayed in blue.

Inundation and erosion hazards are considered separately. Assets are grouped according to classification for ease of interpretation. Ratings were discussed with the Steering Group to ensure they reflect the community views.

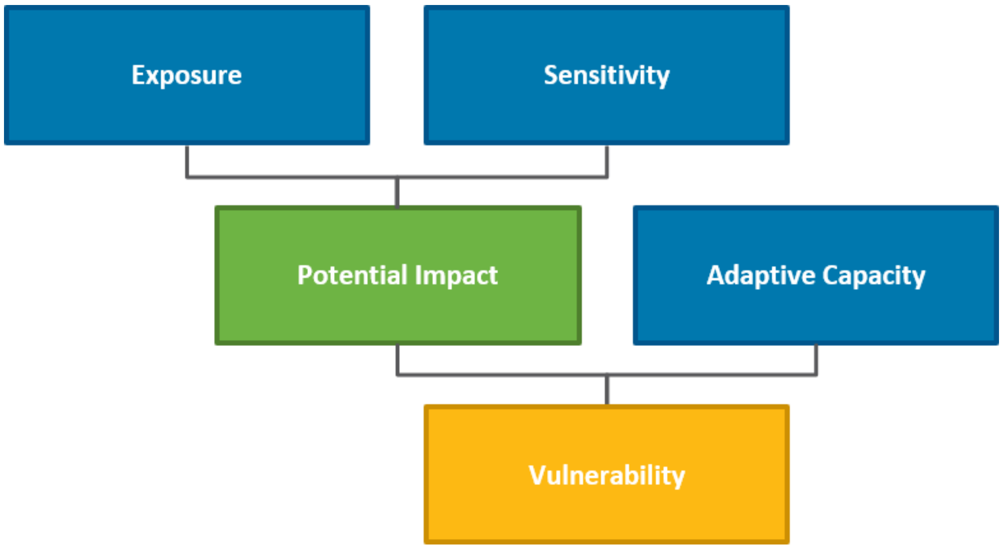


Figure 5-1 Vulnerability assessment components (reproduced from Allen Consulting, 2005)

5.2 Identification of Assets

One of the main challenges of this CHRMAP is the numerous assets and management zones. The asset classification presented in Section 4.2 was developed to address the main coastal adaptation issues and key locations and enable a simple yet effective method for adaptation planning across the broader study area.

5.3 Exposure / Likelihood

The **exposure / likelihood** of identified assets represents the likelihood of coastal hazards impacting on an asset. That is, the chance of erosion and / or storm surge inundation impacting on existing and future assets and their values (WAPC, 2019). The likelihood scale adopted for this study is presented in Table 5-1. Ratings have been allocated to asset categories for each hazard at each timeframe based on the interpretation of the hazard assessment results. The methods used are explained in detail in Vulnerability Analysis Chapter Report.

Table 5-1 Exposure/Likelihood Rating

Likelihood Rating	Description
Almost Certain	Expected to occur in most circumstances
Likely	Impact to asset shoreline for a given planning timeframe is likely
Possible	Impact to asset shoreline for a given planning timeframe is possible
Unlikely	Impact to asset shoreline for a given planning timeframe is unlikely
Rare	May occur in exceptional circumstances

5.4 Sensitivity / Consequence

The **sensitivity / consequence** is an asset's responsiveness to a coastal hazard. This could be a gradual or stepped change response to discrete events (WAPC, 2019). The sensitivity can be applied to the asset itself, or to the asset's function and the criticality of the service it provides (CoastAdapt, 2017).

The consequence ranking presented in Table 5-2 constitutes the physical impact of the event to the asset, as well as that of the values attributed to it by the success criteria defined earlier in the study.

For each hazard, the consequence was assessed against the criteria qualitatively, based on experience of the impacts of coastal erosion and inundation, and the examples presented in the consequence scale. The purpose of assigning vulnerability is to identify and prioritise what requires adaptation.

Table 5-2 Sensitivity / Consequence ranking

Consequence Level	Physical, Financial	Environment	Community / Social & Cultural
Insignificant	No or minimal damage, perhaps requiring increased maintenance Financial loss less than $20,000	Negligible to no impact to the environment	Minimal short-term inconvenience to the asset, services and function, <5% of community affected. Many alternatives exist
Minor	Minor damage to assets resulting in restrictions in capability, financial loss of $20,000 to $200,000	Short-term damage to environment. Recovery will be strong. Local or regional alternate habitat exists	Isolated but noticeable (short term) decline or disruption to asset, services and function, <10% of community affected. Alternative sites exist
Moderate	Damage to assets resulting in isolated loss of capability, financial loss of $200,000 to $2 million	Medium-term loss of environmental assets. Recovery is likely. Local or regional alternate habitats exist	Moderate (short to medium term) decline or disruption to assets, services and function, <25% of community affected. No convenient alternative exists

Consequence Level	Physical, Financial	Environment	Community / Social & Cultural
Major	Significant damage to many assets resulting in capability constraints, financial loss of $2 million to $5 million	Long-term damage to environmental assets. Limited chance of recovery. No local alternate habitat(s) exist. Regional habitats exist	Severe (medium-term) decline or disruption to asset, services and function, <50% of community affected. No convenient alternative exists
Catastrophic	Significant damage to most assets resulting in loss of capability, financial loss of over $5 million	Permanent damage to environmental assets. No chance of recovery. No alternate habitat(s) exist.	Long-term or permanent loss of asset, services and function >75% of community affected. No alternative exists

Each asset category is assigned a sensitivity / consequence rating, for erosion and inundation respectively. A GIS-based approach to vulnerability analysis was used as it was practical for the study area size and complexity. This involved an “averaging" process, by applying blanket analysis on categories; suitable for delineation of vulnerabilities within a Management Unit, and comparisons between Management Units. A rating is assigned to each of the consequence columns, and then the overall rating is assigned as the worst of the ratings. This applies a conservative factor to this large-scale approach.

5.5 Potential Impact (Level of Risk)

Risk level, or **potential impact**, is calculated as the **product** of exposure and sensitivity (see Table 5-3). It provides a classification of the potential impact of coastal hazards on identified assets, which was determined for each project timeframe. Definitions are provided in Table 5-4.

Table 5-3 Risk Level (Potential Impact) Matrix as Product of Sensitivity (Consequence) and Exposure (Likelihood)

Sensitivity / Consequence	Exposure / Likelihood				
	Rare	Unlikely	Possible	Likely	Almost Certain
Catastrophic	Medium	High	Extreme	Extreme	Extreme
Major	Medium	Medium	High	Extreme	Extreme
Moderate	Low	Medium	Medium	High	High
Minor	Low	Low	Low	Medium	Medium
Insignificant	Low	Low	Low	Low	Low

Table 5-4 Risk profile definition

Risk Profile	Definition
Low	Tolerable risk. A level of risk that is low and manageable without intervention outside routine asset maintenance.
Medium	A level of risk that may require intervention to mitigate, such as changes to design standards or asset maintenance. Short to medium term action required.
High	A level of risk requiring significant intervention to mitigate in the immediate to short term.
Extreme	Immediate action required to reduce risk to acceptable levels

5.6 Adaptive Capacity

The **adaptive capacity** is the asset's ability to adjust/adapt to the identified hazard. It was determined based on the potential for the system to be modified to cope with the impacts from coastal hazards. Assets with high adaptive capacity can easily be adapted. For instance, beach and dune systems often have higher adaptive capacity than coastal infrastructure and residential land. The scale of adaptive capacity is provided in Table 5-5. Rating of adaptive capacity was determined by assets/asset groups as well as opinions from stakeholders and community.

Table 5-5 Adaptive Capacity

Adaptive Capacity	Description
No adaptation required	Potential impact has insignificant effect on asset. Controls are re-established naturally or with ease before more damage would likely occur.
Very High	Good adaptive capacity. Functionality restored easily. Adaptive systems restored at a relatively low cost or naturally over time.
High	Decent adaptive capacity. Functionality can be restored, although additional adaptive measures should still be considered. Natural adaptive capacity restored slowly over time under average conditions
Moderate	Small amount of adaptive capacity. Difficult but possible to restore functionality through repair and redesign.
Low	Little or no adaptive capacity. Potential impact would destroy all functionality. Redesign required.

5.7 Vulnerability Ratings

Vulnerability is calculated as the **product** of potential impact (risk level) and the adaptive capacity (Figure 5-2 and Table 5-6). As per WAPC (2019), four levels of vulnerability are considered in this study which should be assessed for each of the planning timeframes considered by this CHRMAP. **Vulnerability** ratings are EX (extreme), HI (High), ME (Medium) and LO (Low).

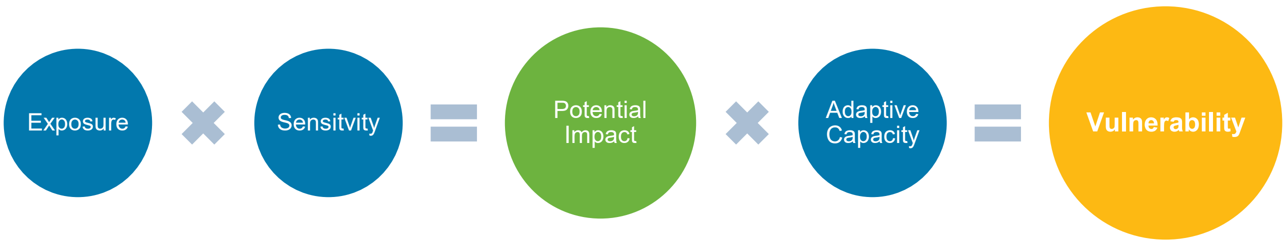


Figure 5-2 Vulnerability relationship

Table 5-6 Vulnerability Matrix as a Product of Risk Level and Adaptive Capacity

Risk Level	Adaptive Capacity			
	Low	Moderate	High	Very High
Extreme	**Extreme**	**Extreme**	**High**	**Medium**
High	**Extreme**	**High**	**Medium**	**Medium**
Medium	**High**	**Medium**	**Medium**	**Low**

Risk Level	Adaptive Capacity			
	Low	Moderate	High	Very High
Low	**Medium**	**Medium**	**Low**	**Low**

For each planning horizon, each category was then assigned an overall vulnerability rating. The most conservative rating for each category for each horizon was selected, except when there are less than 5 assets in the highest rating, with the majority in lower ratings. In those cases, the next highest rating has been selected, with the small number in brackets indicating the assets in the rating above.

The overall vulnerability ratings for each category within each management unit for each planning horizon is presented in Table 5-7 and Table 5-8 below for erosion and inundation respectively. Extreme vulnerability has been identified from the present day onwards. Most of this extreme vulnerability is predicted to be from erosion, with the exception of residential and commercial inundation.

The enormous number of at-risk assets, a total of approximately 48,000 across the broader study area, means grouping and summarising is the only meaningful method of assessing the risk at this stage of the planning process.

Table 5-7 Erosion vulnerability ratings, grouped by management unit & planning horizon

Management Unit	2020	2035	2050	2120	Summary
MU4 - Bunbury South					
Public and Community	High	High	High	Extreme	Erosion is a key risk for 4 of the 9 categories within this management unit. Adaptation in some form is required from the present day.
Foreshore - Developed	Medium	Medium	Medium	Medium	
Foreshore - Undeveloped	High	Extreme	Extreme	Extreme	
Environmental	Extreme	Extreme	Extreme	Extreme	
MU5 - Bunbury					
Roads	Extreme	Extreme	Extreme	Extreme	Erosion is a key risk for 8 of the 9 categories within this management unit. Adaptation in some form is required from the present day.
Residential	High (4Ex)	Extreme	Extreme	Extreme	
Commercial	High (3Ex)	Extreme	Extreme	Extreme	
Public and Community	High (5Ex)	High (5Ex)	Extreme	Extreme	
Foreshore - Developed	Medium	Medium	Medium	Medium	
Foreshore - Undeveloped	High	Extreme	Extreme	Extreme	
Environmental	Extreme	Extreme	Extreme	Extreme	
Aboriginal Heritage	Extreme	Extreme	Extreme	Extreme	
MU6 - Bunbury Port					
Roads	Extreme	Extreme	Extreme	Extreme	Erosion is a key risk for 6 of the 9 categories within this management unit. Adaptation in some form is required from the present day.
Commercial	Extreme	Extreme	Extreme	Extreme	
Public and Community	Extreme	Extreme	Extreme	Extreme	
Foreshore - Undeveloped	High	Extreme	Extreme	Extreme	
Environmental	Extreme	Extreme	Extreme	Extreme	
Agricultural / Rural	Medium	Medium	Medium	Extreme	
MU7 - The Cut					
Foreshore - Undeveloped	High	Extreme	Extreme	Extreme	Erosion is a key risk for 2 of the 9 categories within this management unit. Adaptation in some form is required from the present day.
Environmental	Extreme	Extreme	Extreme	Extreme	
MU8 - Bunbury East					
Roads	Extreme	Extreme	Extreme	Extreme	Erosion is a key risk for 8 of the 9 categories within this management unit. Adaptation in some form is required from the present day.
Residential	High (3Ex)	Extreme	Extreme	Extreme	
Commercial	Extreme	Extreme	Extreme	Extreme	
Public and Community	Extreme	Extreme	Extreme	Extreme	
Foreshore - Developed	Medium	Medium	Medium	Medium	
Foreshore - Undeveloped	High	Extreme	Extreme	Extreme	
Environmental	Extreme	Extreme	Extreme	Extreme	
Aboriginal Heritage	Extreme	Extreme	Extreme	Extreme	

Table 5-8 Inundation vulnerability ratings, grouped by management unit & planning horizon

Management Unit	2020	2035	2050	2120	Summary
MU4 - Bunbury South					
Foreshore - Developed	Medium	Medium	Medium	Medium	Inundation is a medium risk for 3 of the 9 categories within this management unit. Adaptation in some form may be required from the present day.
Foreshore - Undeveloped	Medium	Medium	Medium	Medium	
Environmental	Medium	Medium	Medium	Medium	
MU5 - Bunbury					
Roads	Medium	Medium	Medium	Medium	▪ Inundation is a medium / high risk for 6 of the 9 categories within this management unit. Adaptation in some form may be required from the present day. ▪ Inundation is an extreme risk for residential and commercial assets. For these categories, adaptation in some form is required from the present day.
Residential	Extreme	Extreme	Extreme	Extreme	
Commercial	Extreme	Extreme	Extreme	Extreme	
Public and Community	High	High	High	High	
Foreshore - Developed	Medium	Medium	Medium	Medium	
Foreshore - Undeveloped	Medium	Medium	Medium	Medium	
Environmental	Medium	Medium	Medium	Medium	
Aboriginal Heritage	High	High	High	High	
MU6 - Bunbury Port					
Roads	Medium	Medium	Medium	Medium	▪ Inundation is a medium / high risk for 5 of the 9 categories within this management unit. Adaptation in some form may be required from the present day. ▪ Inundation is an extreme risk for commercial assets. For these categories, Adaptation in some form is required from the present day.
Commercial	Extreme	Extreme	Extreme	Extreme	
Public and Community	Medium	Medium	Medium	High	
Foreshore - Undeveloped	Medium	Medium	Medium	Medium	
Environmental	Medium	Medium	Medium	Medium	
Agricultural / Rural	Medium	Medium	Medium	Medium	
MU7 - The Cut					
Foreshore - Undeveloped	Medium	Medium	Medium	Medium	Inundation is a medium risk for 2 of the 9 categories within this management unit. Adaptation in some form may be required from the present day.
Environmental	Medium	Medium	Medium	Medium	
MU8 - Bunbury East					
Roads	Medium	Medium	Medium	Medium	▪ Inundation is a medium / high risk for 7 of the 9 categories within this management unit. Adaptation in some form may be required from the present day. ▪ Inundation is an extreme risk for residential and commercial assets. For these categories, adaptation in some form is required from the present day.
Residential	Extreme	Extreme	Extreme	Extreme	
Commercial	Extreme	Extreme	Extreme	Extreme	
Public and Community	High	High	High	High	
Foreshore - Developed	Medium	Medium	Medium	Medium	
Foreshore - Undeveloped	Medium	Medium	Medium	Medium	
Environmental	Medium	Medium	Medium	Medium	
Agricultural / Rural	Low	Medium	Medium	Medium	
Aboriginal Heritage	High	High	High	High	

6 STAGE F - RISK EVALUATION AND TREATMENT

A Risk Evaluation and Treatment Chapter Report (Appendix E) was prepared, identifying risks and presenting and assessing treatment options using multi-criteria analysis. A summary is provided below.

6.1 Risk Evaluation - Priorities for Treatment

The erosion and inundation vulnerability ratings presented in Section 5 were considered for each MU as a whole by averaging the vulnerability ratings of individual asset categories; see Table 6-1 and Table 6-2. All MUs at all planning horizons have unacceptable levels of vulnerability for both erosion and inundation (medium or above) for one or more asset categories, and therefore need to be considered for risk treatment options. There are greater vulnerabilities to erosion in the study area compared to inundation.

Table 6-1 Erosion vulnerability ratings by management unit & planning horizon

Management Unit	2020	2035	2050	2120
MU4 – Bunbury South	High	High	High	Extreme
MU5 - Bunbury	High	Extreme	Extreme	Extreme
MU6 – Bunbury Port	Extreme	Extreme	Extreme	Extreme
MU7 – The Cut	Extreme	Extreme	Extreme	Extreme
MU8 – Bunbury East	Extreme	Extreme	Extreme	Extreme

Table 6-2 Inundation vulnerability ratings by management unit & planning horizon

Management Unit	2020	2035	2050	2120
MU4 – Bunbury South	Medium	Medium	Medium	Medium
MU5 - Bunbury	High	High	High	High
MU6 – Bunbury Port	Medium	Medium	Medium	High
MU7 – The Cut	Medium	Medium	Medium	Medium
MU8 – Bunbury East	High	High	High	High

6.2 Risk Management and Adaptation Hierarchy

SPP2.6 provides a hierarchy of adaptation pathways to guide decision-making in coastal areas to be used by planning authorities and development proponents when considering adaptation options to minimise coastal hazard risks at the local level. The hierarchy, presented in Figure 6-1, indicates a clear preference against the adoption of 'protect' as a long-term adaptation pathway. This preference is re-emphasised in SPP2.6, the policy guidelines, the CHRMAP Guidelines and the WA Coastal Zone Strategy. This hierarchy is discussed further below.

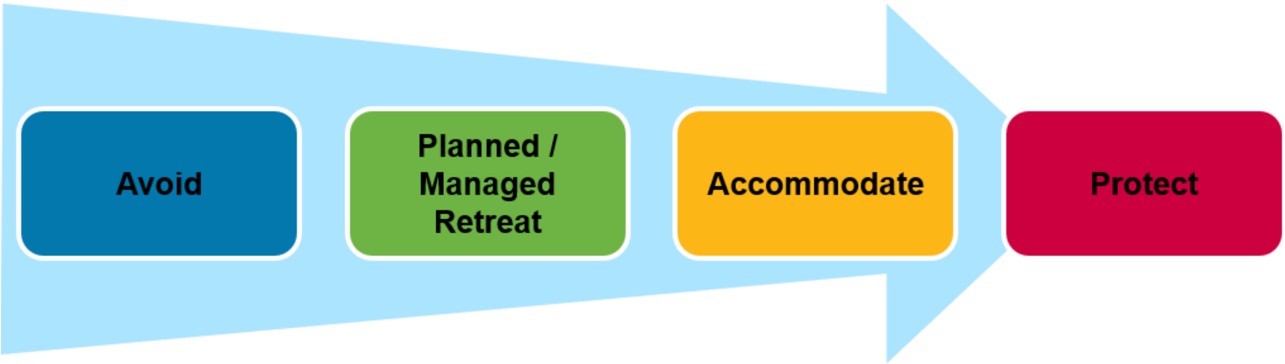


Figure 6-1 Coastal hazard risk management and adaptation planning hierarchy (adapted from WAPC, 2019)

Maintaining public access to the coast in developed areas is one of the main objectives of SPP2.6. The current State legislative framework means that where the shoreline recedes beyond private property boundaries, public access and trespass issues are likely to arise. This situation implies that public authorities have two main adaptation options available to them for preserving public coastal access:

- **Planned or Managed Retreat** i.e., maintaining a foreshore reserve through public acquisition of private property; or,
- **Protect** i.e., preventing the shoreline from receding beyond private property boundaries by stabilising the current shoreline position using various protection measures

Where public authorities cannot commit to either of these options over the long term, it is likely that public authorities will need to **Accommodate**, by modifying local planning frameworks to help ensure that new development is appropriately designed and located. Public authorities in this situation may also choose to consider the appropriateness of interim Protection measures to preserve public interests by delaying shoreline recession and minimising the effect of regular nuisance inundation events on existing development and infrastructure.

Table 6-3 presents a summary of the relevant information for adaptation. It is important to note that no law requires public authorities to protect private property from natural hazards nor compensation when land is lost due to coastal hazards. The CHRMAP process aims to minimise coastal hazard risks and maximise the beneficial use of the coast.

Table 6-3 Adaptation consideration summary

• Adaptation options should minimise coastal process interference and legacy issues
  o The adaptation hierarchy is presented in Figure 6-1.
• Coastal development must be sustainable in the long term, and must balance the community, economic, environmental and cultural needs
• Local Governments are responsible for managing risks to **public assets** and any assets they manage. They should also:
  o Develop local policies and regulations consistent with state legislation and policy
  o Facilitate building resilience and adaptive capacity within the local community
  o Work in partnership with the community to identity and manage risks / impacts
• Management strategies that preserve the natural coastline and move development away from the active coastal zone in an orderly manner are considered ideal. Of particular relevance to the CHRMAP process is the user pays principle, whereby those who benefit most from protection must provide the greatest financial contribution
• Adaptation options should maintain future flexibility, in order to build resilient coastal communities.
• A key adaptation option will be the use of planning instruments, including managed retreat.

6.3 Risk Treatment Options

Table 6-4 below presents a list of generally available adaptation options suitable for most coastal sites. These relate to both short-term and long-term adaptation to coastal hazards in general, not just in relation to planning for climate change impacts. The column on the right-hand side provides some discussion as to the possibility of its application for the study area.

Table 6-4 Risk treatment options from WAPC (2019)

Option Category	Option Name	Option Code	Description of how it will help
Avoid	Locating assets in areas that will not be vulnerable to coastal hazards	AV	Assets will not be vulnerable to risk arising from coastal hazards.
Planned / Managed Retreat	Leaving assets unprotected	PMR1	Accept loss following hazard event. Only implement repairs to maintain public safety. Allow for retreat that allows natural recession of the shoreline over the long-term.
	Demolition / removal / relocation of asset from inside hazard area.	PMR2	Relevant for assets of low value where it is impractical both technically and financially to design the asset to withstand the impact of the coastal hazards instead of relocating it.
	Prevention of further development / prohibit expansion of existing use rights	PMR3	This risk treatment option would enable existing development and use rights to continue without increasing them, until such time that risk arising from coastal hazards is intolerable. Specified in a local planning scheme.
	Voluntary acquisition	PMR4	This risk treatment option would require the acquisition of affected properties, on a voluntary basis.
Accommodate	Design assets to withstand impacts	AC1	Where avoiding or relocating an asset is not an option, design of assets to withstand the impact of inundation.
Protect	Beach nourishment or replenishment	PR1	Placement of sand within the beach profile and/or dunes to activate beach coastal processes and provide a sediment supply.
	Groyne	PR2	Construction of groynes to stop or restrict the movement of sand around the end of the structure, to provide protection to assets behind the beach/foreshore reserve. They are primarily effective where there is longshore sand supply or when partnered with sand nourishment.
	Seawall	PR3	Construction of a seawall usually along an entire section of shoreline. Where a beach is to be retained, this risk treatment option should generally be accompanied with beach nourishment or replenishment.
	Artificial reef	PR4	Construction of a submerged artificial reef offshore, to dissipate wave energy impacting the shore by causing waves to break on their seaward side and reducing wave energy on the leeward side. Artificial reefs do not block waves and during storm events water depths over the reef may be sufficient to allow waves to pass over the reef without breaking, reducing their effectiveness in protecting the beach from erosion.
	Offshore breakwater	PR5	Construction of an emergent offshore barrier (often referred to as an offshore breakwater). Offshore breakwaters effectively block wave energy by absorbing wave impact on their seaward side. They create a lower wave energy section of beach immediately in its lee, which is characterised by a salient where sand accretes in the low energy environment.
	Levee / Weir / Storm Surge Barrier	PR6	Inundation protection to minimise inundation on low-lying land. This could be a levee on the banks of a river, a storm surge barrier at the entrance to an inlet / estuary and so on. Details would be specific to the relevant conditions of each MU.
No Regrets	Monitoring	NR1	Involves long-term baseline monitoring and event-based monitoring following storm erosion events.
	Protection Structure Audit	NR2	Involves undertaking an audit of existing protection structures, to determine their current condition, effectiveness and future protection potential.
	Notification on title	NR3	Indicates to current and future landowners that an asset is likely to be affected by coastal erosion and/or inundation over the planning timeframe. Helps current and future owners make informed decisions about level of risk they are/may be willing to accept, and that risk management is likely to be required at some stage within the planning timeframe.
	Emergency evacuation plans	NR4	Where existing assets may be affected by inundation and are not already identified in an existing emergency evacuation management plan. Such plans are important in managing the safety of community and stakeholders.
Do Nothing	Do Nothing	DN1	Assumes all levels of risk are accepted and assumes that there is no change in existing planning controls, and no actions are implemented (i.e., no controls are implemented to treat known coastal risks).

6.4 Multi-Criteria Analysis

Successful risk management and adaptation planning requires identification and diligent assessment of suitable options to ensure selection of the best strategy. The chosen option should mitigate risk to an acceptable level whilst maximising the values important to the stakeholders and community. For this CHRMAP the key assessment criteria were:

- Effectiveness
  - Ability for the option to mitigate the coastal hazard risk
- Environmental Impact
  - Impact on existing native vegetation / dunes / coastal processes
  - Includes consideration of:
    - Any construction / clearing impacts
    - Impact of maintenance on the environment
- Social Impact
  - This considers stakeholder and community impacts from previous CHRMAP chapters
  - Potential impacts on Aboriginal and European heritage sites and values are considered in this criterion.
- Aesthetic Impact
  - The visual appeal of the option
  - Consideration of option aesthetics tying into the wider town / Management Unit vision
- Cost
  - Upfront capital costs
  - Ongoing maintenance costs
  - Economic affects – such as loss of businesses, income, value
- Future Adaptability
  - Whether the option is easily adaptable in future, such as for updated sea level rise actuals or predictions
  - If the option limits the feasibility of selecting other options in future

Water Technology undertook an initial assessment of options against the criteria. The qualitative criteria (environmental, social and aesthetic) were then modified following review and confirmation by the Steering Group. **While ratings are somewhat subjective, these have been reviewed by the Steering Group to ensure the ratings are reflective of stakeholder knowledge and community feedback.**

A Coastal Community Advisory Group (CCAG) was formed, comprising community members from across the study area. Members attended a workshop to further review and calibrate the MCA scoring, focusing on the Environmental, Social and Aesthetic Impact categories. Several component category scores changed during this review process, but only one option in three MUs changed recommendations and only one of these was within the City:

- MU8 Bunbury East – PR5 Offshore Breakwater – changed from 'Suitability Unclear' to 'Not Recommended', so will be excluded from CBA process.

In most cases it is necessary to implement more than one option, and the options selected through the MCA may vary between management units and with implementation timeframes. Table 6-5 summarises the evaluated status of each option for each management unit. Options receiving a positive score are recommended for further consideration.

Table 6-5 Multi-Criteria Analysis summary by MU. Green indicates recommended for further investigation; orange is unclear.

Option	MU4	MU5	MU6	MU7	MU8
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	11	11	11	11	11
Leaving assets unprotected (PMR1)	2	2	2	2	2
Demolition / removal / relocation of asset from inside hazard area (PMR2)	7	7	7	7	7
Prevention of further development / prohibit expansion of existing use rights (PMR3)	10	6	6	N/A	6
Voluntary acquisition (PMR4)	N/A	5	5	N/A	5
Design assets to withstand impacts (AC1)	10	9	10	12	9
Beach nourishment or replenishment (PR1)	-7	3	4	4	2
Groynes (PR2)	-11	1	3	3	0
Seawalls (PR3)	-12	-2	0	0	0
Artificial reef (PR4)	-10	-3	-4	-4	-5
Offshore breakwater (PR5)	-12	0	-3	-4	-1
Levee / Weir / Storm Surge Barrier (PR6)	N/A	4	3	N/A	1
Monitoring (NR1)	7	7	7	7	7
Protection Structure Audit (NR2)	N/A	6	6	6	6
Notification on title (NR3)	7	7	7	7	6
Emergency evacuation plans (NR4)	N/A	6	6	N/A	7
Do nothing (DN1)	-8	-8	-8	-8	-8

7 STAGE G – RISK TREATMENT ANALYSIS

7.1 Cost Benefit Analysis

7.1.1 Approach

The Cost-Benefit Analysis (CBA) aims to examine the selection of coastal adaptation options through economic analysis. This CBA includes coastal adaptation options requiring significant financial investment and scoring positively in the MCA. While the CBA process assists in contrasting options available "*at the time of the analysis"* and "*for a set of specific assumptions",* it is not the Panacea for decision-making. For instance, changing scientific, environmental and macro-economic considerations can upset cost estimates in the future. Some of the CBA assumptions may not hold true for the long duration often considered in CBA analysis for major infrastructure (Covid pandemic, technological advances, etc.).

The CBA analysis allows selection of coastal adaptation options which are economically more defendable than other options which could require more effort to achieve a reduced outcome. However, to prepare a CBA some assumptions must be made, and changing these assumptions can significantly affect the valuation of economic benefits.

For instance, the CHRMAP CBA has only addressed valuing the loss of assets, managed retreat and physical protection options. This CBA does not consider indirect costs that another user might consider to be a loss. For example, the analysis did not include costs associated with Special Control Area (SCA) title notifications, emergency planning, and development restrictions. Also, options selected have been designed to provide similar level of beach and foreshore amenities to the present-day situation. This may not be practical. There may be further decisions about coastal amenities management (such as policies, planning decisions, legal proceedings, etc.), guided by community values, which may alter this assumption. Furthermore, in this CBA all coastal adaptation options are designed to provide beach and foreshore amenities into the future.

The cost-benefit of each coastal adaptation option is presented in net present value (NPV) terms. NPV is a standard economic analysis to compare options with time-variable costs and benefits. It allows for the adjustment of all future economic considerations to present-day dollars for a more direct comparison. This relates to the time-value of money, as planned expenses in the future are, in a sense, cheaper than equivalent costs today. The real discount rate chosen for this project was 4%, with sensitivity analyses at 7% and 2%. This decision was based on similar assessments the very long timeframe of analysis, and concerns about valuing future spending so low, which is at odds with resilient coastal planning principles.

The CBA has been performed over a 100-year period, to match the project planning timeframe and meet the requirements of the CHRMAP. It should be noted that the uncertainty around the CBA estimates and assumptions made grows with time. Cost estimates beyond 2040 should be viewed as indicative trends only. Long-term coastal adaptation pathways should be monitored and updated regularly.

7.1.2 Options Suitable for Cost-Benefit Analysis

The CBA has only addressed options, including practical and economic actions across the planning timeframe. The economic base case used for comparison is calculated by valuing the loss of assets and values in an assumed scenario of inaction rather than "Business As Usual" (BAU). Total inaction is unrealistic in practical terms as emergency management works and obligations of other legislation would require LGAs and State Departments to act when projected coastal erosion and inundation occur. The economic inaction scenario is also different to the "Do-Nothing" adaptation option, which would assume that anyone over the planning timeframe undertakes no actions or management, and that hazards and resultant asset loss/damage occur exactly as the hazard analysis suggests. The adaptation options considered suitable for CBA are summarised in Table 6-4 – managed retreat and physical protection options (e.g., nourishment, groynes, seawalls, artificial reefs, offshore breakwaters, levee/weir/storm-surge-barrier).

Table 7-1 Risk treatment options from WAPC (2019) suitable for CBA. Note PR4 is greyed out as it did not progress through MCA for any MU's.

Option Category	Option Name	Option Code
Planned / Managed Retreat	Voluntary acquisition	PMR4
Protect	Beach nourishment or replenishment	PR1
	Groyne	PR2
	Seawall	PR3
	Artificial reef	PR4
	Offshore breakwater	PR5
	Levee / Weir / Storm Surge Barrier	PR6

7.1.3 Other Options

The remaining adaptation options from WAPC (2019) are not considered suitable for CBA and have been costed using traditional budgeting techniques for MUs where they received a positive MCA score. Section 8 provides cost estimates and notes on any scoping details or assumptions.

7.1.4 Cost Benefit Analysis Methodology

The steps taken to complete the CBA are presented in detail in the relevant Chapter Report and summarised below:

1. Re-analysis of GIS vulnerability datasets to extract asset category data by area. This was undertaken where previous counts of assets were not considered to provide enough detail for economic analysis
2. Finalise quantities of assets at risk for all nine categories for both erosion and inundation hazards for each Management Unit (MU) at each timeframe
3. Determine an appropriate unit value for each category for both loss to erosion or damage by inundation
4. Valuing the loss of existing assets and values – this assumes the scenario of complete inaction over the next 100 years
5. Scoping and designing the adaptation options
6. Pricing the adaptation options
7. Reducing all costs to NPV
8. Conducting sensitivity analysis on NPV discount rate used in analysis
9. Presenting a summary of the inaction scenario and adaptation options in NPV for both erosion and inundation
10. Recommendation of options to proceed to for further consideration.

7.1.5 Recommended option(s) for further consideration for each MU

The CBA has been used as an additional tool to assist decision-making when assessing adaptation options with which to proceed. However, the reality that only some of the WAPC adaptation options are suitable for CBA, and the uncertainty in the effectiveness of those that are not suitable, means that the CBA results need to be used cautiously whilst considering the rest of the information identified during the CHRMAP project.

The review of the CBA results shows that the ranking of options for each MU by current NPV price depends on which discount rate is used. If options stayed in the same ranking for all three discount rates, there would be a stronger argument for selecting a single option with which to proceed. Options recommended to proceed are presented in Table 7-2 for erosion and Table 7-3 for inundation.

Table 7-2 Recommended CBA options for erosion for each MU

Management Unit	Recommended Option	Secondary Option (s)	Notes
MU4 – Bunbury South	Not applicable	Not applicable	▪ There are no CBA options for MU4.
MU5 – Bunbury	PR2 - Groynes	PMR4 - Voluntary acquisition	▪ PR2 is best value for one discount rate (2%). ▪ PMR4 was best value for the other two discount rates (7% and 4%) but not by a significant amount. ▪ PMR4 has a lot more uncertainty around its implementation, given the large size of this MU and the large amount of values and built assets that are vulnerable including the Transforming Bunbury Waterfront project. Further investigation could consider more detailed analysis on subsections of this MU. ▪ PR1 may be suitable as an interim option in parts of this MU.
MU6 – Bunbury Port	PR2 - Groynes	PR1 – Beach Nourishment	▪ PR2 is best value for one of the discount rates (2%). ▪ PR1 was best value for the other two discount rates (7% and 4 %) and its risks around implementation and longevity are less of a concern within this more-sheltered MU. It may be suitable as an interim option.
MU7 – the Cut	PR1 – Beach Nourishment	PR3 - Seawall	▪ PR1 is best value for two discount rates (7% and 4%). ▪ PR3 is not recommended as it would mean the loss of the beach. Should the objectives of this MU change in the future PR3 may be suitable long-term. ▪ PR1 could later be transitioned to PR3 if required.

Management Unit	Recommended Option	Secondary Option (s)	Notes
MU8 – Bunbury E including Vittoria Bay, Pelican Point and Districts along Preston River	PR2 - Groynes	PR1 – Beach Nourishment	▪ PR2 is best value for two discount rates (4% and 2%) and almost equal best for the 7% rate.

Table 7-3 Recommended CBA options for inundation for each MU

Management Unit	Recommended Option (s)	Notes
MU4 – Bunbury South	Not applicable	▪ There are no CBA options for MU4.
MU5 – Bunbury	PR6 – Storm Surge Barrier	▪ PR6 is better value than the base case for all discount rates and no other options were recommended for CBA.
MU6 – Bunbury Port Ocean frontage	PR6 - Levee	▪ PR6 is better value than the base case for all discount rates and no other options were recommended for CBA.
MU6 – Bunbury Port Estuary frontage	Not applicable	▪ Further investigation is required as the broader PR6 option comprising a new storm surge barrier at The Cut did not perform better than the base case for any discount rate.
MU7 – the Cut	Not applicable	▪ There are no CBA options for MU4.
MU8, 9, 10, 11 Bunbury East, Leschenault Estuary, Collie River North and South	Not applicable	▪ Further investigation is required as the broader PR6 option comprising a new storm surge barrier at The Cut did not perform better than the base case for any discount rate. A feasibility analysis is recommended to assess its effectiveness with consideration of freshwater flooding events and further civil and maritime design considerations as to what scale of facility would be required.

7.2 Benefit Distribution Analysis

7.2.1 Selection of Options for Benefit Distribution Analysis

After completing the CBA and reviewing the results, Water Technology discussed possible coastal adaptation options to proceed to Benefit Distribution Analysis (BDA). Following several discussions, considering projected vulnerable assets, nature of hazards, tenure of land projected to be vulnerable, the following three options were selected:

- MU 1 and 2 (in the Shire of Capel) - PR6 - Levees along the banks of the Capel River to minimise inundation. This option shall also consider inundation protection at Higgins Cut and the Minninup Drain outlet near Tatton Place in Stratham.
- MU 3 (in the Shire of Capel) - PR2 - Groynes to manage beach erosion at Dalyellup, the Dalyellup Residual Waste Disposal Facility and the wastewater treatment plant to the north from erosion. Although this option has not scored positively in the CBA, its analysis in the BDA will still be valuable and provide further information about the selection of adaptation options.
- MU 5 Bunbury - PR2 - Groynes to protect Bunbury Back Beach and Koombana bay from erosion.

The BDA was undertaken by sub-consultant Marsden Jacobs and Associates, who have produced a stand-alone report on their BDA work, contained within the Risk Treatment BDA Chapter Report. Their work used the CBA results prepared by Water Technology as their inputs and is summarised below.

7.2.2 Method

A BDA is undertaken to allocate the derived benefits from the options identified to the relevant stakeholder. The relevant stakeholders are all those who are expected to benefit from the protection of the identified area. Key beneficiaries include:

- Private landholders
- Local community (Direct users of the area under threat)
- Broader community (Indirect users)

Identifying the beneficiaries and accurately evaluating their individual share of benefits is important. This paves the way for the next step in the BDA: identifying funding options and a funding model. CHRMAP follows a “beneficiary pay principle” and, thus, requires the accurate allocation of the proportion of benefits to the beneficiaries.

In order to identify the full range of benefits and beneficiaries that will arise from climate interventions, it is first important to identify the full range of uses and values. The concept of total economic value (TEV, Figure 7-1) is a well-established and useful framework for identifying the various values associated with protected areas. This framework is a useful tool for economic valuation, which measures market and non-market values that people hold for the study area and can be applied to value coastal areas and other natural resources such as wetlands, parks etc.

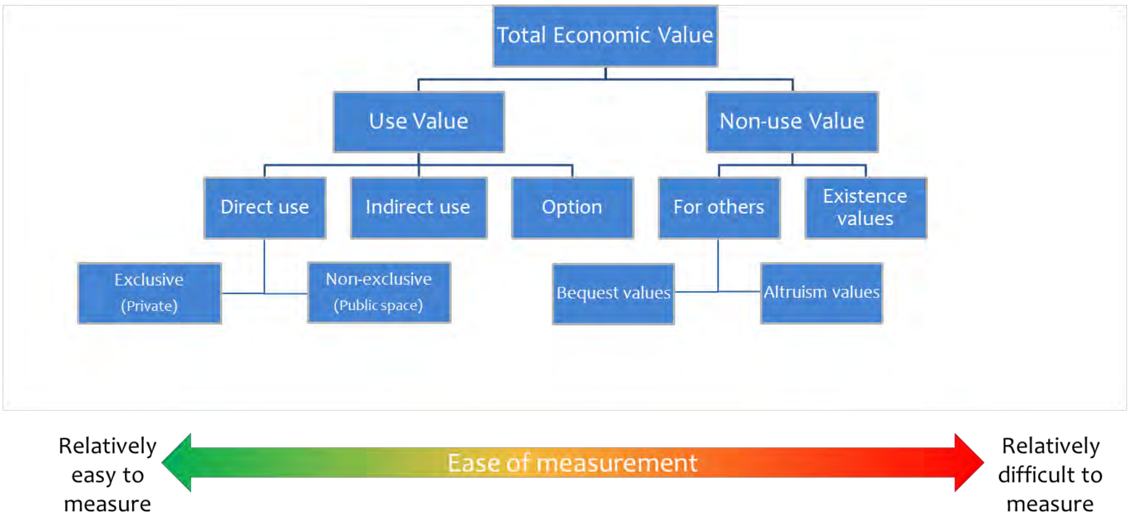


Figure 7-1 Total Economic Value Framework

The TEV framework provides a useful classification for the full range of community values. The framework's basic premise is that an area's total economic value is a function of its use and non-use values. The use values are made up of its direct use values, indirect use values, and option values. Non-use values typically include bequest and existence values.

The framework also helps avoid double counting of ecosystem functions, intermediate services, and final services.

TEV includes both use values, which measure the value of using assets that are protected, and non-use values, which refer to an individual's willingness to contribute to the cost of protecting public assets (such as beaches and estuaries), even if the individual will not use the areas themselves.

On the left-hand side of the TEV framework there are values for the exclusive direct use of assets – such as private land. The value the community places on these assets may be impacted by the market price paid for private land. There is no direct market value for the benefit obtained for all the other uses. These are often referred to as non-market values.

Applying the different types of values identified in the TEV framework, the 9 asset categories and their value type were assessed based on the TEV framework to determine an appropriate valuation method for each category, and their beneficiaries. The CBA base case results were used to determine the economic impact and apportion it to each asset category for each MU.

7.2.3 Results

Table 7-4 summarises the percentage of total benefits for each asset category for each MU. Results are highly variable across the different MU's.

Table 7-4 Percentage of total benefits for each asset category at each MU

Asset Category	MU 1 & 2	MU 3	MU 5
Roads	6%	0%	23%
Residential	3%	11%	2%
Commercial	1%	2%	1%
Public and Community	3%	6%	2%
Foreshore – Developed	0%	1%	45%
Foreshore – Undeveloped	0%	17%	17%
Environmental	68%	64%	11%
Agricultural / Rural	5%	0%	0%
Aboriginal Heritage	14%	0%	0%

Table 7-5 to Table 7-13 below summarise the financial contributions required from the custodians of each asset category to implement the preferred treatment options set out in the CBA. Note DBCA data largely informed the Environmental asset category. It includes habitat areas potentially suitable for Matters of National Environmental Significance (such as Carnaby's Cockatoo's and Western Ringtail Possums), Threatened and Priority Ecological Communities, and known locations of threatened flora.

For each of the stakeholders identified as a key beneficiary for each asset category, the financial contribution would be required as a singular payment and the annuity payment that would be required if the funds were collected over a 15-year period and at a 7% discount rate. 15 years is an arbitrary period – but it aligns with the duration between the first three assessment periods (2020, 2035, 2050). If funds started to be collected now, the projects would be largely funded ahead of the 2035 timeframe for implementation. Ahead of 2035, the risks and work required for 2050 could be reviewed, and then annuity payments could be required for 15 years to ensure any activities undertaken at that time were also funded ahead of work commencing.

7.2.3.1 Peppermint Grove Beach and Capel Coast Inundation Risk - MU1 and MU2

Table 7-5 Private asset categories – Annual funds to be collected per property for 15 years for each timeframe for number of properties protected.

Asset Category	2020	2035	2050	2120
Residential	$1,396	-	-	$2
Commercial	$1,047	-	-	-
Agricultural / Rural	$52	$19	$7	$1

Table 7-6 Local community asset categories

Asset Category	Total funds to be collected	Annuity (15 years)
Public and Community	$79,026	$8,677
Foreshore – Undeveloped	$1,593	$175

Asset Category	Total funds to be collected	Annuity (15 years)
Total	$80,619	$8,852

Table 7-7 Broader community asset categories

Asset Category	Total funds to be collected	Annuity (15 years)
Roads	$163,542	$17,956
Environmental	$1,750,742	$192,222
Aboriginal Heritage	$362,624	$39,814
Total	$2,276,908	$249,992

7.2.3.2 Dalyellup Erosion Risk - MU3

Table 7-8 Private asset categories – Annual funds to be collected per property for 15 years for each timeframe for number of properties protected.

Asset Category	2020	2035	2050	2120
Residential	-	$31,124	-	$99
Commercial	-	$23,343	-	-
Agricultural / Rural	-	-	-	-

Table 7-9 Local community asset categories

Asset Category	Total funds to be collected	Annuity (15 years)
Public and Community	$647,749	$71,119
Foreshore – Undeveloped	$68,076	$7,474
Foreshore – Developed	$1,926,599	$211,530
Total	$2,642,423	$290,124

Table 7-10 Broader community asset categories

Asset Category	Total funds to be collected	Annuity (15 years)
Environmental	$7,245,106	$795,473.73

7.2.3.3 Bunbury Erosion Risk - MU5

Table 7-11 Private asset categories – Annual funds to be collected per property for 15 years for each timeframe for number of properties protected.

Asset Category	2020	2035	2050	2120
Residential	-	$9,659	$3,501	$31
Commercial	$19,987	-	$2,626	$23

Table 7-12 Local community asset categories

Asset Category	Total funds to be collected	Annuity (15 years)
Public and Community	$1,133,001	$124,397

Asset Category	Total funds to be collected	Annuity (15 years)
Foreshore – Undeveloped	$32,206,592	$3,536,111
Foreshore – Developed	$12,268,686	$1,347,036
Total	$45,608,279	$5,007,544

Table 7-13 Broader community asset categories

Asset Category	Total funds to be collected	Annuity (15 years)
Roads	$16,766,838	$1,840,909
Environmental	$7,738,666	$849,664
Aboriginal Heritage	$1,119	$123
Total	$24,506,622	$2,690,695

7.2.4 Discussion

The BDA has found that allocating beneficiaries when forecasting coastal management is a complicated process. The process provides information to assist decision-makers with information about the approximate proportion of beneficiaries between private and public parties. Table 7-14 defines potential funding sources and collection methods for each asset category.

Table 7-14 Potential funding sources and collection methods

Asset Category	Funding Source	Collection Method
Roads	WA Taxpayers	State Government grant
Residential	Property owners	Special levy on relevant properties - collected through rates
Commercial	Property owners	Special levy on relevant properties - collected through rates
Public and Community	Indirect users	Added to all rate payers
Foreshore - Developed	Direct users	Added to all rate payers
Foreshore - Undeveloped	Rate payers	Added to all rate payers
Environmental	WA Taxpayers	State Government grant
Agricultural / Rural	Property owners	Special levy on relevant properties - collected through rates
Aboriginal Heritage	WA Taxpayers	State Government grant

Table 7-15 summarises the annuity funds proposed to be collected from the local community via each relevant LGA, against the total expected rates revenue for 2022/23. Results are markedly different between the Shire of Capel and City of Bunbury.

Table 7-15 Comparison of required funds to LGA rate base

Management Unit	LGA	Annuity funds to be collected from the community	Total expected rates for 2022/23	Percentage proportion of annual rates
MU1 & 2	Shire of Capel	$8,691	$14,179,504	0.06%
MU3	Shire of Capel	$285,677	$14,179,504	2.01%
MU5	City of Bunbury	$5,007,544	$42,800,000	11.70%

While indicative funds appear to be relatively small compared to the value delivered and the overall cost, the costs are not insignificant and further work remains to detail each intervention (ie risk treatment option selected in the CHRMAP), their extents, design standard, program and costs through additional detailed technical studies. Also, the proposed interventions for MU3 do pass significant costs (e.g., $31,000) onto a small number of private beneficiaries. While the costs are well below the value of the benefit delivered it may not be within the capacity of the property owners to pay for these costs. In these instances, further consultation may be necessary to establish a suitable approach to apportioning and collecting these funds.

8 STAGE H - IMPLEMENTATION

8.1 Land-Use Planning Instruments

There is a direct relationship between coastal hazard exposure and development. How buildings and assets are designed and located determines their exposure, ultimately impacting risk to people and property.

Therefore, the policy instruments that govern development are an important tool to reduce risk exposure. The following sections detail the relevant state and local measures that can be used to increase coastal resilience. In this section, the following land use planning instruments are described:

- Inclusion of coastal hazard exposure to be considered in **structure planning**
- Establishment of **Special Control Area**/s as an overlay to further regulate development in high-exposure areas
- Inclusion of coastal hazard information for buyers through **Notifications on Titles** to increase awareness of hazard exposure and risk
- Establishment of a program for **Compulsory Acquisition** of land where coastal hazard risk is deems intolerable for habitation
- **Reservation of Land** to prevent intensification or inappropriate land use in areas exposed to coastal hazard
- **Other instruments** such as leaseback arrangements and land swaps, which are presently conceptual, may become feasible as further investigation is completed over time.

8.1.1 General Land Use Planning Instruments

Western Australia has a well-established approach to coastal hazard planning via SPP 2.6 and CHRMAP Guideline, which refer to several planning instruments that can manage coastal hazards, as follows:

8.1.1.1 Structure Planning

Structure Plans are prepared and approved prior to the subdivision or development of land in development areas identified within the Local Council Planning Scheme, or where required by WAPC.

In areas where further development or redevelopment of land is possible or anticipated, structure plans should incorporate the requirements of the CHRMAP. This would allow the formation of a coastal foreshore reserve to manage coastal erosion and to infill low-lying areas to manage coastal inundation. It is important to not increase the number of buildings and assets that are exposed to coastal hazards, so resources can be focused on managing the residual risk on existing development already at risk.

8.1.1.2 Local Planning Scheme Amendments

8.1.1.2.1 Special Control Area

What is an SCA?

A Local Government Authority (LGA) may declare a Special Control Area (SCA) over areas that are regarded as significant and where special provisions may need to apply.

To enable targeted planning measures to be applied to locations with the highest coastal hazard exposure, a local planning scheme (LPS) amendment can be progressed. This should be informed by SPP 2.6, to classify vulnerable areas as a Special Control Area (SCA).

An SCA overlay typically includes a mapped area that special development conditions apply to. The requirements of a SCA apply in addition to the underlying planning controls dictated by the planning scheme and state framework, such as zoning, building requirements and matters of significance.

Why implement a SCA?

A coastal hazard SCA could be designed to address erosion or inundation separately or relate to combined coastal hazard risk. The effect of the SCA includes further development regulation to manage hazard exposure, which should be assessed on a case-by-case basis to control over the intensification of land where coastal risks are prominent. For example, a development that might otherwise be exempt from development approval would require a planning approval in addition to a building approval.

This may also include referencing a local planning policy to describe assessment procedures and development standards on land prone to coastal hazard, to provide government specific mechanisms for managing coastal risk in areas where it is most relevant.

Where would a coastal hazard SCA apply?

An SCA can facilitate land use changes and development control within that area. The SCA can be determined by the position of either the 2120 coastal processes setback line, or the inundation extent of the 500-year ARI event in the year 2120, whichever is the more landward.

An SCA should be applied to relate specifically to land subject to coastal processes (as recommended in WAPC, 2019). The SCA is allocated a number and depicted on the Scheme Map (as an overlay map).

8.1.1.2.2 Local Planning Policy (LPP)

LPPs are prepared and adopted according to the provisions in Part 2 Division 2 of the Deemed Provisions of the relevant local planning scheme. An LPP can be prepared in respect of any matter related to the planning and development of the Scheme area. The LPP may apply to a particular class or classes of matter specified in the policy and may apply to the whole of the Scheme area or to parts specified in the policy.

> A Special Control Area is suitable across the CHRMAP area. There may be some merit in consolidating the existing SCA for Flood Prone Areas in to the SCA for Coastal Hazard Planning. This will need to be investigated as the Flood Prone Areas SCA also sits within the Greater Bunbury Region Scheme.

An LPP can provide more detail and guidance on what sort of development would be acceptable and will also assist the LGA in making planning decisions on coastal development requiring the exercise of discretion (e.g., it might specify appropriate design responses for individual development proposals; relocatable dwellings; prescribed setbacks; finished floor levels). The policy would further identify the Council’s intention to require notifications on title as a condition of development approval.

> A Local Planning Policy responsive to coastal hazard management is suitable across the CHRMAP area.

8.1.1.2.3 Notifications on Titles

Supported by a suitable SCA, there is an opportunity to require the provision of a Section 70A Notification on the Certificate of Title of land as a condition of any planning approval to alert prospective purchasers of the potential coastal hazard impacts on the lot, as required by SPP2.6. These Notifications can only be applied where triggered by a subdivision or development application. These can either be general alerts or more specific time-limited approvals (e.g., where the temporary use of land in hazard areas is allowed, where appropriate, until hazards materialise, while ensuring that the LGA maintains discretion over development in these areas).

The proponent may apply for an extension to the approval if the approval expires before hazards occur, whilst the LGA would be in a position to require demolition or removal of compromised structures if hazards occur ahead of the Notification timeframe. This option potentially supports landowners with larger risk appetites but may also be a source of future opportunities for conflicts, which will need ongoing management (funding, monitoring, reporting, etc.).

A Notice of Title planning instrument is suitable across the CHRMAP area and there may need to be some alignment with existing Notifications linked to the flood prone nature of some areas.

8.1.1.2.4 Advice to Real Estate and Settlement Agents

Real estate agents and settlement agents are usually the first people that a prospective landowner will meet on their journey to buying into a town or region. Real estate agents have an obligation to provide information to prospective purchasers, whilst settlement agents are often in touch with the local government during settlement to ascertain the current monies owed or conditions applying to land. Although not a catch-all, providing information about the CHRMAP to these parties may help to alert prospective purchasers of the potential coastal hazard impacts on the lot, where a notification of the Certificate of Title has not yet been included.

This could include:

- Communication as soon as practical with all local real estate agents regarding identified hazards so that they will be obliged to share the vulnerability of land in the area.
- Implementation of an internal procedure to provide information regarding identified hazards to settlement agencies through the Orders and Requisitions request process linked to the sale of land to elevate the potential impact to the prospective purchaser (settlement agencies typically request these and they include details of rates paid, outstanding issues, approved development etc).

Advice could be provided to all known real estate agencies and settlement agencies operating in the area; recognising that some purchasers may use our of area services, as is their right, and would not get the benefit of this early advice.

8.1.1.3 Compulsory Acquisition

Compulsory acquisition is an option where no other planning instrument has been able to suitably set aside land for coastal hazard processes, when hazards have advanced to a stage where land exceeds tolerable risk thresholds. This would require the reservation of land for public purposes via a scheme amendment. Options include:

- Purchase of the land by the LGA if the owner is willing to sell it by ordinary sale under Section 190 of the Planning and Development Act (2005) (PD Act)
- Compulsory taking by the LGA without agreement under Section 191 of the PD Act coupled with the Land Administration Act (1997).

If the land remains zoned (within an SCA overlay) then the above options are not available. This instrument should be carefully considered in relation to any protective structures being proposed.

8.1.1.4 Reservation of Land

Subject to remaining consistent with the Greater Bunbury Region Scheme and associated Floodplain Management Policy, land within the local planning scheme may be reserved as 'Foreshore'. This is particularly the case for public assets, where such a reservation would give rise to improved asset management and planning of the foreshore, including information about when and how to relocate public assets such as public amenities, seating, shelter, playground etc when they reach end of life.

Reservation of land is suitable across the CHRMAP area.

8.1.1.5 Other Instruments

Innovative planning instruments, such as 'leaseback of land' and 'land swaps' may be considered. While there is growing interest in these and much work interstate on these matters, these instruments have not been tested in the WA planning context and are not explicitly provided for or anticipated under the State's current planning framework. However, some research into these treatments may be suitable and palatable for the community for locations where "coastal retreat" is possible to adjacent location. In such a scenario, the nature of compensation may be limited to depreciating assets rather than the combination of land and structures.

Considerations of other instruments should be informed by research, implementation case studies from other locations, suitability to the local context, and receptiveness of decision-makers and the community.

8.2 Specific Land-Use Planning Instruments

The City and its partners have acknowledged coastal based hazard for many decades since the flooding experienced from Cyclone Alby in 1978. Planning conditions have been used to support an 'accommodate' option in the suburb of East Bunbury since that time, with flood-prone land noted via planning instruments in the Greater Bunbury Region Scheme and the City's Local Planning Scheme No. 8. A recent CHRMAP has also been prepared for Koombana Bay. The Koombana Bay, Casuarina Drive and Leschenault Inlet Master Plans refer to flooding and coastal vulnerability, as well as the importance of the waterfront environment.

However, few provisions exist within the City's planning instruments to directly respond to the broader coastal hazard challenge and there is a need to establish a response within the town planning legislative framework to best manage the challenge and make the associated risks more apparent / visible.

Structure planning may be effective in the coastal zone where some property development or redevelopment may be considered in low lying areas along the Leschenault Inlet and Koombana Bay (MU5), however, the whole of the City is generally built out and unlikely to experience this pathway.

Any changes to the land use planning framework to reflect the identified risks would be undertaken after detailed investigation into proposed coastal protection measures, as the specific coastal protection measure may alter the land use instrument required.

Recommended land use planning instruments, subject to detailed investigations, are detailed in Table 8-1.

Table 8-1 Land use planning recommendations for the City of Bunbury

Action	Description	Timing	Cost
LU1	The City should prepare an amendment to the Local Planning Scheme No. 8 to include provisions relating to the coastal erosion and inundation hazard zones to 2120 as identified in this study. The amendment shall be inserted Schedule 7 and shall read: *Coastal Hazard Risk Area Special Control Area* and include the information provided in Table 8-2.	Short - Medium	$5,000
LU2	The City should prepare an amendment to the Local Planning Scheme No. 8 to include a Foreshore Reserve encompassing public land within the coastal erosion and inundation hazard zones to 2120 as identified in this study. The amendment shall be inserted at Part II – Reserves, Clause 14 (3). A new Reserve name shall be included and shall read: 'Foreshore' The Objectives of the reserve shall read: ▪ set aside areas for foreshore reserved abutting a body of water or water course ▪ provide for the protection of natural values and processes, including a coastal retreat to accommodate a range of active and passive recreational uses that would be capable of relocation or rehabilitation	Aligned with LU1	$5,000
LU3	The City should prepare a Local Planning Policy (LPP) to be linked to the SCA under Local Planning Scheme No. 8 and provide guidance for applicants and decision-makers in relation to assessment procedures and development standards on land prone to coastal hazards. This may include recommended finished floor levels where impacted by inundation or siting of development to the least vulnerable portion of a lot for both erosion and inundation where possible. The LPP may also specify appropriate design responses for individual development proposals e.g., relocatable dwellings, prescribed setbacks and revegetation responses. The preparation of the LPP should also comprise a review of design guidelines which are located within the same zone, such as the Grand Canals Design Guidelines, to ensure there is no misinterpretation of the role and power of each document. Consolidation is recommended where it can be achieved.	Aligned with LU1	$25,000
LU4	In areas where further development or redevelopment of land is possible or anticipated, structure plans should incorporate the requirements of the CHRMAP, ensuring an appropriate coastal foreshore reserve is included and that any low-lying areas are adequately avoided or suitably filled to avoid inundation impacts. Existing and proposed structure plans should be reviewed to ensure they adhere to SPP2.6 and account for the risks identified in the CHRMAP.	At application	N/A
LU5	The City should notify landholders, real estate agents and settlement agents (operating in the local area) of land that may be affected by coastal hazards by 2120 .	Aligned with LU1	$5,000

Action	Description	Timing	Cost
	Supported by a suitable SCA, there is an opportunity to require the provision of a Section 70A notification on the Title of land as a condition of any planning approval to alert landowners of the potential coastal hazard impacts on the lot, as required by SPP2.6. These notifications can only be applied where triggered by a subdivision (under Section 165 of the *Planning and Development Act 2005)* or development application (Section 70A of the *Transfer of Land Act 1893*). These can either be general alerts or more specific time limited approvals (e.g., where the temporary use of land in hazard areas is allowed, where appropriate, until hazards materialise, while ensuring that the City maintains discretion over development in these areas). The proponent may apply for an extension to the approval if the approval expires before hazards occur, whilst the City would be in a position to require demolition or removal of compromised structures if hazards occur ahead of predicted timeframe. This option potentially supports landowners with larger risk appetites. The LPP should include details of this potential framework.		
LU6	The City should notify prospective purchasers through the 'orders and requisitions' process with information relating to land that may be affected by coastal hazards by 2120 . Such advice should include the predictive nature of the investigations and provide advice on the ongoing investigations and monitoring that will result from the CHRMAP.	Immediate	N/A
LU7	The City should review existing leasehold facilities located within the hazard zone and notify the lessee of the CHRMAP. Leases should be reviewed at renewal timeframes to determine the suitability and/or length of future leases. The Foreshore Reservation in LU2 establishes the zone of interest.	Aligned with LU1	N/A

Table 8-2 Recommended content for City of Bunbury local planning scheme amendment appendix in accordance with LU1.

Item	Recommended Text
Name of Area	Coastal Hazard Risk Area Special Control Area
Purpose	To provide guidance for land use and development within areas subject to coastal erosion and inundation
Objectives	▪ To ensure land in the coastal zone is continuously provided for coastal foreshore management, public access, recreation and conservation. ▪ To ensure public safety and reduce risk associated with coastal erosion and inundation. ▪ To avoid inappropriate land use and development of land at risk from coastal erosion and inundation. ▪ To ensure land use and development does not accelerate coastal erosion or inundation risks; or have a detrimental impact on the functions of public reserves. ▪ To ensure that development addresses the Capel to Leschenault Coastal Hazard Risk Management and Adaptation Plan 2023 prepared in accordance with State Planning Policy No. 2.6 State Coastal Planning Policy (as amended) and any relevant local planning policy.
Additional Provisions	1. All proposed development within the SCA requires approval

Item	Recommended Text
	2. In considering proposed structure plans, subdivision or development applications due regard shall be given to – a) the Capel to Leschenault Coastal Hazard Risk Management and Adaptation Plan 2023. b) State Planning Policy 2.6 - State Coastal Planning Policy; and c) Relevant local planning policies. 3. Where subdivision or development applications are received within SCA1, the local government shall require a notification pursuant to section 70A of the Transfer of Land Act 1983 to be placed on the Certificate(s) of Title of the subject land, at the cost of the landowner and to the satisfaction of the local government. The notification is to read as follows: *"Vulnerable Coastal Area – This lot is located in an area likely to be subject to coastal erosion and/or inundation over the next 100 years"* 4. Notwithstanding the provisions of above (1), (2) and (3) development approval is not required within SCA1 for the following development if such development is otherwise exempt from requiring development approval under the Scheme: a) temporary or non-permanent structures not used for human habitation. b) extensions to an existing single, grouped or multiple dwelling where the net floor area of the proposed extensions is no more than 50m2; and c) a change of use where no new structures are proposed.
Advice Notes	On the occasion of any development approval pursuant to the Additional Provisions of SCA 1, the following "Advice Notes" indicate suitable and tested advice to be provided to applicants: ▪ The development subject of this approval may be impacted by coastal hazards in the short to medium term (likely by 2050). Should the development be affected by coastal hazards in the future as predicted, the development and any associated works are likely to require partial or complete relocation. The local government is under no obligation to assist or protect structures from coastal erosion/inundation threats and accepts no liability and will pay no costs associated with relocation or any protection from or damages caused by coastal processes. ▪ The applicant is advised that the Horizontal Shoreline Datum means the active limit of the shoreline under storm activity, as defined in State Planning Policy 2.6 – State Coastal Planning Policy (2013). ▪ The applicant is advised that the [x insert here] metre distance between the Horizontal Shoreline Datum and the most seaward part of the lot boundary is the S1 value for this location which is obtained from the Capel to Leschenault Coastal Hazard Risk Management Adaptation Plan 2023. S1 is the allowance for absorbing the current risk of storm erosion, as defined in State Planning Policy 2.6 – State Coastal Planning Policy (2013). ▪ Should the development be affected by Coastal Hazards in the future the applicant will be responsible for relocating/removing the development and all costs associated. The local government is under no obligation to assist or protect structures from coastal erosion/inundation threats and accepts no liability and will pay no costs associated with any protection from or damages caused by coastal processes. ▪ In relation to condition [x insert here], upon removal of the development the site is to be rehabilitated to pre-development condition which comprises of a bare earth lot, free of any buildings, demolition rubble or remnants of the approved development.

8.3 Funding Options

This section identifies all revenue-raising mechanisms available for obtaining funds to assist implementation. Funding mechanisms considered include:

- Operating budget, general rates and coastal management fund
- Special area rates / differential rating
- Yearly budgeting
- Levies
- Lease land management
- State grants
- Federal grants
- Beneficiary pays

8.3.1 Operating Budget, General Rates and Coastal Management Fund

The individual land managers within the study area should consider establishing a coastal management fund that includes specific allowance for managing and adapting to the risk posed by coastal erosion and inundation. The purpose of this fund includes:

- To allocate a percentage of the organisation's operating budget for coastal management. The percentage and amounts will vary for each organisation but between 0.5% and 3.0% is proposed.
- To save funds routinely so that when triggers are met the established management actions can be implemented efficiently.
- Acknowledge coastal management costs are forecast to increase in line with sea level rise and the realisation of coastal hazard projections.

8.3.2 Specified Area Rate

Where adaptation options are designed to protect specific sections of coastal land and assets, such as private property, it is recommended that the City progress the establishment of a specified area rate. The rate can be applied to those beneficiaries within the 100-year hazard zone, and the amount raised should consider the estimated 100-year cost for each Option and the Benefit Distribution Analysis (BDA) report.

8.3.3 Levies

It is recommended the City investigate the feasibility of establishing a particular levy for coastal management that would be a transparent source of the coastal management fund discussed above.

8.3.4 Lease Land Management

Coastal land vested with coastal managers in the study area and leased to third parties represents a unique scenario whereby implementation of some Options may require specific lease clauses, but there is also potential to raise funds for coastal management. During considerations of lease renewal, coastal managers should consider the land use, vulnerability of the land, projected timeframe of unacceptable vulnerability, length of lease, recommended implementation Options and need for any specific clause around triggers or required management actions by the lessee. Increases in lease amounts may be able to raise funds to help offset the cost of management.

8.3.5 State Grants - CoastWA

CoastWA aims to implement a strategic response to the growing impacts of coastal hazards to ensure sustainable land use and development on the coast for the long-term. CoastWA has committed $33.5 million of funding over five years from 2021-26. For further information visit https://www.wa.gov.au/government/document-collections/coastwa-grants It comprises the following grant programs:

- Coastal Adaptation and Protection grants
- Hotspot Coastal Adaptation and Protection Major Project Fund
- Coastwest grants
- Coastal Management Plan Assistance Program

There are also two other grant programs relevant to coastal hazard risk management in WA:

- Royalties for Regions
- Local Government Financial Assistance Grants

The Department of Transport administers the Coastal Adaptation and Protection (CAP) grants and the Hotspot Coastal Adaptation and Protection (H-CAP) Major Project Fund. CAP grants provide financial assistance for local projects that identify and manage coastal hazards. The program aims to build partnerships with local coastal managers, such as local governments and help them understand and adapt to coastal hazards. CAP Grants fund up to 50% of project costs. H-CAP supports projects which design and implement adaptation Options at coastal erosion hotpots identified by the DoT in recent years. Invitations to apply for H-CAP are sent directly to eligible coastal managers (those with a completed CHRMAP and an identified erosion hotspot) There are two identified erosion hotspots – The Cut in MU7 and Koombana Beach in MU5.

Coastwest grants support eligible coastal land managers and community organisations to undertake projects that manage and enhance WA's coastal environments through rehabilitation, restoration and preventative actions. Coastwest grants are administered by the Department of Planning, Lands and Heritage.

Coastal Management Plan Assistance Program (CMPAP) grants support eligible coastal land managers to develop adaptation and management plans and strategies for coastal areas that are, or are predicted to become, under pressure from a variety of challenges. CMPAP grants are administered by the Department of Planning, Lands and Heritage.

Other WA grant programs which may provide funding for coastal projects include Royalties for Regions and Local Government Financial Assistance Grants.

Royalties for Regions is facilitated by Department of Primary Industries and Regional Development and promotes and facilitates economic, business and social development in regional Western Australia for the benefit of all Western Australians. For further information visit: http://www.drd.wa.gov.au/rfr/whatisrfr/Pages/default.aspx

Local Government Financial Assistance Grants are administered by the Department of Local Government, Sport and Cultural Industries. They are grants funded by the Commonwealth Government and are distributed among 137 local governments in WA each year. The grants allow councils to spend the funds according to local priorities. For further information visit: https://www.dlgsc.wa.gov.au/local-government/local-governments/financial-assistance-grants

8.3.6 Federal Grants

Federal grants are variable and often unpredictable, but it is important for coastal managers to stay aware of any funding and grant programs available. Early planning and preparation will mean more-competitive applications can be prepared quickly when grants are announced.

On 13 February 2022 the Australian Government announced the $50 million Coastal and Estuarine Risk Mitigation Program which is funded by the Emergency Response Fund. This program supports projects that reduce the impact of disasters on coastal communities. Successful applicants were announced on 4 November 2022. The Coastal and Estuarine Risk Mitigation Program will help drive long term resilience and sustainability by delivering priority projects that mitigate the impact of disasters on communities and economies.

Areas of focus for the Program include:

- Adaptation and resilience actions, including investment in grey infrastructure and green-blue infrastructure (which includes nature-based solutions)
- Planning, including local and regional risk assessments and mapping, business case development, preparation of community focused regional coastal management programs; and
- Investment in monitoring infrastructure and activities to understand the coastal and estuarine zone over time.

For more information visit https://nema.gov.au/programs/emergency-response-fund/coastal-estuarine-risk-mitigation-program#Overview

The Australian Government has also established the Disaster Ready Fund to provide up to one billion dollars over five years from 2023-24. The fund aims to decrease impacts of natural hazards, and eligible projects include direct investment in flood levees, seawalls, constructed wetlands and reefs. For more information visit https://nema.gov.au/disaster-ready-fund

8.3.7 Beneficiary Pays

'User Pays' principles essentially dictate that the beneficiaries of adaptation Options should pay for them. Mechanisms for fund raising may include:

- Specified Area Rates – as described above and considering the findings of the BDA.
- Mechanisms for visitors to the town, as user of the coastline, to contribute. This could be in the form of a levy applied to their accommodation, or paid parking at key tourist sites.
- Developer contributions where specific developments benefit from their coastal location

8.4 Short-term Implementation

The coastal adaptation pathway includes short-term, medium-term and long-term actions. Short-term actions are anticipated to be implemented by 2035, corresponding to a 10-15 year planning horizon; medium-term actions implementation would occur before 2050 (15-30); while long-term actions would be implemented beyond 2050, towards 2120.

8.4.1 Key assumptions

The timeframes envisaged in the coastal adaptation pathways are not absolute. These timeframes are related to the current state of local land planning, coastal processes knowledge and climate projections, as outlined in the CHRMAP. Therefore, the timeframes are typically not aligned on "worst-case" scenarios but instead consider risk-adjusted and/or consensus-based adjustments and quantifications. Other Options may be envisaged, particularly if land planning practices, coastal processes knowledge or climate projections are changed. Therefore, the implementation pathway will evolve overtime.

The Options have been selected based on information gathered through all the previous CHRMAP project stages. Although the Multi-Criteria Analysis and Cost Benefit Analysis have been key gateway decision points for selecting many Options. The preparation of the MCA and CBA required interpretation and approximations, particularly regarding the criteria and cost quantifications, and have limitations. Also, the proposed Options have been developed only at a conceptual level to draw comparisons between several Options.

The CHRMAP proposed Options should be the subject of further investigations, surveys, policy review, impact investigations (environmental, visual and social), development approval and authorities endorsement, local stakeholder and community engagement, preliminary design, detailed design, costing and any other applicable preparation work required prior to be implemented. The Options should be optimised and modified following such additional investigations.

An example of this could be changes to Management Unit boundaries, to optimise Option effectiveness and to reduce costs. It may also be practical to develop a staged implementation approach to some of these management actions to test their effectiveness and to refine design of subsequent stages (e.g., staged installation of beach groynes). Some interim management Options may also be progressed, such as the development of emergency evacuation procedures and systems, until inundation protection measures can be fully implemented.

8.4.2 Further Investigations

Information gaps identified in the CHRMAP should be gathered early. Some of these gaps can be closed by the collection of data, as discussed further in Section 8.5. Other information gaps can be closed during the preliminary and/or detailed design phase when specific or detailed analysis of available data, information, modelling, and projections are carried out. The "governance/support" role currently undertaken by the PNP should continue with funding support for coordination of coastal management, planning, engineering and research in the study area.

A number of the recommended investigations may already exist in LGA technical or planning documents. The CHRMAP recommended investigations have been scoped specifically to meet coastal hazard planning elements introduced in the State Coastal Planning Policy 2.6.

The following investigations are recommended:

11. Prepare an Asset Management Plan, which identifies existing infrastructure and recreational facilities in the coastal erosion and inundation hazard zone and provides direction to:
    a. Progressively relocate non-critical assets (PMR2) away from the coastal hazard zone once they reach the end of asset life or replace assets with suitably durable and/or sacrificial infrastructure. This may include vulnerable recreational car parks; recreational amenities such as public ablutions; barbeque/picnic/shade areas; playground and other recreational equipment; and access structures such as ramps, stairs and paths and fences, etc.
    b. Plan for the relocation of critical service infrastructure outside of the coastal hazard zone once they reach the end of asset life, or at a minimum, modify the service infrastructure asset so that it does not run parallel to the coastline where possible and can be progressively removed when exposed to intolerable risk levels. This may include public safety infrastructure.
12. Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat. Seek legal advice regarding the basis of agreements with landholders and whether opt-ins can be time constrained.

13. Sand source feasibility study – Several MU's have recommended Options which require sand nourishment, both for erosion management (such as beach groynes including sand nourishment) and inundation management (such as raising beach levels to improve coastal drainage). The availability of suitable sand for beach nourishment works is unfortunately not well understood in the study area. It is recommended that a sand source feasibility is undertaken for the PNP to determine the capacity and cost of local sand supplies. This study should consider both land-based and marine sand sources as well as evaluate potential environmental impacts and approvals required. Cost estimates in this CHRMAP have assumed that a reliable source of sand in reasonable proximity to the study area may be available. If this assumption is incorrect, costs may increase and affect the CHRMAP recommendations. The City's MU's would benefit from detailed consideration of sand available via Southern Ports maintenance dredging works.
14. Rock source feasibility study – Similar to the above but for armour rock suitable for building coastal management structures. Several MU's have recommended Options requiring armour rock which needs to be fit for purpose. An analysis of the availability of such rock suitable for marine works, with suitable density, quarry yields, close location and tolerable costs should be undertaken. Potential environmental impacts should be considered in the rock source feasibility study, as well as any approvals required. Cost estimates in this CHRMAP have assumed that a reliable source of rock can be found in the study area. If this assumption is incorrect, costs may increase and affect the CHRMAP recommendations.
15. Emergency evacuation planning – A review of emergency evacuation plans in the study area should be undertaken to assess if the evacuation plans are suitable for managing the projected coastal hazards. Existing documents may need to be updated or revised as required. Plans should detail emergency response to coastal erosion and flooding impacts, as well as storm damage causing infrastructure to collapse into the public foreshore or coastal environment. Evacuation planning for inundation should clearly identify appropriate evacuation routes, assess their suitability, and plan for upgrades required to meet future LGA developments. Scenario planning could also be undertaken to test the plans.
16. Foreshore Management Plans (FMPs) - Updated foreshore management plans for the study areas may increase the protective capacity of the natural dune system. Foreshore management plans should address:
    a. The requirements of SPP2.6 and its supporting documentation
    b. The findings of this CHRMAP
    c. Potential environmental issues such as biodiversity and environmental impacts, and detail a weed management strategy for the coastline
    d. Incorporate findings of Asset Management Plans as appropriate
    e. Include recommendations for closing excess beach access points, ensuring appropriately fenced and signed paths, signage for dune repair and clear signage for 4-wheel drive access and permissibility
    f. Develop an education strategy for coastal and environmental management. The strategy should work to inform the community about the CHRMAP and FMP and their findings and use suitable engagement methods such as infographics, FAQ's. The education strategy should also include appropriate on-ground signage and information for beach access, camping and 4-wheel driving, where applicable.
    g. Monitor impacts of 4WD vehicles (where applicable) and general beach access on nesting habitats and migratory bird species in dune areas
    h. Determine the need for a bush fire management plan for the dune and coastal areas
17. Coastal Hazard Mapping Study – the study partners should consider an advocacy program with the support of organisations such as the Western Australian Local Government Association (WALGA) and Local Government Planners Association (LGPA) to achieve a state-wide coastal mapping database similar

to the Fire and Emergency Services (FESA) mapping of bushfire prone areas recognised as a result of applying *State Planning Policy 3.7: Planning in Bushfire Prone Areas*. Such mapping could become a vital knowledge-building tool for communities across the state coming to terms with increasing coastal hazards. NB: it is recognised that only areas where a CHRMAP has been completed and endorsed could be mapped accurately, however, other identified coastal hazard hotspots could be included in this mapping with future studies determining the extent of the coastal hazard risk area. This undertaking would complement the local-scale education strategies.

8.5 Monitoring

8.5.1 Recommended Coastal Monitoring Activities

The monitoring activities described below are designed to identify the impacts of the recommended Options and to record the evolution of the coastal trigger points. Indicative costs for budgeting purposes are provided.

Should any Option be modified, or other coastal projects be undertaken (such as maritime, or recreation/tourism projects) where coastal hazard risk management is not the primary focus, they should be subject to the same CHRMAP principles and require their own monitoring program appropriate to their location, size and objectives. The following coastal monitoring activities are recommended:

1. Routine beach and dune surveys, in the form of beach profiles, , every 400m along the coast.
    a. MU5 and MU6 should aim to have annual beach profiles at the end of winter while MU4 and MU7 could be undertaken every second year. More frequent profiles (every six months following summer and winter seasons) could be undertaken for areas of concern following collection and review of initial dataset.
    b. Beach profiles may be spaced more closely where Options include trigger points monitoring and/or to support specific project requirements.
    c. The beach survey may also be continuous along the coast using LiDAR or other appropriate techniques with a view to capture more accurately coastal processes, while allowing the compilation of beach profile data.
    d. At the minimum, beach profiles should be carried out following winter every three years for MU5 and MU6 and every five years for MU4 and MU7.
    e. Additionally, surveys can be undertaken immediately following severe storms producing significant beach erosion. These are useful for recording historical events, confirming the presence of bedrock, and calibrating models.
    f. Beach profile datasets should include the location of the Horizontal Shoreline Datum (HSD). The beach profiles must extend from the edge of the coastal cadastral boundary down to the Lowest Astronomical Tide (LAT). The survey datasets should be centralised into a database, which includes previous historical beach profiles and quality control information such as survey date, datum, survey mark, beach material encountered (rock vs sand) and method used.
2. Corresponding monitoring photos should be taken at the same time as beach surveys – particularly for inundation events as it is often impractical to organise detailed survey at short notice.
3. Regular monitoring of the coastal management structures (Protection Structure Audit – NR2) – e.g., seawalls, groynes, breakwaters and storm surge barrier. These should be undertaken with consistent methodology to allow comparison between inspections. These can be commenced immediately, and the initial assessment would identify an appropriate review schedule for each structure, or if there is an issue with an asset. Such assessment would occur yearly to blend into the existing LGA asset management reporting systems.

4. Geotechnical investigations are proposed to determine the presence of bedrock below the beach. When bedrock is located relatively near the surface, it can provide some natural protection to erosion and reduce the scope of works. However, in low-lying areas, the presence of bedrock may not significantly mitigate the coastal hazards. Such investigation may be carried out by ground penetration radar, test pits or survey observations following beach erosion events. The priority for this investigation is MU5 and then the secondary priority is MU6.

8.5.2 Trigger Points

The CHRMAP considers four types of physical trigger points, as follows:

- **Proximity trigger**: Where the most landward part of the Horizontal Shoreline Datum (HSD) is within the Storm Erosion Allowance of the most seaward point of a public asset of interest or private property lot boundary. Due to the high value of the foreshore reserve, the foreshore reserve may be considered to be "the most seaward point". If individual assets have a specific distance-based trigger relating to the HSD then the beach and dune survey activities described above should be used to collect topographic data that can be used to map the updated HSD position.
- **Access trigger**: Where a public road is considered no longer available or able to provide legal access to the property
- **Utilities trigger**: When water, sewage, communications or electricity to the lot is no longer available as they have been removed/decommissioned by the relevant authority due to coastal hazards.
- **Damage trigger**: Any property within the hazard zone and within a dedicated Special Control Area, that is damaged by a coastal hazard from an extreme weather event shall require LGA approval before being repaired. The review process should involve re-fit of minor or moderately damaged assets to accommodate coastal hazards in the future; or removal and redevelopment outside the hazard zone for damaged assets.

This list follows a sequential / prioritisation order. That is, a "proximity trigger" is recommended over a "damage trigger".

8.5.3 CHRMAP Review

The CHRMAP should be updated at least every 10 years to maintain its currency and ensure it remains a "living document". Also, the CHRMAP should be revisited when the triggers are reached to update the coastal hazard assessment.

There are several pitfalls to relying on triggers alone for coastal management. As described in Section 8.5.2, physical triggers provide limited flexibility, rely on monitoring, and assume that conflicting interests have been resolved. In addition, it is essential to recognise that environmental and societal considerations significantly affect the implementation of management actions. These external triggers would include:

- Environmental Triggers, such as:
  - Substantial storm events generating severe coastal hazards approaching or exceeding the CHRMAP projections
  - Environmental Impacts
- Societal Triggers, such as:
  - Change to governance, planning and/or laws, such as a significant change to State land-use planning or a major change in a Local Planning Scheme within the Greater Bunbury Region Scheme
  - New information becomes available that substantially affects the summary of local community values
  - Major societal events such as macro-economic context, public protests, etc.

Such unplanned external triggers will be determinant in actioning and timing some of the Options recommended in the CHRMAP. An earlier review of the CHRMAP may be considered when such an external trigger occurs. Therefore, it is essential to support coastal zone managers to be opportunistic and reactive to such external triggers rather than be only mandated to follow the CHRMAP actions.

To prepare a coherent CHRMAP update it may be necessary to update the Hazard modelling / assessment to include:

- Recent monitoring data
- Planning changes and changes to the CHRMAP success criteria and stakeholder feedback
- Updates in climate change science, specifically local sea level rise projections
- Updated coastal engineering science and methodologies

8.6 Medium and Long-term Implementation

Medium (15 – 30 years) and long-term (30 – 100 years) implementation provides a strategic consideration of how the PNP and its member organisations will adapt to long-term climate change impacts. Therefore, medium- and long-term implementation are not described in detail in the CHRMAP. Longer-term responses include:

- Actioning the revised planning instruments
- Managing coastal retreat
- Exhausting the SPP2.6 hierarchy of actions, high value assets may be protected where sustainable impacts and funding are identified/prioritised
- Providing temporary/interim hazard protection may also become more costly and a change in adaptation pathway could be required. For example, as sea level rise progresses, it is likely that Options using sand or rock resources to protect assets near the coast may become unsustainable.

The two primary coastal management actions mitigating erosion hazards are:

- Planned / Managed retreat (PMR4 – Voluntary Acquisition): Use the planning instruments and long-term plan to systematically move assets with low adaptive capacity out of the hazard zone
- Protect (PR2 - Groynes): Undertake the construction of groynes with beach renourishment as necessary to prevent erosion of natural and built assets

The three coastal management actions mitigating inundation hazards are:

- Planned / Managed retreat (PMR4 – Voluntary Acquisition): Use the planning instruments and long-term plan to systematically move assets with low adaptive capacity out of the hazard zone
- Accommodate (AC1 - Design Assets to Withstand Impacts): limit damage from inundation events through finished floor level requirements
- Protect (PR6 - Levee PR6): Undertake works as necessary to prevent or limit inundation of assets exposed along the coast

8.7 Recommendations

The following recommendations are based on currently available information. Recommendations that are included in this document are made based on the assumptions provided throughout this document, recognising the gaps in information that still need to be resolved, and a multi-criteria analysis based on technical, economic, social and environmental criteria.

Future investigations are required to confirm they are suitable, including further consultation with stakeholders and the community. The next step, following finalisation of this CHRMAP, is to develop a program of investigative works over the short to medium term, to help inform the timing and scope of future investigations. Subsequently a likely outcome is that a combination of options may be the preferred approach in some locations. The recommendations are based on the analysis presented in this report. Additional considerations may be incorporated into future analyses.

All recommendations still need further research. The CHRMAP provides the basis for which for the City may access grant funding to undertake this work; after which, recommendations may be updated, improved, or confirmed. This process requires ongoing engagement with affected communities.

Short, medium- and long-term recommendations are summarised in Table 8-3 to Table 8-7 below. In addition, long-term adaptation strategies/pathways have been recommended for erosion and inundation that will allow for the continuous function of local communities whilst accommodating the increasing burden of coastal hazards. The long-term strategy informs future planning instruments, supports monitoring, recommends planning reviews and underpins collaboration between coastal land managers, stakeholders and the community.

Table 8-3 MU4 Bunbury South Recommendations

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
INVESTIGATION 1 Sand Source Feasibility Study	▪ Determine the capacity and cost of local sand supplies, including both land-based and marine sources ▪ Likely require repetition over Medium-term ▪ Focus for this MU is appropriate sand for ad hoc sand nourishment	▪ LGA ▪ Can seek support from neighbouring LGA's, PNP, and state departments	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	
INVESTIGATION 2 Update Foreshore Management Plans (FMPs)	▪ Prepare an updated Foreshore Management Plan ▪ An updated FMP could help increase the protective capacity of the natural dune system. Updates should address the requirements of SPP2.6 and incorporate the findings of this CHRMAP	▪ LGA	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants		x	x	x	x
INVESTIGATION 3 Audit of assets within 2035 erosion hazard zone	▪ Audit of assets within 2035 erosion hazard zone and identification of assets where damage would be unacceptable to determine between PMR1 and PMR2 ▪ Investigation to determine acceptable foreshore amenity facilities within hazard zone	▪ LGA	▪ Completed CHRMAP	▪ Included under component items below	▪ Operational ▪ Grants	x	x	x		
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	▪ Item cost for investigations and management plans	▪ LGA	▪ Completed CHRMAP	▪ $150,000	▪ Operational	x	x			
Monitoring (NR1)	▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ Routine beach profiles every two years in Spring	▪ LGA ▪ Can seek support and assistance from DoT	▪ Completed CHRMAP ▪ Severe storm event(s)	▪ $5,000 ▪ (Plus 10% annual maintenance of $5,000)	▪ Operational ▪ Grants	x	x	x		
Notification on title (NR3)	▪ Item cost for investigations and implementation plans	▪ LGA ▪ Can seek support and assistance from DPLH, WALGA	▪ Completed CHRMAP	▪ $50,000 ▪ (Plus 1% annual maintenance of $500)	▪ Operational ▪ Grants		x	x		
Prevention of further development / prohibit expansion of existing use rights (PMR3)	▪ Item cost for investigations and management plans ▪ Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat. Seek legal advice regarding the basis of agreements with landholders and whether opt-ins can be time constrained	▪ LGA	▪ Completed CHRMAP	▪ $50,000 ▪ (Plus 1% annual maintenance of $500)	▪ Operational ▪ Grants		x	x		

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Demolition / removal / relocation of asset from inside hazard area (PMR2)	▪ Preparation of Asset Management Plan ▪ To 2035 for public-built assets ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ Removal / Relocation of assets as required	▪ LGA	▪ Audit of assets within 2035 erosion hazard zone and identification of assets where damage would be unacceptable	▪ $129,000 ▪ (Plus 1% annual maintenance of $1,290)	▪ Operational ▪ Grants	x	x	x		
Recommended Short-Term Option to address Erosion is Planned / managed Retreat combining Leaving Assets Unprotected (PMR1); Removal of Assets from Inside Hazard Area (PMR2), and Prevention of Further Development (PMR3)	▪ Implementation of recommendation actions (PMR1-PMR3), following investigation.	▪ LGA	▪ Completed CHRMAP	▪ Included under component items below	▪ Operational ▪ Grants	x	x	x		
Leaving assets unprotected (PMR1)	▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve	▪ LGA	▪ Storm damage	▪ $59,000 ▪ (Plus 3% annual maintenance of $1,770)	▪ Operational	x	x	x		
Recommended Medium and Long-term pathway to address Erosion is Planned / managed Retreat combining Leaving Assets Unprotected (PMR1); Removal of Assets from Inside Hazard Area (PMR2), and Prevention of Further Development (PMR3)	▪ Implement when triggers are met ▪ See explanation in Land Use Planning Section of this report	▪ LGA	▪ HSD within 11m of low-value public assets, equivalent of approximately half of storm erosion allowance for this MU (21m)	▪ Included under component items	▪ Operational ▪ Grants				x	x

Table 8-4 MU5 Bunbury Recommendations

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
INVESTIGATION 1 Detailed investigations to confirm assumptions used in the CHRMAP	▪ Determine program of investigative works ▪ Undertake detailed investigations to confirm assumptions used in the CHRMAP; and determine if rock groynes are most appropriate option	▪ LGA	▪ Completed CHRMAP	▪ $200,000	▪ Operational	x	x			
INVESTIGATION 2 Sand Source Feasibility Study	▪ Determine the capacity and cost of local sand supplies, including both land-based and marine sources ▪ Likely require repetition over Medium-term ▪ Focus for this MU is bulk sand nourishment for ocean coast, but should also consider the need for appropriate fill to raise height of land in the inundation hazard zone	▪ LGA ▪ Can seek support from neighbouring LGA's, PNP, Southern Ports and state departments	▪ Completed CHRMAP	▪ $60,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	
INVESTIGATION 3 Rock Source Feasibility Study	▪ Analyse the availability of rock in terms of density, quarry yields, location and costs ▪ Likely require repetition over Medium-term ▪ Focus for this MU is armour and core rock of all sizes	▪ LGA ▪ Can seek support from neighbouring LGA's, PNP, Southern Ports and state departments	▪ Completed CHRMAP	▪ $60,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	
INVESTIGATION 4 Update Foreshore Management Plans (FMPs)	▪ Prepare an updated Foreshore Management Plan ▪ An updated FMP could help increase the protective capacity of the natural dune system. Updates should address the requirements of SPP2.6 and incorporate the findings of this CHRMAP	▪ LGA	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants		x	x	x	x
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	▪ Item cost for investigations and management plans	▪ LGA	▪ Completed CHRMAP	▪ $150,000	▪ Operational	x	x			
Monitoring (NR1)	▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ Routine beach profiles every year in Spring	▪ LGA ▪ Can seek support and assistance from DoT	▪ Completed CHRMAP ▪ Severe storm event(s)	▪ $10,000 ▪ (Plus 10% annual maintenance of $1,000)	▪ Operational ▪ Grants	x	x	x		
Notification on title (NR3)	▪ Item cost for investigations and implementation plans	▪ LGA ▪ Can seek support and assistance from DPLH, WALGA	▪ Completed CHRMAP	▪ $250,000 ▪ (Plus 1% annual maintenance of $2,500)	▪ Operational ▪ Grants		x	x		
Protection Structure Audit (NR2)	▪ Item cost to inspect asset condition, influence on sediment transport and inundation and remaining design life on all coastal management structures ▪ Includes ocean coast seawalls Outer Harbour breakwater and spur groynes, Casuarina Harbour breakwaters and causeway, Koombana Bay groynes and Dolphin Discovery Centre buried seawall	▪ LGA ▪ DoT ▪ Koombana Sailing Club ▪ Southern Ports, Bunbury	▪ Completed CHRMAP	▪ $75,000 ▪ (Plus 2% annual maintenance of $1,500)	▪ Operational ▪ Grants		x	x		

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Emergency evacuation plans (NR4)	▪ Item cost for investigations and evacuation plans	▪ LGA	▪ Completed CHRMAP	▪ $250,000 ▪ (Plus 1% annual maintenance of $2,500)	▪ Operational ▪ Grants	x	x			
Demolition / removal / relocation of asset from inside hazard area (PMR2)	▪ Preparation of Asset Management Plan ▪ To 2035 for public-built assets ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ Removal / Relocation of assets as required	▪ LGA	▪ Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable	▪ $4,506,000 ▪ (Plus 1% annual maintenance of $45,060)	▪ Operational ▪ Grants	x	x	x		
Prevention of further development / prohibit expansion of existing use rights (PMR3)	▪ Item cost for investigations and management plans ▪ Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat. Seek legal advice regarding the basis of agreements with landholders and whether opt-ins can be time constrained	▪ LGA	▪ Completed CHRMAP	▪ $100,000 ▪ (Plus 1% annual maintenance of $1,000)	▪ Operational ▪ Grants		x	x		
Design assets to withstand impacts (AC1)	▪ Item cost for investigations and management plans – primarily any case-by-case work needed for public assets	▪ LGA	▪ Completed CHRMAP	▪ $500,000 ▪ (Plus 1% annual maintenance of $5,000)	▪ Operational ▪ Grants	x	x			
Recommended Short-Term Option to address Erosion is to investigate and prepare for Protection with Groynes (PR2)	▪ CHRMAP analysis has found that the Protection Pathway is appropriate for this MU with provision of a sandy beach Currently the option assumes the following: ▪ 15 rock groynes 100m long, 400m apart (13 on ocean coast and 2 in Koombana Bay) ▪ Present day Implementation ▪ Interim management may use Beach Renourishment as temporary protection while implementation of primary option is organised	▪ LGA	▪ Completed CHRMAP ▪ Completed detailed investigations ▪ Monitoring ▪ Confirmation of design, costs and funding ▪ Construction likely to be staged	▪ $83.5M at NPV 4% for a 100-year timeframe ▪ Detailed design and costings estimated at $250,000 ▪ BDA analysis estimates a fair and reasonable breakdown of % costs to different benefiting parties is: ▪ Private Landholders at ~3% ▪ City at ~64% ▪ WA State Government at ~34%	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays	x	x	x		
Recommended Short-Term Option to address Inundation is to replace storm surge barrier (PR6)	▪ Replacement of storm surge barrier at the Leschenault Inlet ▪ 2035 Implementation	▪ State Government with DoT likely to be the lead agency with support by LGA	▪ Completed CHRMAP ▪ Monitoring ▪ Confirmation of design, costs and funding ▪ Confirmation of SLR in accordance with projections to 2035	▪ $17.9M at NPV 4% ▪ Detailed design and costings estimated at $250,000	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays		x	x	x	

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Leaving assets unprotected (PMR1)	▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve	▪ LGA	▪ Storm damage ▪ Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable	▪ $2,011,000 ▪ (Plus 3% annual maintenance of $60,330)	▪ Operational	x	x	x		
Recommended Medium and Long-term pathway to address Erosion is Protection with Groynes (PR2)	▪ Monitoring will determine need for additional stages of groynes (or alternative protection method) in future and the eventual need for major refurbishment or replacement of the structures and associated beach renourishment	▪ LGA	▪ Monitoring ▪ Updated CHRMAP	▪ Annual maintenance estimate of approximately $1.0M	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays				x	x
Recommended Medium and Long-term pathway to address Inundation is to replace storm surge barrier (PR6)	▪ Monitoring and maintenance of infrastructure and design and performance reviews in accordance with new information and CHRMAP updates. ▪ Secondary components may include the need for additional levees and drainage improvements as sea level rise progresses	▪ LGA	▪ Monitoring ▪ Updated CHRMAP	▪ Annual maintenance estimate of approximately $0.25M	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays				x	x

Table 8-5 MU6 Bunbury Port Recommendations

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
INVESTIGATION 1 Detailed investigations to confirm assumptions used in the CHRMAP	▪ Determine program of investigative works ▪ Undertake detailed investigations to confirm assumptions used in the CHRMAP; and determine if rock groynes are most appropriate option	▪ LGA	▪ Completed CHRMAP	▪ $200,000	▪ Operational	x	x			
INVESTIGATION 2 Sand Source Feasibility Study	▪ Determine the capacity and cost of local sand supplies, including both land-based and marine sources ▪ Likely require repetition over Medium-term ▪ Focus for this MU is sand nourishment for Southern Ports ocean and estuary frontage, but should also consider the need for appropriate fill to raise height of land in inundation hazard zone	▪ Southern Ports, Bunbury ▪ Can seek support from neighbouring LGA's, PNP, Southern Ports and state departments	▪ Completed CHRMAP	▪ $40,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	
INVESTIGATION 3 Rock Source Feasibility Study	▪ Analyse the availability of rock in terms of density, quarry yields, location and costs ▪ Likely require repetition over Medium-term ▪ Focus for this MU is armour and core rock of all sizes	▪ LGA ▪ Can seek support from neighbouring LGA's, PNP, and state departments	▪ Completed CHRMAP	▪ $40,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	
INVESTIGATION 4 Update Foreshore Management Plans (FMPs)	▪ Prepare an updated Foreshore Management Plan ▪ An updated FMP could help increase the protective capacity of the natural dune system. Updates should address the requirements of SPP2.6 and incorporate the findings of this CHRMAP ▪ For this MU controlled by Southern Ports Bunbury it is envisaged the work may incorporate appropriate clauses into operational and strategic planning and lease conditions as well as a joint approach with neighbouring LGA's.	▪ Southern Ports, Bunbury ▪ LGA	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants		x	x	x	x
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	▪ Item cost for investigations and management plans	▪ LGA ▪ Southern Ports, Bunbury	▪ Completed CHRMAP	▪ $50,000	▪ Operational	x	x			
Monitoring (NR1)	▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ Routine beach profiles every year in Spring	▪ Southern Ports, Bunbury ▪ Can seek support and assistance from LGA, DoT	▪ Completed CHRMAP ▪ Severe storm event(s)	▪ $5,000 ▪ (Plus 10% annual maintenance of $5,000)	▪ Operational ▪ Grants	x	x	x		

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Notification on title (NR3)	▪ Item cost for investigations and implementation plans ▪ For this MU controlled by Southern Ports, Bunbury it is envisaged the work may incorporate appropriate clauses into operational and strategic planning and lease conditions.	▪ Southern Ports, Bunbury ▪ Can seek support and assistance from LGA, DPLH, WALGA	▪ Completed CHRMAP	▪ $50,000 ▪ (Plus 1% annual maintenance of $500)	▪ Operational ▪ Grants		x	x		
Protection Structure Audit (NR2)	▪ Item cost to inspect coastal asset condition, influence on sediment transport and inundation and remaining design life on all coastal management structures ▪ Includes Port seawall and Port Breakwaters for Inner Harbour	▪ Southern Ports, Bunbury	▪ Completed CHRMAP	▪ $50,000 ▪ (Plus 2% annual maintenance of $1,500)	▪ Operational ▪ Grants		x	x		
Emergency evacuation plans (NR4)	▪ Item cost for investigations and evacuation plans	▪ Southern Ports, Bunbury	▪ Completed CHRMAP	▪ $100,000 ▪ (Plus 1% annual maintenance of $1,000)	▪ Operational ▪ Grants	x	x			
Demolition / removal / relocation of asset from inside hazard area (PMR2)	▪ Preparation of Asset Management Plan ▪ To 2035 for public-built assets ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ Removal / Relocation of assets as required	▪ Southern Ports, Bunbury	▪ Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable	▪ $791,000 ▪ (Plus 1% annual maintenance of $7,910)	▪ Operational ▪ Grants	x	x	x		
Prevention of further development / prohibit expansion of existing use rights (PMR3)	▪ Item cost for investigations and management plans ▪ Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat. Seek legal advice regarding the basis of agreements with landholders and whether opt-ins can be time constrained ▪ For this MU controlled by Southern Ports, Bunbury it is envisaged the work may incorporate appropriate clauses into operational and strategic planning and lease conditions.	▪ Southern Ports, Bunbury	▪ Completed CHRMAP	▪ $30,000 ▪ (Plus 1% annual maintenance of $3,00)	▪ Operational ▪ Grants		x	x		
Design assets to withstand impacts (AC1)	▪ Item cost for investigations and management plans – primarily any case-by-case work needed for public assets	▪ Southern Ports, Bunbury	▪ Completed CHRMAP	▪ $100,000 ▪ (Plus 1% annual maintenance of $1,000)	▪ Operational ▪ Grants	x	x			
Recommended Short-Term Option to address Erosion is to investigate and prepare for Protection with Groynes (PR2)	▪ CHRMAP analysis has found that the Protection Pathway is appropriate for this MU with provision of a sandy beach Currently the option assumes the following: ▪ 5 rock groynes 75m long, 300m apart along ocean coast ▪ 800m revetment seawall along estuary coast ▪ 2035 Implementation	▪ Southern Ports, Bunbury ▪ LGA	▪ Completed CHRMAP ▪ Completed detailed investigations ▪ Monitoring ▪ Confirmation of design, costs and funding ▪ Construction likely to be staged	▪ $8.8M at NPV 4% for a 100-year timeframe ▪ Detailed design and costings estimated at $200,000	▪ Operational ▪ Grants	x	x	x		

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Recommended Short-Term Option to address Inundation is a Levee (PR6)	▪ Assumes 700m levee to cover ocean frontage (400m east of port and 300m on west) ▪ Assumes present day implementation ▪ Does not address inundation risk from estuary frontage. Further investigation is required as the broader PR6 Option comprising a new storm surge barrier at The Cut did not perform better than the base case for any discount rate	▪ Southern Ports, Bunbury	▪ Completed CHRMAP ▪ Monitoring ▪ Confirmation of design, costs and funding ▪ Confirmation of SLR in accordance with projections to 2035	▪ $1.2M at NPV 4% ▪ Detailed design and costings estimated at $150,000 ▪ Further Investigation of Options for inundation that come from estuary frontage - $150,000	▪ Operational ▪ Grants	x	x	x		
Leaving assets unprotected (PMR1)	▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve	▪ Southern Ports, Bunbury	▪ Storm damage ▪ Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable	▪ $360,000 ▪ (Plus 3% annual maintenance of $10,800)	▪ Operational	x	x	x		
Recommended Medium and Long-term pathway to address Erosion is Protection with Groynes (PR2)	▪ Monitoring will determine the need for additional stages of groynes (or alternative protection method) in future and the eventual need for major refurbishment or replacement of the structures and associated beach renourishment	▪ Southern Ports, Bunbury ▪ LGA	▪ Monitoring ▪ Updated CHRMAP	▪ Annual maintenance estimate of approximately $0.2M	▪ Operational ▪ Grants				x	x
Recommended Medium and Long-term pathway to address Inundation is a Levee (PR6)	▪ Monitoring and maintenance of infrastructure and design and performance reviews in accordance with new information and CHRMAP updates. ▪ Secondary components may include the need for additional levees and drainage improvements as sea level rise progresses	▪ Southern Ports, Bunbury ▪ LGA	▪ Monitoring ▪ Updated CHRMAP	▪ Annual maintenance estimate of approximately $20,000	▪ Operational ▪ Grants				x	x

Table 8-6 MU7 The Cut Recommendations

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
INVESTIGATION 1 Detailed investigations to confirm assumptions used in the CHRMAP	▪ Determine program of investigative works ▪ Undertake detailed investigations to confirm assumptions used in the CHRMAP; and determine if rock groynes are most appropriate option	LGA	▪ Completed CHRMAP	▪ $200,000	▪ Operational	x	x			
INVESTIGATION 2 Sand Source Feasibility Study	▪ Determine the capacity and cost of local sand supplies, including both land-based and marine sources ▪ Likely require repetition over Medium-term ▪ Focus for this MU is sand nourishment for ocean and estuary frontage, but should also consider the need for appropriate fill to raise height of land in the inundation hazard zone	To be confirmed between: ▪ LGA's ▪ DoT ▪ DBCA ▪ Southern Ports, Bunbury	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	
INVESTIGATION 3 Rock Source Feasibility Study	▪ Analyse the availability of rock in terms of density, quarry yields, location and costs ▪ Likely require repetition over Medium-term ▪ Focus for this MU is armour and core rock of all sizes	To be confirmed between: ▪ LGA's ▪ DoT ▪ DBCA ▪ Southern Ports, Bunbury	▪ Completed CHRMAP	▪ $60,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	
INVESTIGATION 4 Update Foreshore Management Plans (FMPs)	▪ Prepare an updated Foreshore Management Plan ▪ An updated FMP could help increase the protective capacity of the natural dune system. Updates should address the requirements of SPP2.6 and incorporate the findings of this CHRMAP ▪ For this MU a joint approach with Southern Ports Bunbury is recommended.	▪ LGA ▪ Southern Ports, Bunbury	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants		x	x	x	x
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	▪ Item cost for investigations and management plans	▪ LGA	▪ Completed CHRMAP	▪ $50,000	▪ Operational	x	x			
Monitoring (NR1)	▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ Routine beach profiles every two years in Spring	▪ LGA ▪ Can seek support and assistance from Southern Ports, Bunbury and DoT	▪ Completed CHRMAP ▪ Severe storm event(s)	▪ $5,000 ▪ (Plus 10% annual maintenance of $5,000)	▪ Operational ▪ Grants	x	x	x		
Notification on title (NR3)	▪ Item cost for investigations and implementation plans	▪ LGA ▪ Can seek support and assistance from DPLH, WALGA	▪ Completed CHRMAP	▪ $50,000 ▪ (Plus 1% annual maintenance of $500)	▪ Operational ▪ Grants		x	x		

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Protection Structure Audit (NR2)	▪ Item cost to inspect condition, influence on sediment transport and inundation and remaining design life on all coastal management structures ▪ Includes structures at The Cut	To be confirmed between: ▪ LGA's ▪ DoT ▪ DBCA ▪ Southern Ports, Bunbury	▪ Completed CHRMAP	▪ $50,000 ▪ (Plus 2% annual maintenance of $1,500)	▪ Operational ▪ Grants		x	x		
Demolition / removal / relocation of asset from inside hazard area (PMR2)	▪ Preparation of Asset Management Plan ▪ To 2035 for public-built assets ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ Removal / Relocation of assets as required	▪ LGA	▪ Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable	▪ $194,000 ▪ (Plus 1% annual maintenance of $1,940)	▪ Operational ▪ Grants	x	x	x		
Design assets to withstand impacts (AC1)	▪ Item cost for investigations and management plans – primarily any case-by-case work needed for public assets	▪ LGA	▪ Completed CHRMAP	▪ $50,000 ▪ (Plus 1% annual maintenance of $5,00)	▪ Operational ▪ Grants ▪ Levies	x	x	x		
Recommended Short-Term Option to address Erosion is to investigate and prepare for Protection with Groynes (PR2)	▪ CHRMAP analysis has found that the Protection Pathway is appropriate for this MU with provision of a sandy beach Currently the option assumes the following: ▪ 2 rock groynes, 75m long on ocean-side beach, ▪ 320m revetment seawall along estuary coast ▪ 2050 Implementation ▪ Only monitoring and confirmation of concept design required in short-term	▪ LGA	▪ Completed CHRMAP ▪ Completed detailed investigations ▪ Monitoring ▪ Confirmation of design, costs and funding ▪ Construction likely to be staged	▪ $2.0M at NPV 4% for a 100-year timeframe ▪ Detailed design and costings estimated at $200,000	▪ Operational ▪ Grants ▪ Levies	x	x	x		
Recommended Short-Term Option to address Inundation is Design assets to withstand impacts (AC1)	▪ See AC1	▪ See AC1	▪ See AC1	▪ See AC1	▪ Operational ▪ Grants ▪ Levies	x	x	x		
Leaving assets unprotected (PMR1)	▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve	▪ LGA	▪ Storm damage ▪ Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable	▪ $88,000 ▪ (Plus 3% annual maintenance of $2,640)	▪ Operational	x	x	x		
Recommended Medium and Long-term pathway to address Erosion is Protection with Groynes (PR2)	▪ Monitoring will determine need for additional stages of groynes (or alternative protection method) in future and the eventual need for major refurbishment or replacement of the structures and associated beach renourishment	▪ LGA	▪ Monitoring ▪ Updated CHRMAP	▪ Annual maintenance estimate of approximately $90,000	▪ Operational ▪ Grants ▪ Levies				x	x
Recommended Medium and Long-term pathway to address Inundation is Design assets to withstand impacts (AC1)	▪ Monitoring ▪ Secondary components may include the need for additional levees and drainage improvements as sea level rise progresses	▪ LGA	▪ Monitoring ▪ Updated CHRMAP	▪ Included as part of Monitoring (NR1)	▪ Operational ▪ Grants ▪ Levies				x	x

Table 8-7 MU8 Bunbury East Recommendations

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
INVESTIGATION 1 Detailed investigations to confirm assumptions used in the CHRMAP	▪ Determine program of investigative works ▪ Undertake detailed investigations to confirm assumptions used in the CHRMAP; and determine if rock groynes are most appropriate option	▪ LGA	▪ Completed CHRMAP	▪ $200,000	▪ Operational	x	x			
INVESTIGATION 2 Sand Source Feasibility Study	▪ Determine the capacity and cost of local sand supplies, including both land-based and marine sources ▪ Likely require repetition over Medium-term ▪ Focus for this MU is sand nourishment for estuary coast, but should also consider the need for appropriate fill to raise height of land in the inundation hazard zone	▪ LGA ▪ Can seek support from neighbouring LGA's, PNP, Southern Ports and state departments	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	
INVESTIGATION 3 Rock Source Feasibility Study	▪ Analyse the availability of rock in terms of density, quarry yields, location and costs ▪ Likely require repetition over Medium-term ▪ Focus for this MU is small to medium armour rock	▪ LGA ▪ Can seek support from neighbouring LGA's, PNP, Southern Ports and state departments	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	
INVESTIGATION 4 Update Foreshore Management Plans (FMPs)	▪ Prepare an updated Foreshore Management Plan ▪ An updated FMP could help increase the protective capacity of the natural dune system. Updates should address the requirements of SPP2.6 and incorporate the findings of this CHRMAP	▪ LGA	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants		x	x	x	x
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	▪ Item cost for investigations and management plans	▪ LGA	▪ Completed CHRMAP	▪ $100,000	▪ Operational	x	x			
Monitoring (NR1)	▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ Routine 6-monthly beach profiles following the summer and winter periods. Minimum every two years in Spring	▪ LGA ▪ Can seek support and assistance from DoT	▪ Completed CHRMAP ▪ Severe storm event(s)	▪ $10,000 ▪ (Plus 10% annual maintenance of $1,000)	▪ Operational ▪ Grants	x	x	x		
Notification on title (NR3)	▪ Item cost for investigations and implementation plans	▪ LGA ▪ Can seek support and assistance from DPLH, WALGA	▪ Completed CHRMAP	▪ $250,000 ▪ (Plus 1% annual maintenance of $2,500)	▪ Operational ▪ Grants		x	x		
Protection Structure Audit (NR2)	▪ Item cost to inspect condition, influence on sediment transport and inundation and remaining design life on all coastal management structures ▪ Includes walls along Collie R.	▪ LGA	▪ Completed CHRMAP	▪ $50,000 ▪ (Plus 2% annual maintenance of $1,000)	▪ Operational ▪ Grants		x	x		
Emergency evacuation plans (NR4)	▪ Item cost for investigations and evacuation plans	▪ LGA	▪ Completed CHRMAP	▪ $250,000 ▪ (Plus 1% annual maintenance of $2,500)	▪ Operational ▪ Grants	x	x			

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Demolition / removal / relocation of asset from inside hazard area (PMR2)	▪ Preparation of Asset Management Plan ▪ To 2035 for public-built assets ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ Removal / Relocation of assets as required	▪ LGA	▪ Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable	▪ $244,000 ▪ (Plus 1% annual maintenance of $2,440)	▪ Operational ▪ Grants	x	x	x		
Prevention of further development / prohibit expansion of existing use rights (PMR3)	▪ Item cost for investigations and management plans ▪ Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat. Seek legal advice regarding the basis of agreements with landholders and whether opt-ins can be time constrained	▪ LGA	▪ Completed CHRMAP	▪ $100,000 ▪ (Plus 1% annual maintenance of $1,000)	▪ Operational ▪ Grants		x	x		
Design assets to withstand impacts (AC1)	▪ Item cost for investigations and management plans – primarily any case-by-case work needed for public assets	▪ LGA	▪ Completed CHRMAP	▪ $500,000 ▪ (Plus 1% annual maintenance of $5,000)	▪ Operational ▪ Grants	x	x			
Recommended Short-Term Option to address Erosion is to investigate and prepare for Protection with Groynes (PR2)	▪ CHRMAP analysis has found that the Protection Pathway is appropriate for this MU with provision of a sandy beach Currently the option assumes the following: ▪ 8 rock groynes, 30m long, 100m apart to cover estuary coast from Venezia Blvd north ▪ Assumes 6 groynes to cover section of river foreshore ▪ 2035 Implementation	▪ LGA	▪ Completed CHRMAP ▪ Completed detailed investigations ▪ Monitoring ▪ Confirmation of design, costs and funding ▪ Construction likely to be staged	▪ $2.0M at NPV 4% for a 100-year timeframe ▪ Detailed design and costings estimated at $250,000	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays	x	x	x		
Recommended Short-Term Option to address Inundation requires further investigation	▪ Further investigation is required as the broader PR6 Option comprising a new storm surge barrier at The Cut did not perform better than the base case for any discount rate. A feasibility analysis is recommended to assess its effectiveness with consideration of freshwater flooding events and further civil and maritime design considerations as to what scale of facility would be required.	▪ Jointly between State Government and LGA's	▪ Completed CHRMAP ▪ Monitoring ▪ Investigation of Options, design, costs and funding ▪ Confirmation of SLR in accordance with projections to 2035	▪ Further feasibility investigations estimated at $200,000	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays	x	x	x		
Leaving assets unprotected (PMR1)	▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve	▪ LGA	▪ Storm damage ▪ Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable	▪ $111,000 ▪ (Plus 3% annual maintenance of $3,330)	▪ Operational	x	x	x		
Recommended Medium and Long-term pathway to address Erosion is Protection with Groynes (PR2)	▪ Monitoring will determine need for additional stages of groynes in future and the eventual need for major refurbishment or replacement of the structures and associated beach renourishment	▪ LGA	▪ Monitoring ▪ Updated CHRMAP	▪ Annual maintenance estimate of approximately $50,000	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays				x	x

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Recommended Medium and Long-term pathway to address inundation requires further investigation	▪ Further investigation is required as the broader PR6 Option comprising a new storm surge barrier at The Cut did not perform better than the base case for any discount rate. A feasibility analysis is recommended to assess its effectiveness with consideration of freshwater flooding events and further civil and maritime design considerations as to what scale of facility would be required.	▪ Jointly between State Government and LGA's	▪ Monitoring ▪ Updated CHRMAP	▪ To be determined following further investigations	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays				x	x

9 PUBLIC REVIEW AND COMMENT PERIOD

A draft version of this document was released for public review and comment for 12 weeks, up to the 16th of June 2023. Five comments were related to this document out of 58 public responses received. A summary of the written submissions received and associated responses are included as Appendix H, with contact details removed. Various edits have been made in this this document's Final version in response to the submissions received.

Several respondents were concerned that the recommendations were large scale and long term and would begin to be implemented quickly after the finalisation of this project. The CHRMAP is a strategic planning document that considers long timeframes. While the CHRMAP provides a rationale for coastal hazard management, a substantial amount of preparatory work, detailed in the CHRMAP recommendations, is required before "on-the-ground implementation" can proceed. The CHRMAP is a strategic planning document that considers long timeframes. The next phase of research and studies would consider priority items in more detail, including:

- Community and stakeholder engagement
- Data collection and analysis
- Preliminary and detailed design investigations
- Environmental investigations to mitigate potential impacts
- Economic and budgeting analysis to determine accurate costs, once detailed designs are available

The City held a public information drop-in session at the Bunbury Surf Life Saving Club during the review period, attended by City staff, Councillors, and more than 30 community members.

Concerns specific to the City, particularly at the Bunbury Back Beach area, were raised at the information session and in written submissions, primarily related to concern about the recommended use of groynes as the main protection option and the need for further detailed investigations. Other methods to implement protection, such as sand nourishment and different hard structures were proposed, which will continue to be considered as more detailed investigations, per the CHRMAP, provide greater levels of certainty.

The CHRMAP recommends protection for Bunbury Back Beach and Koombana Bay going forward. Groynes have been identified as the most cost-effective option to implement this pathway based on available information. High-level concept design work has been undertaken to allow budget estimates. Further consideration of the local coastal processes, design and costs is required before these recommendations can be progressed to seek funding, environmental impact assessment and approvals / endorsement. Composite protection options may be effective for Bunbury Back Beach, including sections of sand nourishment in combination with seawalls and offshore breakwaters instead of groynes. Further localised engagement is recommended through this process, including with the Bunbury Surf Life Saving Club. Surf Life Saving Clubs are recognised as a unique development requiring strategic planning within SPP2.6. Local monitoring of coastal processes, as recommended, combined with targeted engagement for this section of coast will allow for more detailed consideration of options.

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APPENDIX A
ESTABLISH THE CONTEXT CHAPTER REPORT

WATER TECHNOLOGY
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APPENDIX B
COASTAL HAZARD ASSESSMENT CHAPTER REPORT

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APPENDIX C
COASTAL ASSETS AND COMMUNITY VALUES CHAPTER REPORT

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RISK EVALUATION AND TREATMENT CHAPTER REPORT

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RISK TREATMENT – BENEFIT DISTRIBUTION ANALYSIS CHAPTER REPORT

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APPENDIX G
IMPLEMENTATION CHAPTER REPORT

APPENDIX H
PUBLIC REVIEW COMMENTS FOR THE CITY OF BUNBURY

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Capel to Leschenault CHRMAP

Chapter Report: Establish the Context

Peron Naturaliste Partnership

26 July 2021

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

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Project Details

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26 July 2021

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Dear Joanne

Chapter Report: Establish the Context

We are pleased to present the Capel to Leschenault Coastal Hazard Risk Management and Adaptation Plan Chapter Report: Establish the Context. If you have any queries, please do not hesitate to contact me on (08) 6555 0105.

Yours sincerely

Joanna Garcia-Webb
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WATER TECHNOLOGY PTY LTD

EXECUTIVE SUMMARY

It is internationally recognised that the mean sea level has been rising globally since the nineteenth century and is predicted to rise at an increasing rate in the future (IPCC 2014). Rising sea levels and intensifying storm activity will increase the risk of coastal inundation (temporary coastal flooding), storm erosion and long-term shoreline recession. State governments across Australia have introduced obligations that require local governments to consider and plan for these hazards. In Western Australia (WA), the governing policy is the Western Australian Planning Commission's State Planning Policy No. 2.6: State Coastal Planning Policy (WAPC, 2013, herein referred to as "SPP2.6"). SPP2.6 recommends management authorities develop a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for land use or development that is vulnerable to coastal hazards. Specific guidelines have been developed to assist in this process (WAPC, 2019).

One of the key objectives of SPP2.6 is to establish coastal foreshore reserves which include allowances for the protection, conservation and enhancement of coastal values across the state. Risk assessment processes are then utilised to identify risks that are intolerable to the community, and other stakeholders such as local governments, indigenous and cultural interests, and private enterprise. Adaptation measures are then developed according to the preferential adaptation hierarchy outlined in SPP2.6.

The Peron Naturaliste Partnership (PNP) comprises membership of nine local government authorities. The PNP's Coastal Adaptation Pathways Project identified the coastal areas of Capel, Leschenault and Greater Bunbury as being particularly exposed to coastal hazards and climate change, which triggered the need for this CHRMAP. The aim of the present study is therefore to investigate and plan for coastal hazards which are likely to affect these regions from Capel to Leschenault.

This CHRMAP project is expected to increase knowledge and understanding of coastal hazard risks and identify risk management and adaptation measures for implementation. The outcomes will be used to inform local government policies, strategies and plans, including (but not limited to); planning strategies, community strategic plans, drainage strategies, asset management plans, emergency management plans, and foreshore management plans. The project will adhere to the WAPC (2019) guidelines with scope and deliverables to be consistent with the objectives identified by these guidelines and SPP2.6. The project will identify the strategic direction for coastal adaptation scenarios from the present to 2120 (100-year management time frame) and detail an implementation plan describing risk management measures to be undertaken to achieve preferred risk treatments. Overall, this CHRMAP will develop a flexible adaptation pathway for the region and serve as a key reference for management, planning and policy making for the short-term (0-15 years), medium-term (15-30 years), and long-term (100 years).

This report outlines the key management and adaptation issues that need to be considered in the CHRMAP. It is the "Establish the Context" component of the CHRMAP process, as described in Figure **1**-**2** and replicated below. The Stakeholder and Community Engagement Plan has been prepared separately. A summary of these is included within this report. We note the coastal assets and community values will be identified during Stage C, which will define the success criteria.

Project Inception Meeting
- Finalise project scope, methods, deliverables, timing, data gap actions and identify key stakeholders

Stakeholder and Community Engagement Plan
- Definition of plan objectives and timelines
- Obtain inputs from key stakeholders
- Identify requirements of internal engagement and requirement of information such as existing controls, values and success criteria

Establish Context: Delineation of study area management units, desktop review of coastal hazards for gap analysis & study approach

The study area covers four Local Government Areas (LGAs) namely Shire of Harvey, City of Bunbury, Shire of Dardanup, and Shire of Capel (see Figure 1-1). Land use and management of the region involves multiple government authorities in addition to the LGAs, such as the PNP, Southern Port Authority (SPA), Department of Biodiversity, Conservation and Attractions (DBCA), Department of Water Environment and Regulation (DWER), Department of Planning Lands and Heritage (DPLH) and Department of Transport (DoT). Each of these play a management role over different sections of the shoreline. Jurisdictions are described in Section 4.

The study area contains a large array of planning documentation. As presented in Section 5 and Appendix A, most of these documents make mention of coastal hazards, or values which will provide input into the CHRMAP process. With the exception of the Shire of Harvey however, none of the existing documents contain planning instruments that can be used to adapt to coastal hazards. This CHRMAP will consider what planning controls may be appropriate as adaptation measures within each management unit. We will also consider what existing actions and controls are appropriate to maintain. Based on a review of the existing planning controls, the statutory planning mechanisms that may be available to address coastal hazards within the study area are summarised in Table 5-1.

Existing physical controls are presented in Section 6.

The management units for the CHRMAP are presented in Figure 7-1.

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1 INTRODUCTION

It is internationally recognised that the mean sea level has been rising globally since the nineteenth century and is predicted to rise at an increasing rate in the future (IPCC 2014). Rising sea levels and intensifying storm activity will increase the risk of coastal inundation (temporary coastal flooding), storm erosion and long-term shoreline recession. State governments across Australia have introduced obligations that require local governments to consider and plan for these hazards. In Western Australia (WA), the governing policy is the Western Australian Planning Commission's State Planning Policy No. 2.6: State Coastal Planning Policy (WAPC, 2013, herein referred to as "SPP2.6"). SPP2.6 recommends management authorities develop a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for land use or development that is vulnerable to coastal hazards. Specific guidelines have been developed to assist in this process (WAPC, 2019).

One of the key objectives of SPP2.6 is to establish coastal foreshore reserves which include allowances for the protection, conservation and enhancement of coastal values across the state. Risk assessment processes are then utilised to identify risks that are intolerable to the community, and other stakeholders such as local governments, indigenous and cultural interests, and private enterprise. Adaptation measures are then developed according to the preferential adaptation hierarchy outlined in SPP2.6.

The Peron Naturaliste Partnership (PNP) comprises membership of nine local government authorities. The PNP's Coastal Adaptation Pathways Project identified the coastal areas of Capel, Leschenault and Greater Bunbury as being particularly exposed to coastal hazards and climate change, which triggered the need for this CHRMAP. The aim of the present study is therefore to investigate and plan for coastal hazards which are likely to affect these regions from Capel to Leschenault – refer Figure 1-1 for locality and study area extent.

This CHRMAP project is expected to increase knowledge and understanding of coastal hazard risks and identify risk management and adaptation measures for implementation. The outcomes will be used to inform local government policies, strategies and plans, including (but not limited to); planning strategies, community strategic plans, drainage strategies, asset management plans, emergency management plans, and foreshore management plans. The project will adhere to the WAPC (2019) guidelines with scope and deliverables to be consistent with the objectives identified by these guidelines and SPP2.6. The project will identify the strategic direction for coastal adaptation scenarios from the present to 2120 (100-year management time frame) and detail an implementation plan describing risk management measures to be undertaken to achieve preferred risk treatments. Overall, this CHRMAP will develop a flexible adaptation pathway for the region and serve as a key reference for management, planning and policy making for the short-term (0-15 years), medium-term (15-30 years), and long-term (100 years).

This report presents the Establish the Context Chapter Report, which outlines the key management and adaptation issues that need to be considered in the CHRMAP. The flow chart displayed in Figure **1**-**2** indicates where this component sits with reference to the greater study; the 'Establishing the Context' phase is the top bubble shaded in red. We note the coastal assets and community values will be identified during Stage C, which will define the success criteria.

Delivery of this project will occur over 9 stages (as summarised in Figure **1**-**2**), each of which represents a key hold point. The staged approached is developed according to the PNP's scope and is in line with CHRMAP Guidelines (WAPC, 2019).

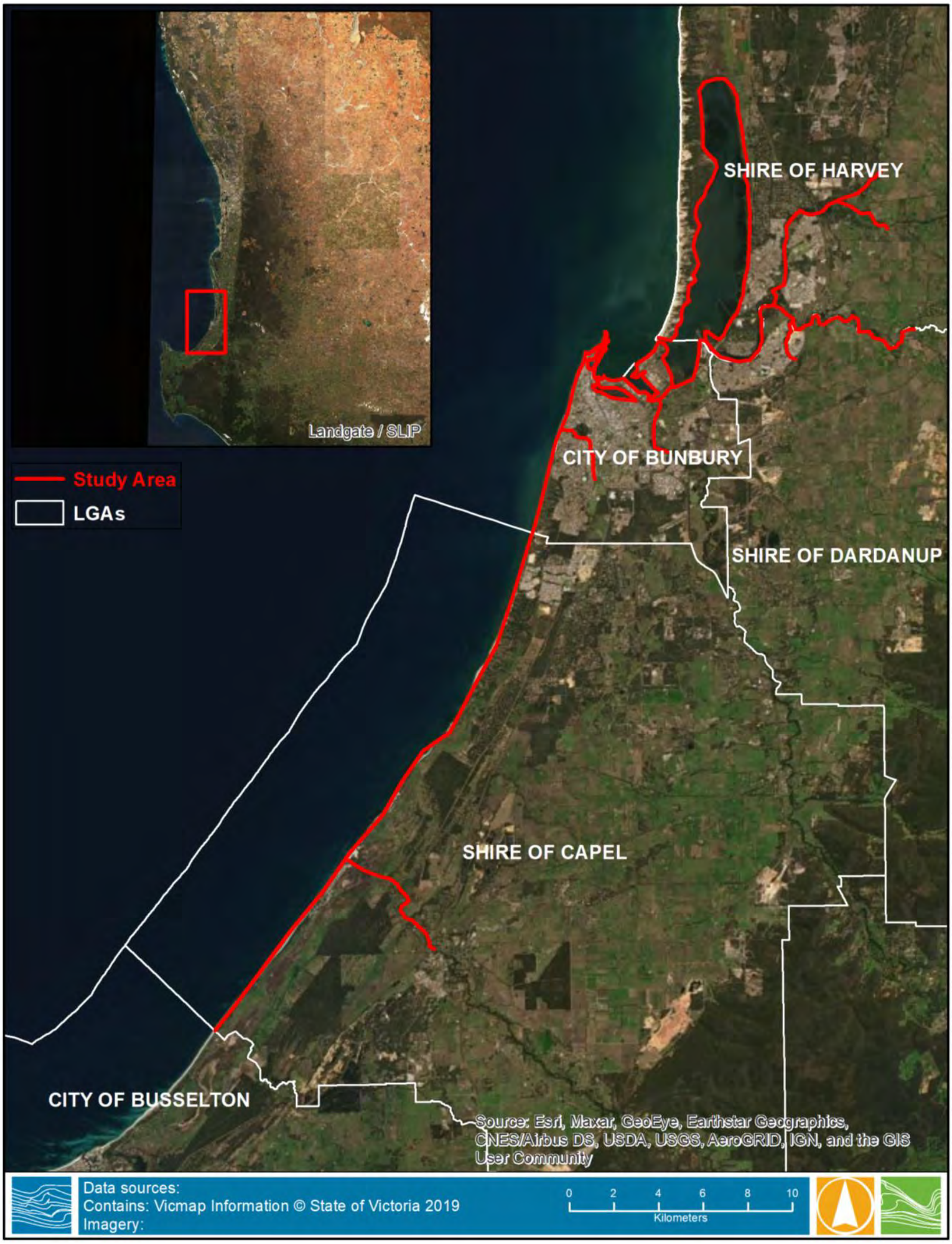

Figure 1-1 Project Area

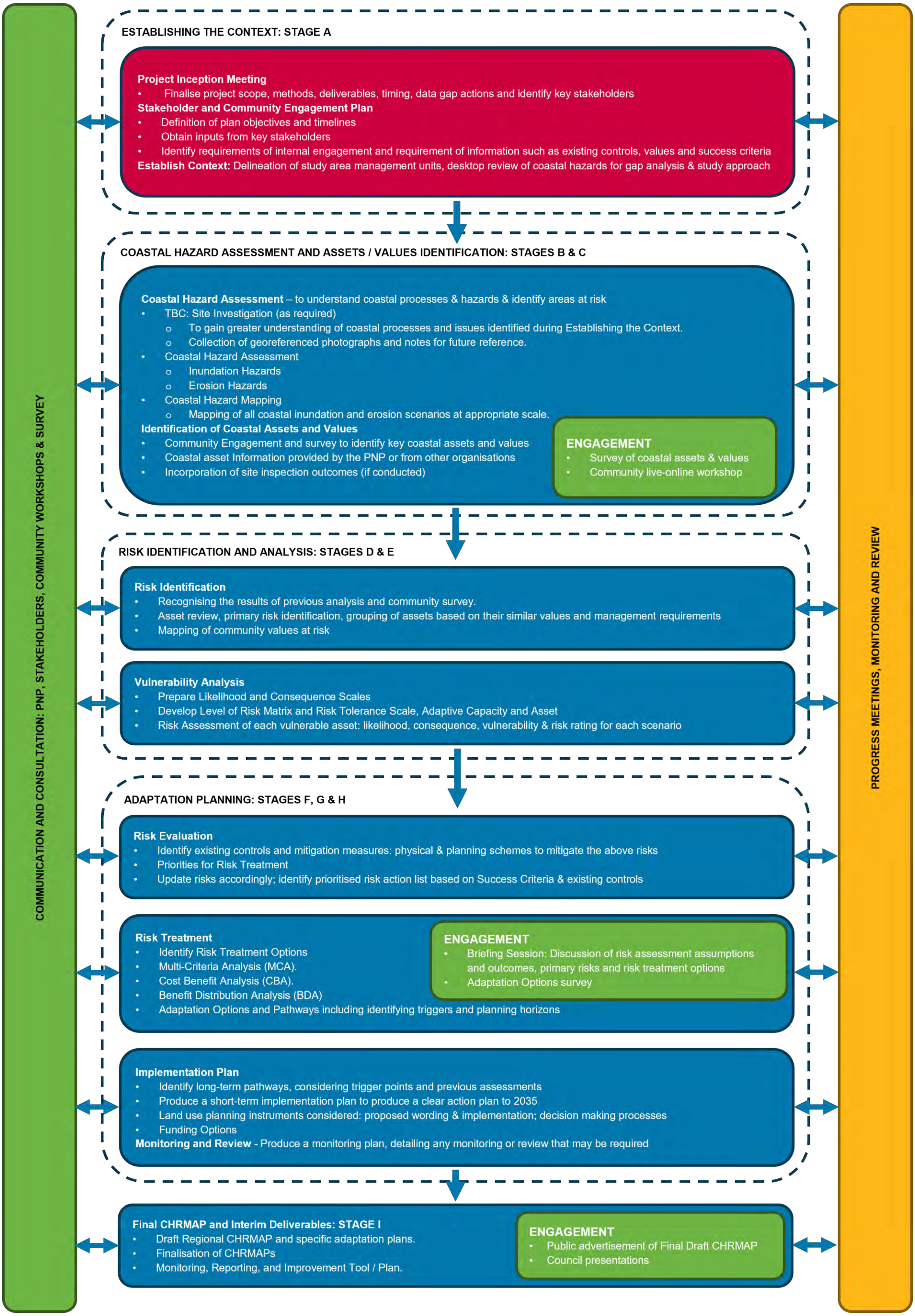

Figure 1-2 CHRMAP methodology flow chart (adapted from WAPC, 2019)

2 CHRMAP PURPOSE & OBJECTIVES

As discussed in Section 1, the CHRMAP process is a requirement of SPP2.6 (WAPC, 2013). A project Steering Group has been established to oversee preparation and completion of the CHRMAP, including review of project deliverables. The Steering Group plays an advisory role in the project and consists of various representatives. The members of project steering group and key stakeholders are summarised in Table 2-1.

Table 2-1 Steering Group members

Organisation	Role of organisation in study area
PNP	Regional facilitator and client project manager.
Shire of Capel	Local coastal land and riverine shoreline manager.
City of Bunbury	Local coastal, riverine shoreline, and estuarine/inlet land manager.
Shire of Harvey	Local coastal, riverine shoreline, and estuarine land manager.
Shire of Dardanup	Local riverine shoreline land manager.
Department of Biodiversity, Conservation & Attractions (DBCA)	Local coastal, riverine shoreline, and estuarine land manager. Data custodian.
Southern Ports, Bunbury	Local coastal land manager; data custodians.
Department of Planning, Lands & Heritage (DPLH)	Technical scoping, advice and review; data custodians, presence required by funding agreement for project
Department of Transport (DoT)	Local coastal land manager; and technical scoping, advice and review; data custodians.
Department of Water & Environmental Regulation (DWER)	Technical scoping, advice and review; data custodians.

2.1 Purpose

The purpose of this project is for the PNP to work with the Steering Group and consultant(s) to develop a CHRMAP. As per Table 2-1, the Steering Group includes the City of Bunbury, the Shires of Capel, Dardanup and Harvey, WA Department of Biodiversity, Conservation and Attractions (DBCA), and the Southern Ports Authority (SPA), with support and technical advice from Department of Water Environment and Regulation (DWER), Department of Planning Lands and Heritage (DPLH), and Department of Transport (DoT).

The purpose of the CHRMAP is to provide strategic guidance for coordinated, integrated, and sustainable decision making for future coastal land use planning, including management of, and adaptation to, coastal hazard risks (coastal erosion and inundation). Management of risks to the study area's land adjacent to the ocean coast, estuaries and rivers is very important for the social, environmental, infrastructure and economic assets and values of the local communities. Although some work on coastal hazards has been undertaken across the study area in the past, a coordinated approach which identifies areas likely to be affected to erosion and/or inundation and requiring management and adaptation to mitigate the risks will provide increased resilience to these communities.

2.2 Objectives

The overall objectives of this CHRMAP are:

- Summarise the existing policies and planning controls, existing physical controls, and jurisdiction boundaries;
- Improve understanding of existing coastal processes, features, and hazards within the study domain;
- Identify coastal assets and values through stakeholder and community engagement;
- Identify coastal hazard risks in terms of both coastal erosion and inundation, as well as potential vulnerability trigger points;
- Improve understanding of asset risk and vulnerability to coastal hazards;
- Determine the consequence, likelihood, and tolerance of assets to the identified risks;
- Identify effective risk management measures through Multicriteria Analysis and Cost Benefit Analysis;
- Identify short, medium, and long-term risk management actions;
- Engage with stakeholders and the community to inform local values, adaptation pathway selection, and the implementation plan.

There are additional specific objectives and outcomes for this CHRMAP, including:

- Delineation of management units through combination of jurisdiction boundaries and physical process boundaries;
- Assessment of inundation and erosion risk along river banks and a tidally influenced estuary and inlet;
- Benefit Distribution Analysis;
- Consideration of the extensive engineering works undertaken inside Koombana Bay, including dredging and disposal, shoreline protection structures, and port infrastructure. Produce a CHRMAP that gives suitable consideration to coastal processes, landform stability, coastal hazards and climate change
- Summarising environmental values, community requirements for foreshore reserves, protection of valued land, and commercial/residential/public assets and providing guidance for the development of statutory planning controls to allow for sustainable provision of these elements.

2.3 Scope

This CHRMAP intends to identify values and assets with intolerable risk levels to the hazards of coastal erosion and inundation within the study area. Risk management measures will be considered to reduce risks to tolerable levels. Tasks to implement the measures will be summarised to provide strategic guidance on medium and longer-term risk management but will provide more focus on short-term (<25years) management measures. The CHRMAP will focus on preserving assets and values which provide public benefit, although private at-risk assets may also be identified.

3 STUDY AREA

The study area covers four Local Government Areas (LGAs) namely Shire of Harvey, City of Bunbury, Shire of Dardanup, and Shire of Capel (see Figure 1-1). Land use and management of the region involves multiple government authorities in addition to the LGAs, such as the PNP, Southern Port Authority (SPA), Department of Biodiversity, Conservation and Attractions (DBCA), Department of Water Environment and Regulation (DWER), Department of Planning Lands and Heritage (DPLH) and Department of Transport (DoT). Each of these play a management role over different sections of the shoreline.

Primary landforms of the region include sandy (e.g., Peppermint Grove Beach) and mixed (e.g., Southern Bunbury) coasts, estuary (e.g., Leschenault estuary) and wetland (e.g., Leschenault Inlet), rivers (e.g., Collie River and Preston River), drains (e.g., Five Mile Brook Diversion Drain), urban areas, and farmlands.

3.1 Shire of Capel

The Shire of Capel (herein referred as SoC) is located between the Bunbury and Busselton LGAs, about 200km south of Perth (refer Figure 3-1). The SoC manages a 29 km long stretch of shoreline between Forrest Beach and Dalyellup, covering approximately 560 km^2 of land. The area was first established as the first Bunbury Road District in 1894. In 1961, it was renamed to Shire of Capel under the Local Government Act 1960. The 2016 census figures indicate the population of the SoC was over 17,000. The SoC has agricultural activities such as beef and dairy farms, light industry commercial, as well as mineral sand mining.

The study area consists of open coast and lowlands potentially impacted by coastal erosion and inundation (Figure 3-1), with particular focus on areas with valued coastal assets (e.g., residential and commercial lands, and recreational parks).

The shoreline within the SoC is partially sheltered from the predominant swell waves generated in the Southern Ocean. Much of the coastline is backed by either soft sediment or vegetated dune system. Significant areas of low-lying land and wetlands are present inland of the dune system.

The Department of Transport (DoT, 2019) recently completed an erosion hotspot assessment for the region, which identified two potential erosion watchlist locations, Peppermint Grove Beach and South Forrest Beach. The SoC does not have a history of reported erosion, likely due to limited existing coastal development and appropriate setbacks to many private assets. No existing coastal protection structures (e.g., groynes, seawalls or revetments) have been identified in this region.

The low-lying land west of Bussell Highway is often connected to the ocean through river openings such as Wonnerup inlet at Forrest Beach and Capel River at Peppermint Grove Beach. Weirs, culverts, and drainage paths have been implemented to mitigate inland flooding and to reduce the impact of surge water from the ocean entering the lowlands behind the dune. Desktop review indicates coastal flooding has been an infrequent hazard. More frequent inundation hazards are often associated with river flood events e.g., the flood at Capel River in August 2013. Nonetheless, inundation risk remains high, particularly under the impact of sea level rise (SLR).

Overall, the coast of the SoC consists of a narrow primary dune system (a few hundred metres) and large areas of lowlands connected to the ocean through various openings.

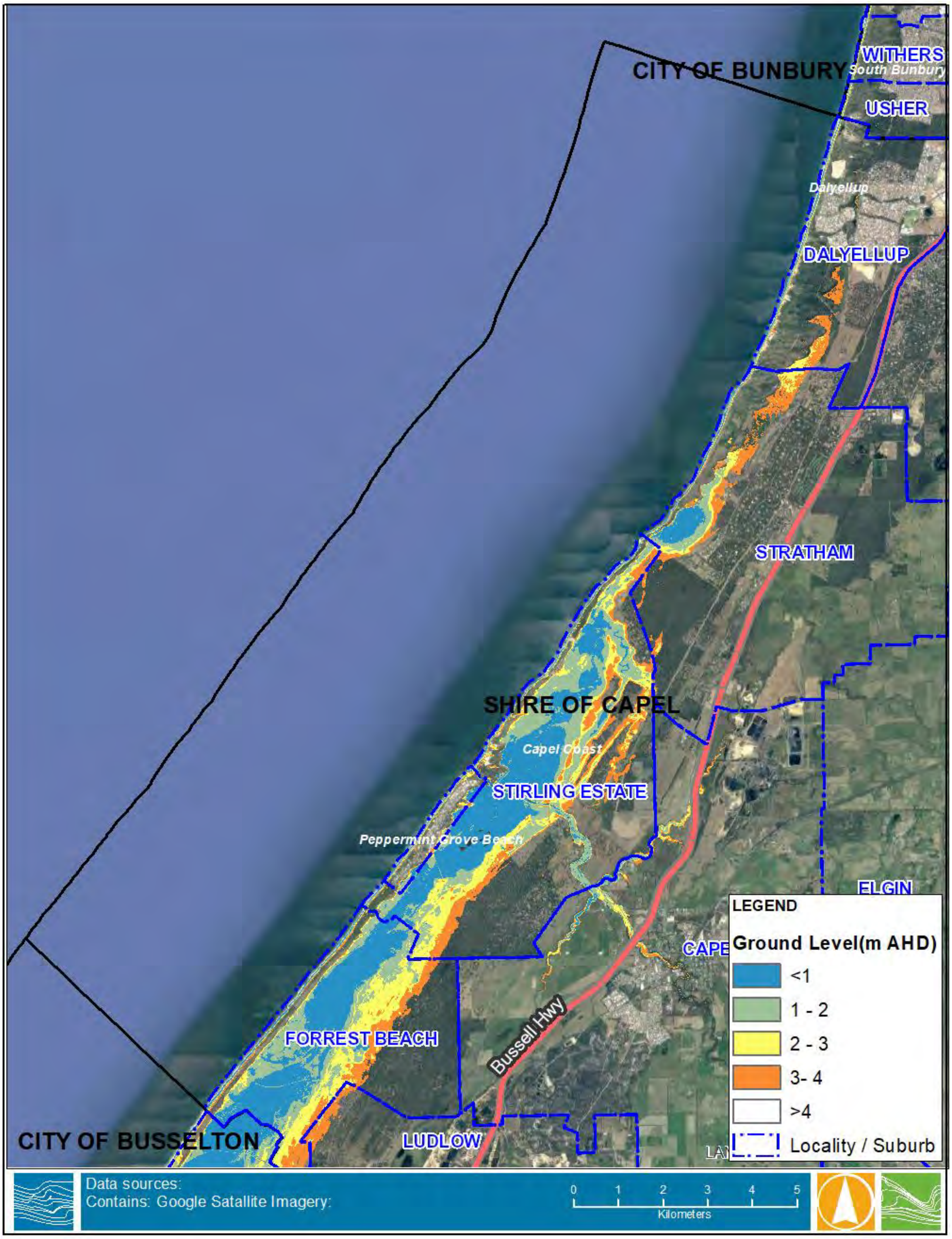

Figure 3-1 Shire of Capel Project Area (Overlayed are Suburbs & Roads and ground levels)

3.2 City of Bunbury

The City of Bunbury (herein referred as CoB) is located approximately 180 km south of Perth covering about 65 km area of coast. The area was first established as Municipality of Bunbury in 1871. In 1961, it became the Town of Bunbury under the Local Government Act 1960 and assumed its current name in Oct 1979. The 2016 census figures indicate the CoB has an established population of almost 32,000.

The study area within CoB LGA comprises of many different sections of coastline with variable shore types and degrees of development (Figure 3-2). Low-lying land is present along Five Mile Brook (e.g., the Big Swamp Wetland), surrounding Leschenault Inlet, and along Preston River. These areas are susceptible to coastal inundation. The CoB is a regional hub and has undertaken numerous developments along its coast. Infrastructure located within Koombana Bay includes shops, restaurants, Koombana Beach foreshore playground, Bunbury Port, Koombana Bay Sailing Club, Casuarina Harbour, Dolphin Discovery Centre, breakwaters, jetties, groynes, seawalls, bridges, roads, the storm surge barrier, as well as foreshore reserves etc. Consideration of the coastal hazards and adaptation constraints of these assets will be crucial for successful risk management and implementation plans.

The current shoreline of Bunbury is a result of combined effects of coastal processes and human intervention. CoB is subject to coastal erosion, despite the numerous physical controls that have been implemented.

- Koombana Beach (one of the erosion hotspots identified by DoT (2019) study) has experienced a westwards littoral drift and progressive erosion on the eastern end. The issue has been studied previously to develop a feasible adaptation option. A seawall structure has been constructed to prevent further erosion.
- A breach of the northern training wall occurred at the Cut channel into Leschenault Estuary (one of the erosion hotspots identified by DoT (2019) study) in 2012 causing erosion of a sand bar along the northern bank. Emergency remedial work (such as minor excavation of the sand bar, landward extension of the northern training wall, tie-in of the extension with existing training wall) was undertaken in 2014, however it was not built to specification due to erosion of the site access point.
- Bunbury Ocean Drive (on the watchlist of coastal erosion by DoT (2019) study). Rock outcrops are present north of Wellington St along Bunbury Ocean Drive and Baudin Terrace. These rocks in general have a low elevation backed by sandy soil. The shoreline further north is protected by the Outer Harbour breakwater and spur groyne.
- Shorelines within Koombana Bay are either modified by engineering controls e.g., breakwaters and seawall, or within the scope of large-scale developments (such as the Port). All beaches in Koombana Bay are heavily modified due to the construction of the Port's inner harbour and river diversion. Sandy beaches are also present inside the bay, e.g., within Casuarina Harbour, Koombana Beach, and near Turkey Point.
- Leschenault Inlet and surroundings have a low-lying nature and are vulnerable to present and future inundation hazards. A tidal gate (Bunbury storm surge barrier) was installed near the entrance to prevent coastal flooding.
- Five Mile Brook is one of the main drainage paths of the CoB. The surrounding areas, including the Big Swamp Reserve, have a low ground elevation. There is a physical control at the outfall location, but it is unclear how it will function during extreme ocean water levels. Water Technology recommend including this site in the (yet to be confirmed) site inspection.
- Flood plain along Preston River. Riverbank protections were built to restrict the spreading of river flood.

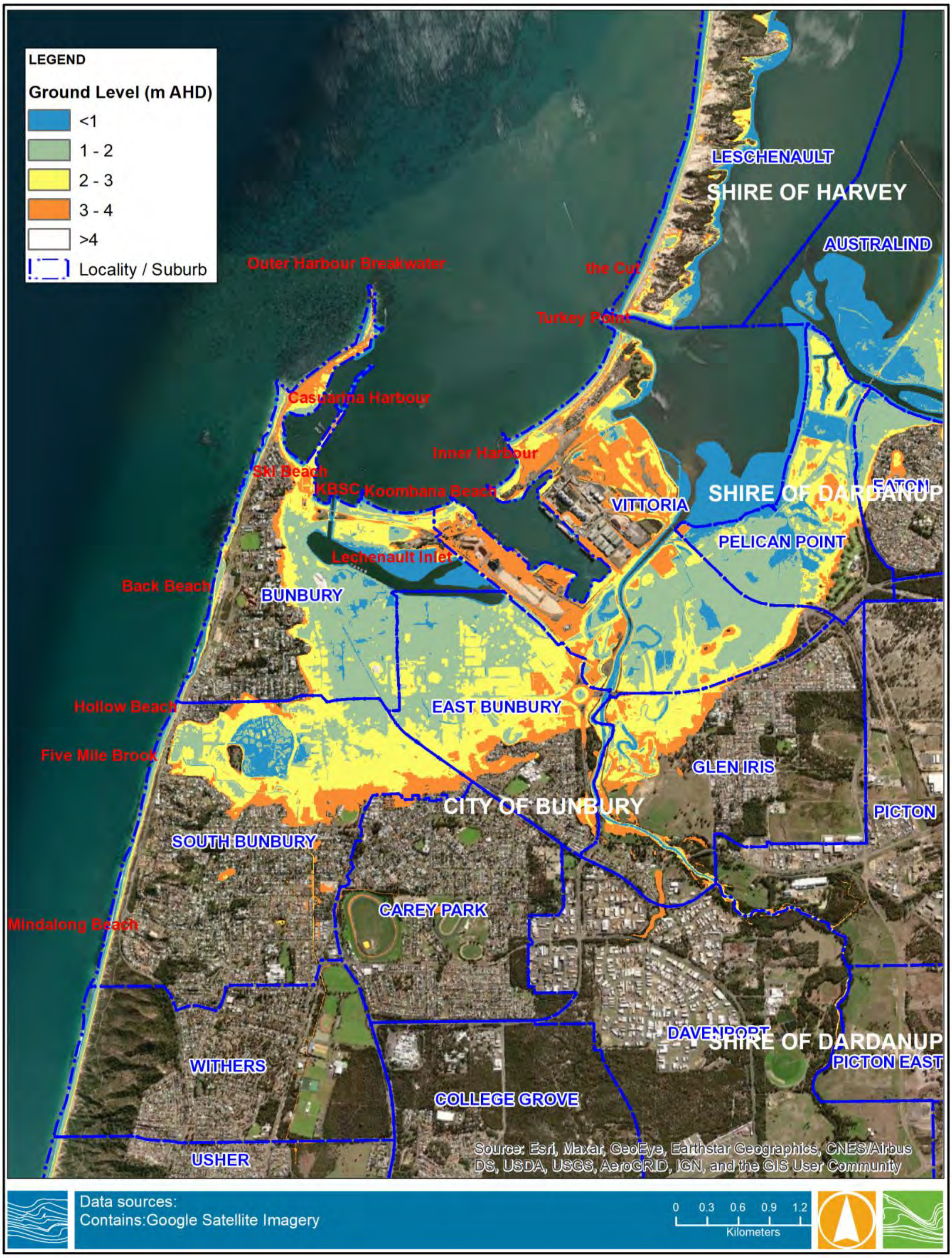

Figure 3-2 Bunbury Project Area (Overlayed are Suburbs & Roads)

3.2.1 Developments in Koombana Bay

Koombana Bay has experienced significant development since the 1900s (see Figure 3-3). The outer harbour breakwater was constructed in the early 1900s which formed the current layout of Koombana Bay. Since then, numerous coastal infrastructure projects have been implemented, including construction of the Inner Harbour and various groynes, breakwaters, and jetties to stabilise the shoreline (e.g., the Plug in 1970s, Inner Harbour in 1970s, the Cut in 1950s-1970s, Northern Breakwater Arm in 1980s). Investment in Bunbury's coastline has increased in recent years, including:

- Planned, yet be implemented, Inner Harbour expansion (see Figure 3-4 for one of the development options) by South Ports Authority (SPA). The expansion of the inner harbour has been in discussion for at least three decades. In 2009, Bunbury Port drafted a structure plan as a policy document to guide the development and decision making of the Inner Harbour. More recently, the Port has considered to redirect the Preston River in order to gain space for this expansion.
- Bunbury waterfront development (Figure 3-5) by the Department of Transport and South West Development Commission. This includes multiple stages:
  - Koombana Foreshore Revitalisation and Dolphin Discovery Centre Redevelopment (completed);
  - Jetty Road Causeway upgrade (completed);
  - Casuarina Drive Redevelopment (underway);
  - Construction of new breakwaters for Casuarina Harbour;
  - Koombana Sailing Club Marina, (planning in progress).

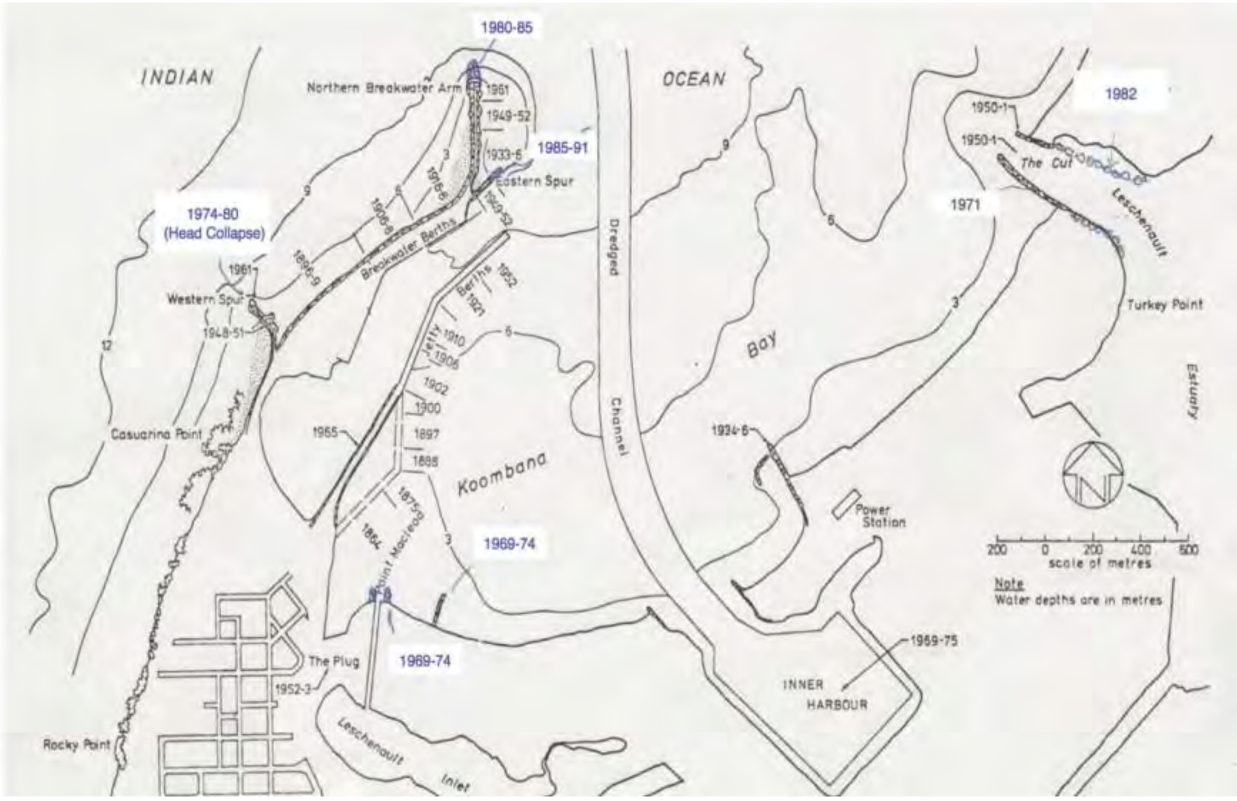

Figure 3-3 Historic Developments in Koombana Bay (until 1990s)

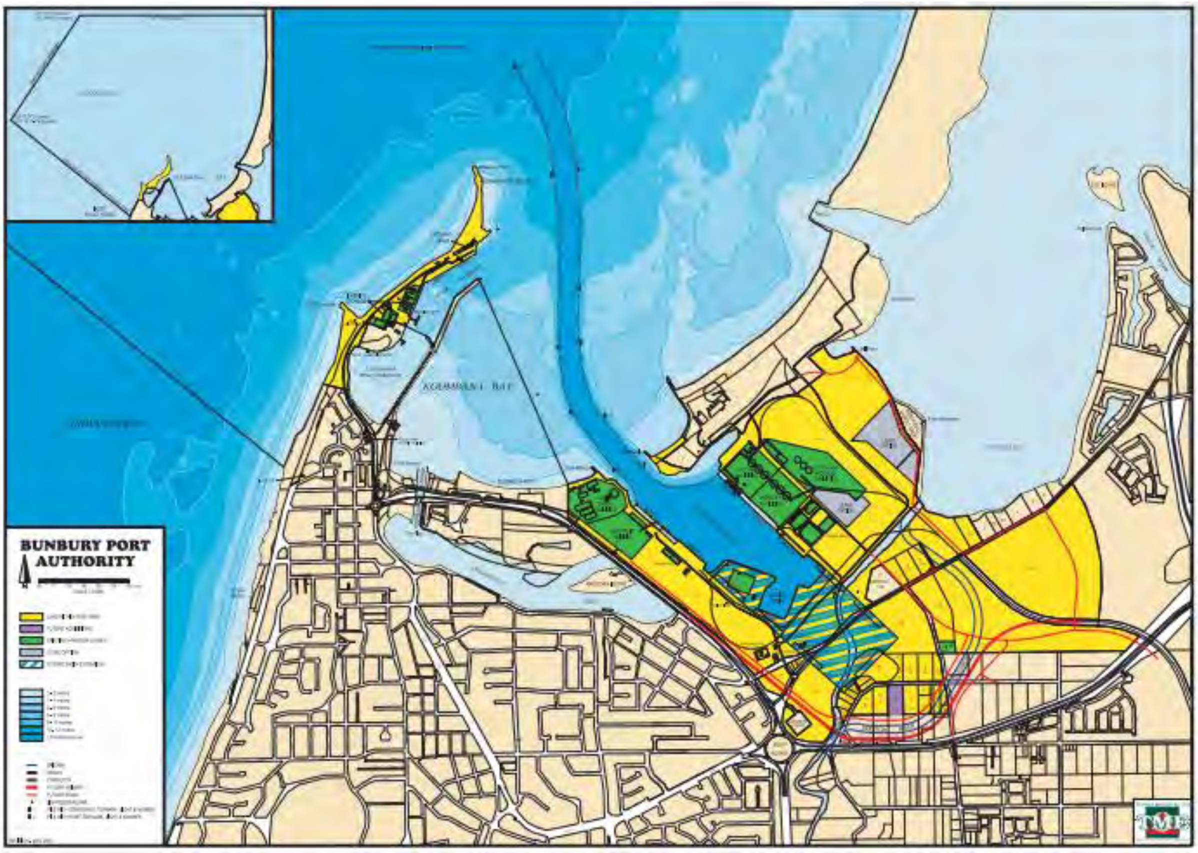

Figure 3-4 Expansion of the Inner Harbour (taken from 2009 Inner Harbour Structure Plan)

Figure 3-5 Bunbury Waterfront transformation - Marina Structures (Taken from RPS 2015)

3.2.2 Developments in Leschenault Inlet

Leschenault Inlet is a remnant of the lower section of the Leschenault Estuary, which was separated from the main water body by the construction of the Inner Harbour in the 1970s. The inlet has an area of approximately 70 hectares and is now one of the most important recreational waterfronts in Bunbury. Since the 1980s, the inlet has undergone significant development including construction of foreshore protection (seawalls), boat ramps, jetties, boat clubs, discovery park, car parks, foreshore reserves, and boardwalks.

In 2013, CoB prepared a Leschenault Inlet Master Plan to guide future development and planning for the area (Figure 3-6). The plan provided an overview of existing planning frameworks and land usage, and prioritised land developments for the future. At present, the inlet comprises a mangrove reserve, and segments of engineered shoreline protecting the foreshore area. The foreshore is backed by paved roads and urban development and has limited setback for shoreline management or additional development beyond its present extent. The Bunbury storm surge barrier is used to limit high ocean water levels impacting the inlet and surrounding lands.

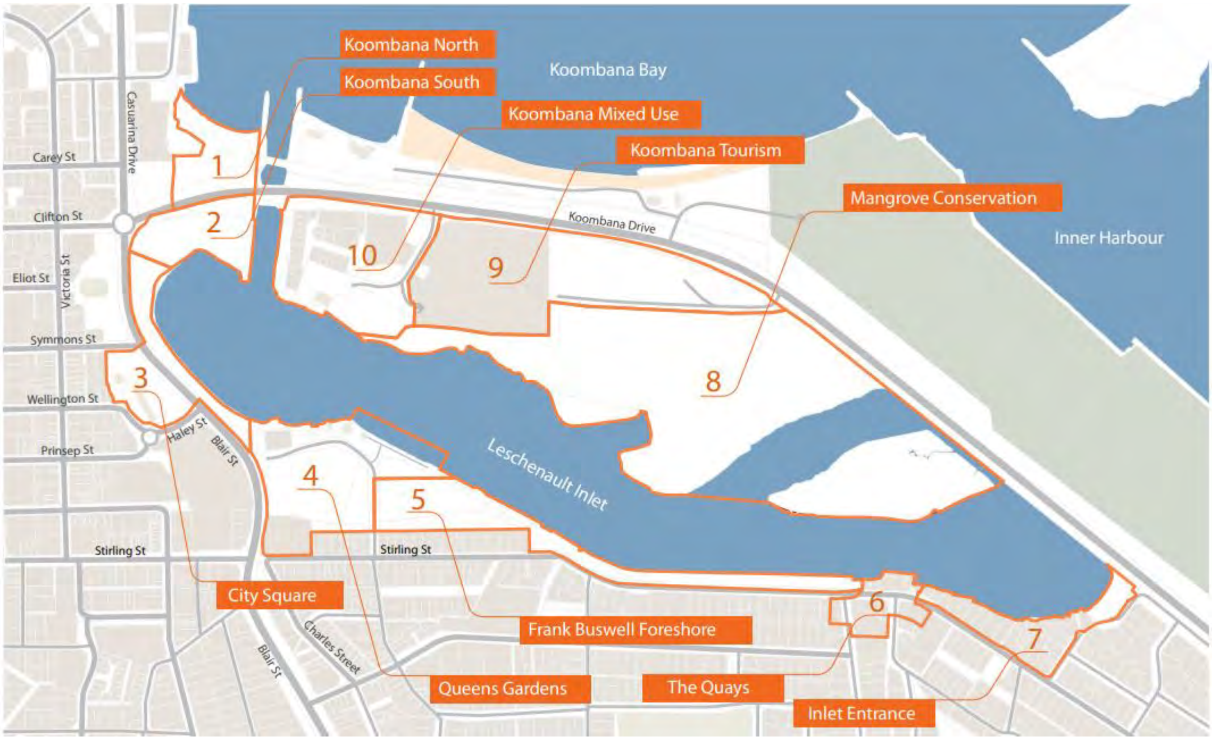

Figure 3-6 Leschenault Inlet Master Plan (City of Bunbury, 2013)

3.3 Shire of Harvey

The Shire of Harvey (herein referred to as SoH) is located immediately north of Bunbury and extends to the Shire of Waroona. SoH manages approximately 42 km of coastline covering about 1700 km^2 of land, but this study is restricted to the Leschenault Estuary and the tidally influenced flood plains of the Collie, Wellesley and Brunswick rivers. The open coastline west of the estuary was not considered as part of this project (coastal hazards along the open coast were previously investigated as part of the Shire of Harvey CHRMAP).

The SoH was first established as Brunswick Road District in 1894. In 1961, it became the Shire of Harvey under the Local Government Act 1960. The 2016 census indicates the Shire has an established population of about 26,000 and an annual growth rate of about 4%.

A map of the relevant project area for Harvey is shown in Figure 3-7. SoH is bounded by the Collie River and the Cut to the south. The western shore of the estuary comprises coastal dunes of varying height. Surrounding the estuary and rivers are lowlands and flood plains. These locations are expected to be most impacted by coastal hazards. While inundation is considered to present the greatest risk here, shoreline stability and erosion risk will also be assessed.

Most residential lots are located at levels beyond the reach of historic floods on the eastern side of Cathedral Ave and Old Coast Rd. The area to the west of Old Coast Rd is primarily Conservation Park with scattered residential lots and foreshore development (e.g., Ridley Place, Leschenault Waterways Discovery Centre).

Damara (2016) undertook the SoH CHRMAP coastal hazard assessment and identified three types of hazards in this region including shoreline erosion, flood inundation, and landform mobility. Key points from the study were:

- Progressive erosion has occurred on the seaside of Leschenault Peninsula (area excluded from the current study). The erosion rate varied over time and was higher during the 1970s and from 2008 to 2015. The situation may be worsened by SLR, in particular during the erosive phases. Erosion on the seaside of Leschenault Peninsula may affect the overall landform stability of the Leschenault Estuary in the long term. The northern bank of the Cut was breached in 2012 due to erosion of the ocean shoreline extending behind the back of the training wall.
- Historic reports indicate storm tide inundation has been an infrequent hazard. The most extreme storm recorded at the site was TC Alby in April 1978, which generated a storm surge level of approximately 1.8 m AHD (or 1.2 m above HAT) at Bunbury tide gauge. The impact was reduced within Leschenault Estuary due to the restricted water exchange through the Cut. For more frequent winter storms, inundation levels are expected to be much lower. Riverine flooding is identified to be the more frequent hazard for low lying land in Leschenault Estuary and along the Collie River.

Within the estuary and immediate surrounds, the primary hazard is most likely associated with coastal inundation from storm surge and catchment flooding.

Land immediately adjacent to the Leschenault Estuary is primarily public foreshore reserve. Some public and private assets are located close to the estuary in Australind near Ridley Place. A concise CHRMAP was undertaken by Damara (2020) to evaluate potential coastal hazards and adaptation options for this area. Based on this assessment, SoH prepared a foreshore management plan at Ridley Place, which proposed several new facilities including foreshore pathways, a playground, boardwalk, restaurant, kiosk, and toilets. Active vegetation management was identified as a "no regret" option for erosion control and protection of the foreshore area.

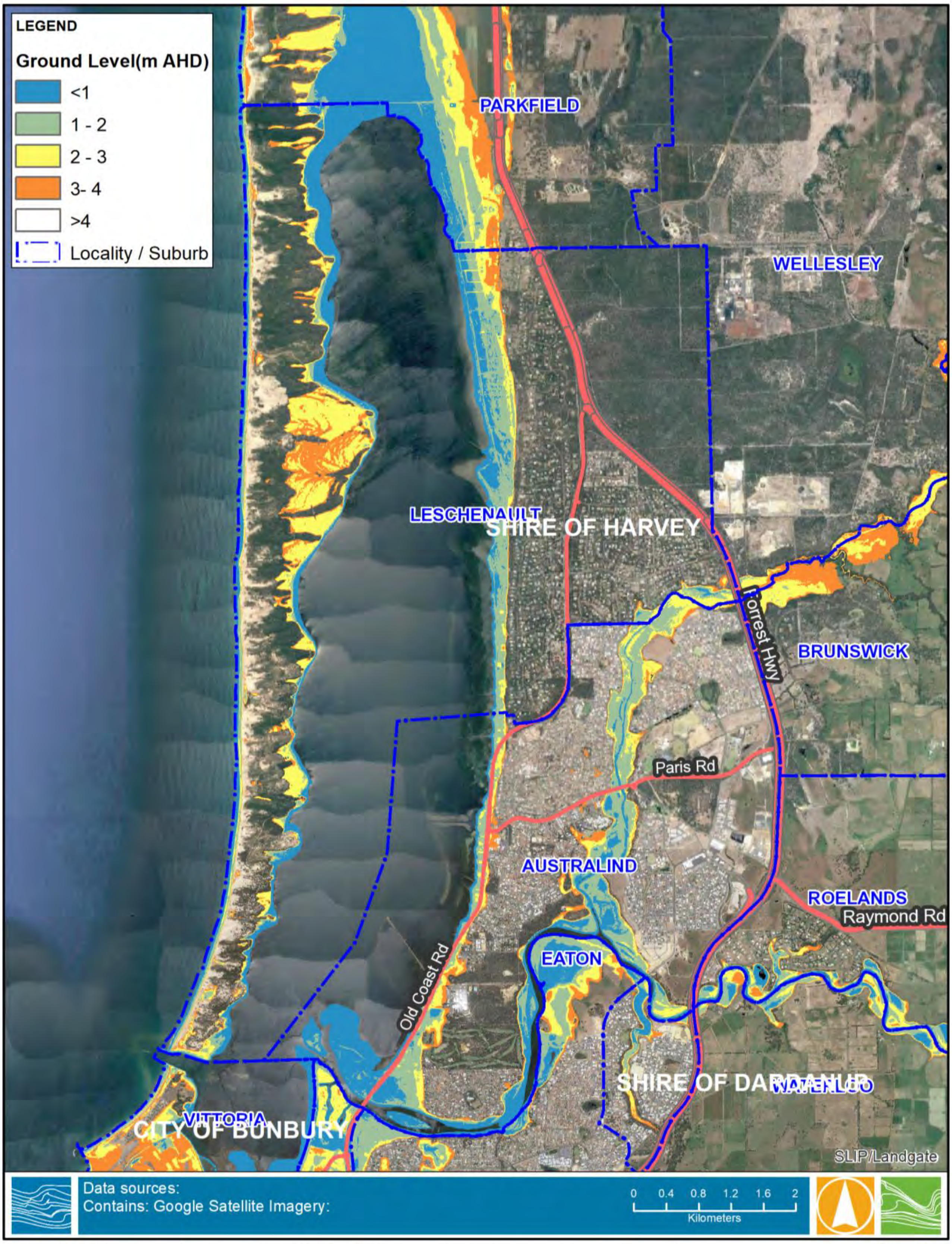

Figure 3-7 Shire of Harvey Project Area (Overlayed are Suburbs, Roads and ground levels)

3.4 Shire of Dardanup

The Shire of Dardanup (herein referred as SoD) is located immediately to the east of the CoB. It was first established as Dardanup Road District and later became the Shire in 1961 according to Local Government Act 1960. The SoD covers about 520 km^2 of land and has an approximate population of 14,000.

The SoD is bounded by Collie River to the north and CoB to the west. It does not have an exposed shoreline like the other three LGAs. Land vulnerable to coastal hazards is primarily located at the lower end of Collie River, which is affected by both marine (e.g., storm surge) and riverine processes (river flood) and is occasionally affected by boat wakes. It is a transitional zone from riverine to an estuary environment showing a widening and meandering channel, as well as the presence of tidal-riverine flow interaction.

Seashore (2020) investigated the riverbank erosion at the Eaton foreshore of the Collie River and noted that the existing foreshore is under moderate erosion risk. Despite a range of foreshore works undertaken, various locations along the riverbank have shown signs of erosion and require prioritised erosion controls. DWER has preprepared a priority map for foreshore erosion control for the Collie River foreshore management plan (see Figure 3-8).

Figure 3-8 Priority of Foreshore Erosion Control (Image source: DWER 2018). Red = priority 1 (0-5 years), Yellow = priority 2 (5-10 years), Green = priority 3 (Greater than 10 years), Blue = no works required

Besides the riverbank erosion, the lower Collie River is also subject to the risk of river flood and coastal inundation (see Figure 3-9 for ground elevation). Much of the flood plain has a ground elevation lower than 2m AHD which are vulnerable to extreme storm surge events (e.g., Tropical Cyclone (TC) Alby). The situation may deteriorate under climate change (e.g., SLR, increasing rainfall intensity, shifting of tropical zone etc.). Roads e.g., Old Coast Rd and Australind Bypass are potential barriers to prevent the spreading of flood water.

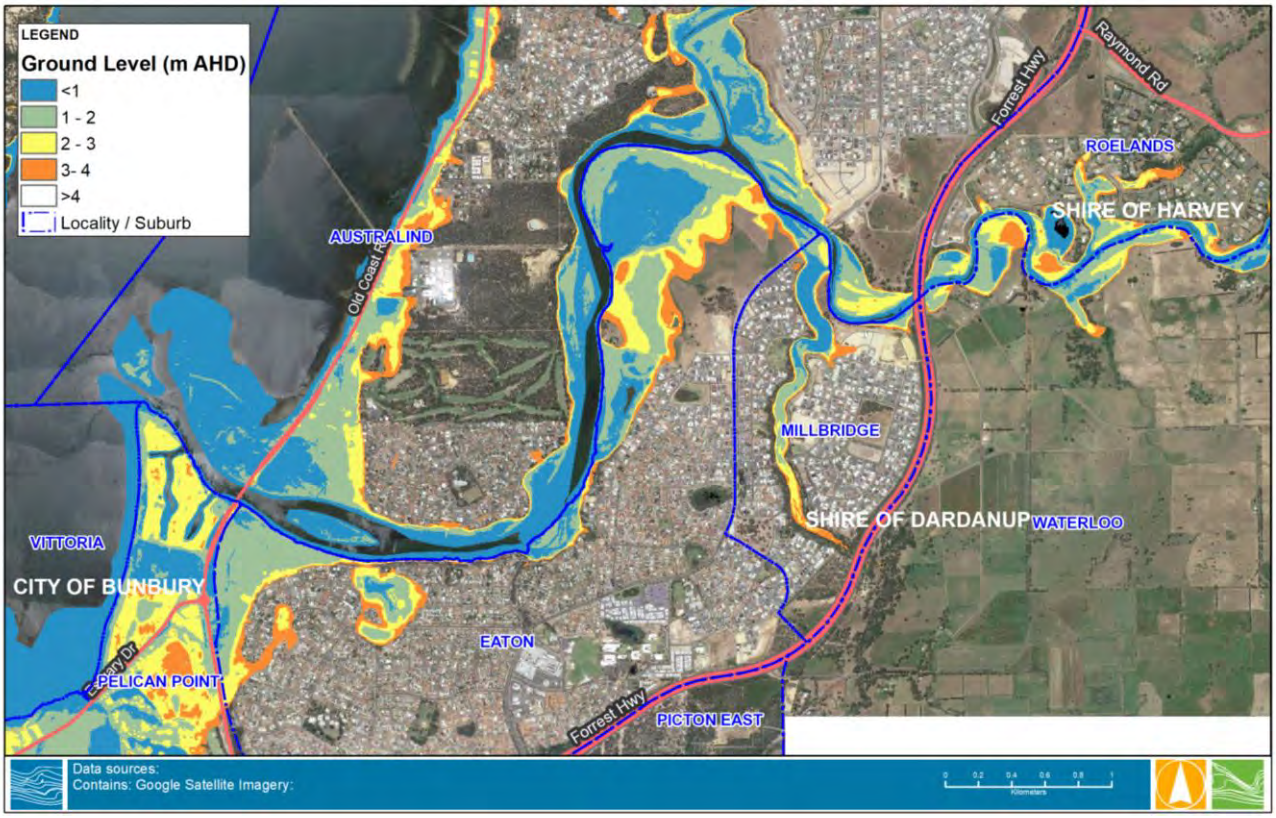

Figure 3-9 Shire of Dardanup Project Site (Overlayed are ground level map, suburbs & roads)

4 JURISDICTIONS

4.1 Boundary of LGAs and Suburbs

Refer to Section 3.

4.2 DBCA Regional Parks

While two proposed regional parks were originally embodied in the Preston River to Ocean Regional Park Establishment Plan (WAPC, 2011) and the Leschenault Regional Park Establishment Plan (WAPC, 2017a), these two proposed regional parks were indicative and subsequently a decision was made to amalgamate all parts of the two proposed parks into one regional park.

Kalgalup Regional Park Draft Management Plan (DBCA, 2020) provides for the protection and enhancement of the conservation recreation and landscape values of the Park. The plan supersedes the Leschenault Regional Park preparatory work and aims to conserve the special features of the park and sustainably manage its values and community use. The park consists of Regional Open Space identified in the Greater Bunbury Region Scheme covering over 3,000ha across three separate locations:

- East and northeast of Bunbury mainly along the foreshores of the Leschenault Estuary and Inlet and the Collie and Brunswick rivers including the lands within the Leschenault Peninsula
- South of Bunbury about 5km from the city centre and mainly within the City of Bunbury
- Southeast of Bunbury along the foreshores of the Preston River

An overview of the Kalgalup Regional Park is presented in Figure 4-1.

The indicative Preston River Link is subject to changes responding to the expansion of Bunbury Inner Harbour.

DBCA Regional Parks are likely located within the primary hazard zones affected by both erosion and inundation risks. Environmental Values are of particular importance and will be considered by this CHRMAP process. Environmental assets and values will be identified during Stage C of this project.

4.3 Bunbury Inner Harbour

The Inner Harbour (under management of South Ports Authority) was first established in 1976, followed by subsequent developments at various locations. At present the port has five berths and dockyards and associated infrastructure on the western side of Preston River. The current layout of the Inner Harbour is shown in Figure 4-2.

The overall area of the Inner Harbour is bounded by Koombana Drive and Australind Bypass to the south, Pelican Point to the East, Koombana Beach to the west and Turkish Point to the north. There is one block of residential land adjacent to the Vittoria Bay. However, most of the land within the boundary of the Inner Harbour is for industry use where shorelines are protected by physical controls.

The recent development plan has considered options to redirect the Preston River to a new entrance and this may affect the general layout of the Harbour in the future.

4.4 Casuarina Boat Harbour

- The South West Development Commission has oversight of the Transforming Bunbury's Waterfront project and has delivered the first stage.

- The Department of Transport (DoT) implemented a major component of Stage 2 - the redevelopment of the Jetty Road causeway. The value of the causeway works was approximately $12.65 million with funds provided through Royalties for Regions.
- DevelopmentWA (previously known as LandCorp) will deliver the Stage 2 redevelopment of Casuarina Drive.
- Jurisdiction of Casuarina Boat Harbour and the foreshore is not yet clearly defined.

4.5 Rivers and Water Courses

- DWER has significant involvement in water and flood management along all major water courses including both surface and ground water.
- LGAs have direct involvement in management of lands along the river flooding zone.
- DBCA has a management role of the regional parks along the rivers and at estuary/inlet surroundings.

4.6 The Cut

There is ongoing discussion regarding the ownership of, and management responsibilities relating to the Cut:

- DoT found the primary function of the Cut is to provide drainage functions for the Collie and Preston Rivers and Leschenault Estuary.
- Small boats do use the Cut to travel between the estuary and ocean, and boat ramps are present in the estuary system.
- DoT considered the Department of Water and Environmental Regulation (DWER) to be the most appropriate agency to have ownership of the Cut training wall structures.
- DWER advised Section 3.53 of the Local Government Act 1995 states that the control and management of unvested facilities is the responsibility of the Local Government Authority, and the southern bank of the Bunbury 'Cut' may fall into this category given it is an unvested facilities on unallocated Crown land.
- There haven't been follow-up discussions with LGAs and DBCA.
- DoT has previously been tasked with repairs to the norther training wall in 2014 but is not currently managing erosion control or structure maintenance at The Cut.
- Jurisdiction of the Cut is still under discussion.

This CHRMAP will potentially identify management tasks required at the Cut. It is recommended that discussions continue in order to assign management responsibilities.

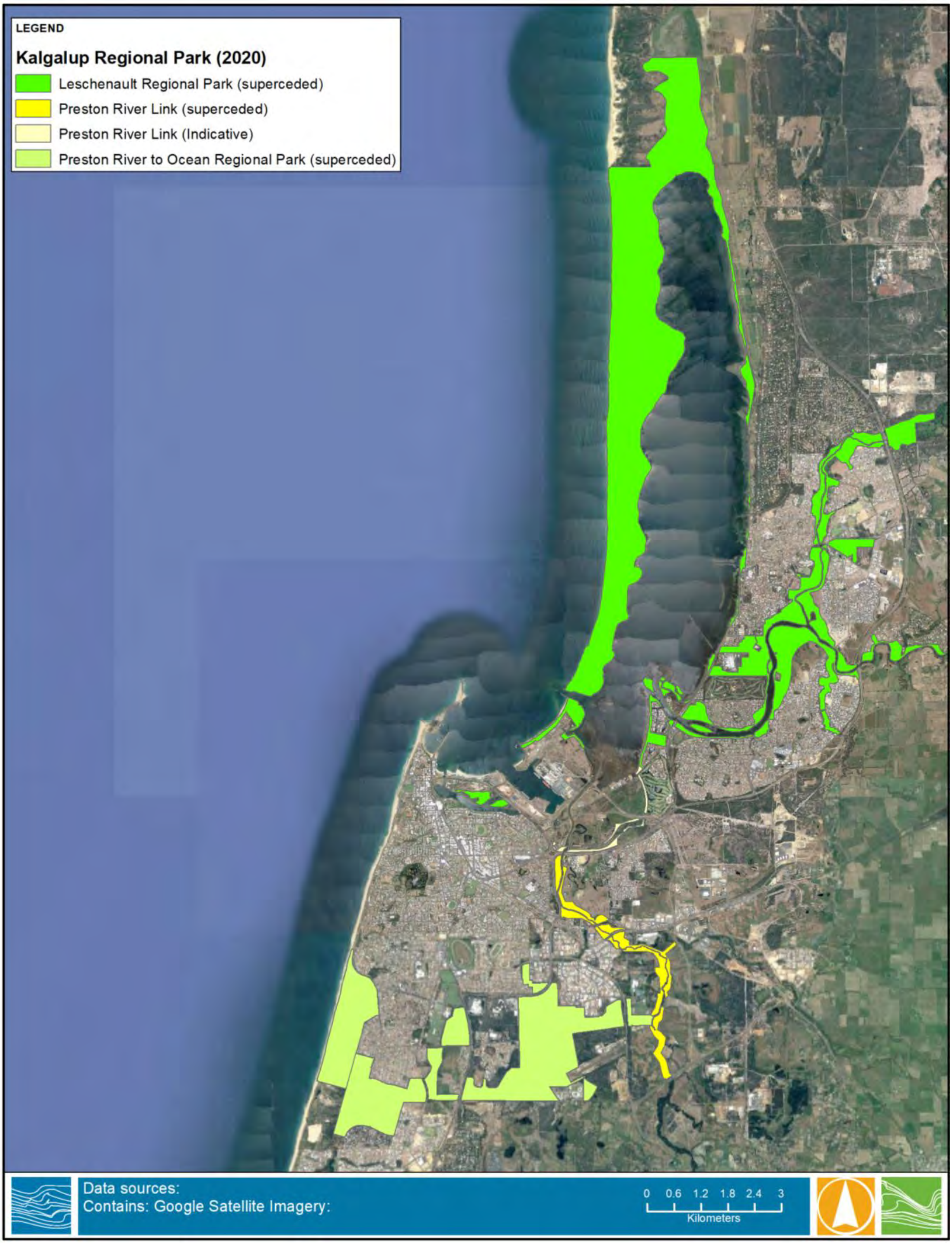

Figure 4-1 Kalgalup Regional Park Overview

Figure 4-2 Bunbury Inner Harbour Layout

5 EXISTING PLANNING CONTROLS

Planning in Western Australia is guided and regulated by the State Planning Framework, which ranges from overarching strategic planning strategies, to specific planning policies and supportive guidelines. Figure 5-1 explains the framework, which includes planning at the state, regional, and local levels and demonstrates how strategic planning is implemented through statutory planning controls (e.g., local planning schemes) and local planning policies. This Framework sits within the Planning and Development Act 2005. The relationships of the various policies are presented in Figure 5-2.

This chapter reviews the planning documents within this Framework which are relevant to coastal hazard planning in the project area; additional information is provided in Appendix A. This review will help to: assess the adequacy of the existing planning documents for addressing coastal hazards; identify gaps that need to be addressed through the CHRMAP process (such as planning controls that are required, or need amending to enable implementation of CHRMAP recommendations); identify any potential planning issues that may constrain the CHRMAP process; and ensure that the adaptation plan aligns with state, regional and local planning frameworks.

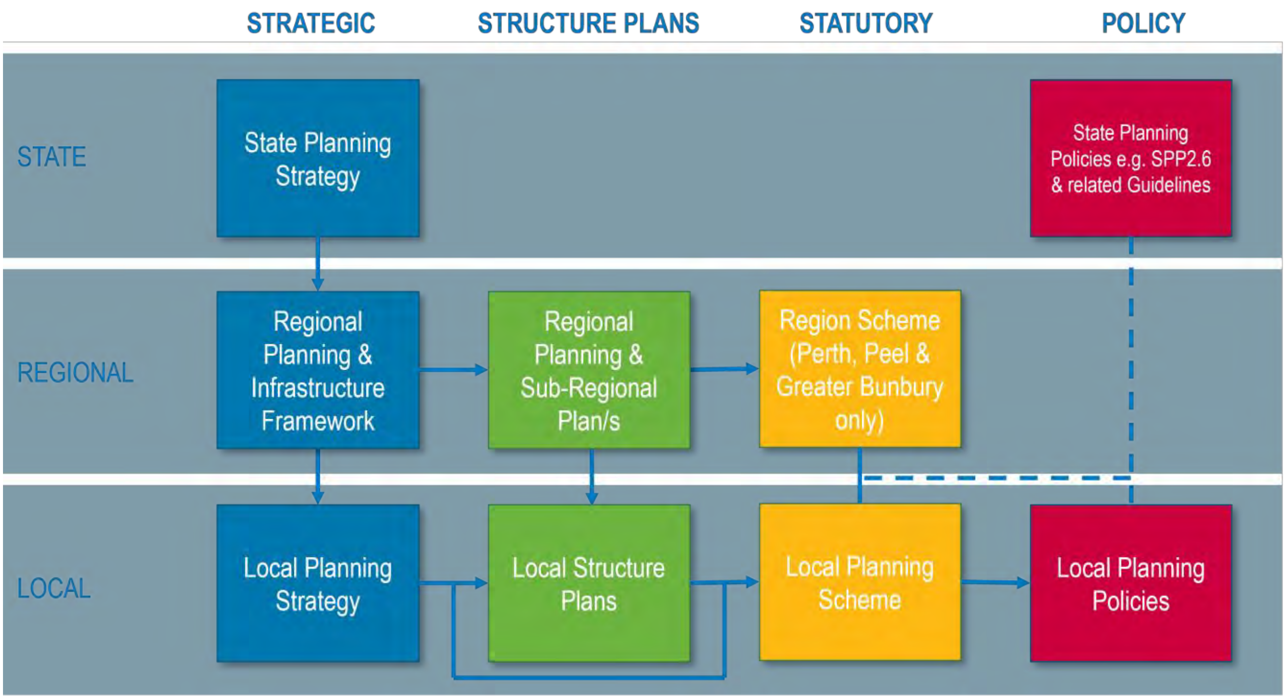

Figure 5-1 State Planning Framework for Western Australia

A summary of information from the planning documents relevant to the coast is included below and in Appendix A-3. This will all be considered as part of the development of the success criteria and adaptation options for the CHRMAP, with appropriate text included in the relevant planning documents as required.

5.1 State Planning Policies and Strategies

The following state documents have been reviewed. Information relevant to the CHRMAP has been included below and in Appendix A-1:

- State Planning Strategy 2050
- The WA Coastal Zone Strategy 2017

- State Planning Policy 2.6 – State Coastal Planning Policy, and associated Guidelines
- State Planning Policy 2.9 – Water Resources
- Coastal Hazard Risk Management and Adaptation Planning Guidelines 2019
- State Planning Policy 3.4: Natural Hazards and Disasters

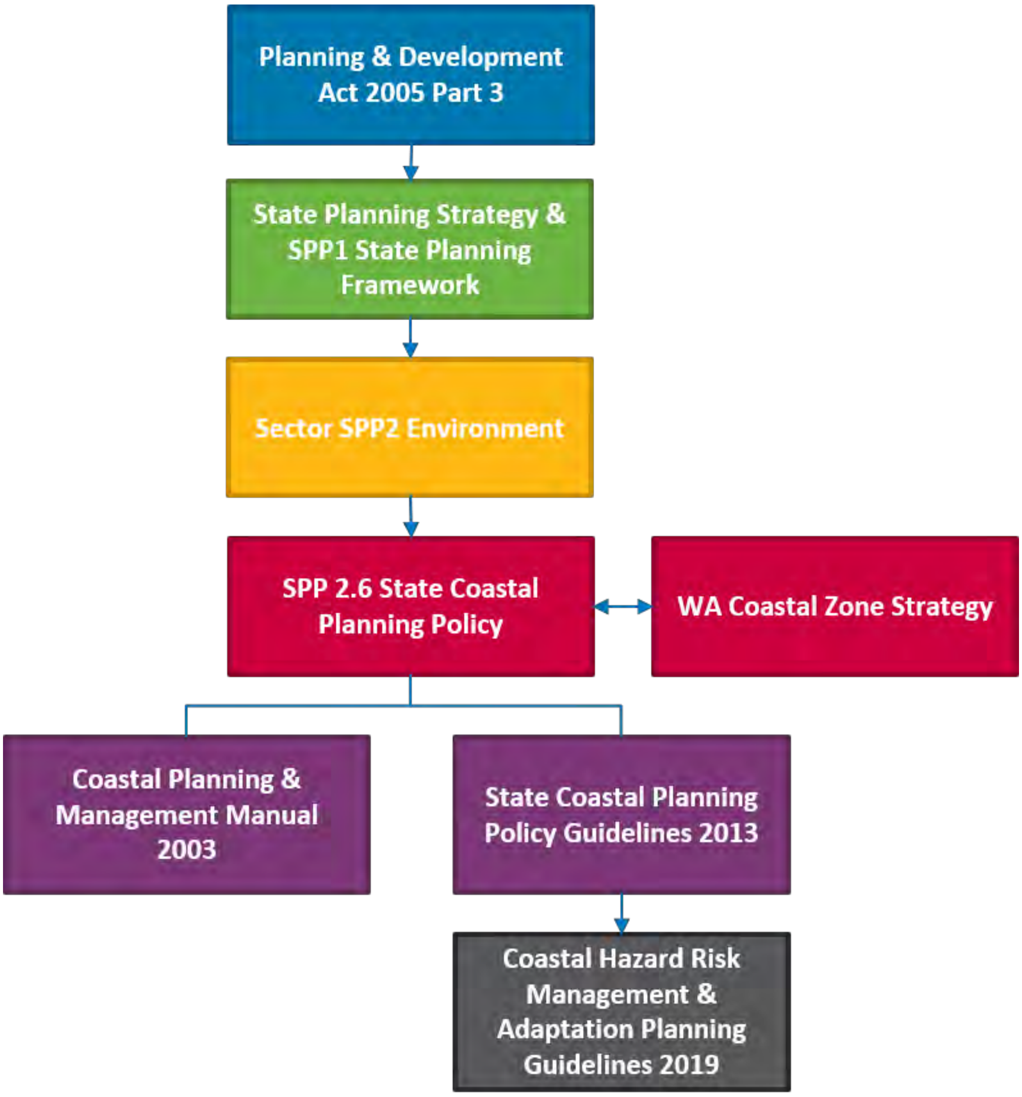

Figure 5-2 Policy Relationships

5.1.1 State Planning Strategy

The *State Planning Strategy 2050 (State Planning Strategy)* provides a strategic framework, principles, strategic goals and strategic directions for planning and development in Western Australia. The *State Planning Strategy* approach to climate change seeks to achieve development and adoption of risk management strategies for natural hazards in the context of climate change patterns and trends.

The *State Planning Strategy* identifies the project area coastline as being at risk of coastal landform change Some of the aspirations listed for mitigation and adaptation planning include:

- Special controls continue to be in place for vulnerable species and areas most affected by climate change.

- Climate change adaptation and mitigation strategies continue to be developed and implemented to minimise impacts on the State's key assets .
- Vulnerable areas continue to be secured and managed to foster ecosystem resilience.
- Risk management strategies continue to be developed and adopted for natural hazards in the context of climate change patterns and trends.

The State Planning Strategy also provides that decisions about sustained growth and prosperity must strike the appropriate balance between environmental issues, economic conditions and community wellbeing.

5.1.2 WA Coastal Zone Strategy

The WA Coastal Strategy was released in 2017, in recognition of the need for a strong land-use planning framework to ensure that coastal development can be sustainable in the long term, meeting community, economic, environmental and cultural needs. It complements existing State legislation, strategies and policies, including SPP2.6. Any new Government and stakeholder strategies and policies are expected to be consistent with this strategy.

The document identifies all relevant legislation and policies related to coastal management. It outlines the key issues affecting the coast. It also defines stakeholder roles and responsibilities for coastal stewardship, making it a good overview document for a range of stakeholders.

The strategy clearly defines the roles and responsibilities for managing the coastal hazards of coastal erosion and inundation. It states that all levels of government, as well as individuals, businesses, and the community, each have important and complementary roles in adapting to coastal hazards. In particular, it outlines the following principles which have relevance to this CHRMAP:

- Private parties are responsible for managing risks to their private assets;
- Governments (i.e.: the Shire/City), on behalf of the community, are primarily responsible for managing risks and impacts to public goods and public assets which they own and manage; they should also seek to:
  - Develop local policies and regulations consistent with state adaptation approaches;
  - Facilitate building resilience and adaptive capacity within the local community.
  - Work in partnership with community to identity and manage risks / impacts.

The strategy then outlines its guide to how management of coastal hazards should be addressed, which will be definitive for the adaptation component of this CHRMAP. The State's coastal planning policy adaptation preferences in order of priority, as outlined in SPP 2.6, are:

Avoid > Planned or Managed Retreat > Accommodate > Protect

The state has a strong preference towards adaptation options that minimise coastal process interference and away from options that may leave legacy issues. Management strategies that preserve the natural coastline and move development away from the active coastal zone are considered ideal. As a result of this hierarchy, the strategy steers planners away from protection options and provides strict rules for the consideration of protection works. Of particular relevance to the CHRMAP process is the user pays principle, whereby those who benefit most from protection must provide the greatest financial contribution. This arrangement applies to any area of the coast and can include incidences where the coastal foreshore reserve is being protected as a buffer to private assets.

The WA Coastal Zone Strategy is a critical planning guide for any coastal community. It outlines the State Government's aims for sustainable coastal development into the future. The State Government emphasises the preference of public interests over private and industry interests and reinforces the presumption of landholder responsibility. The State Government also reiterates earlier planning documents declaring that protection should be used only in the most exceptional circumstances.

5.1.3 State Planning Policy 2.6: State Coastal Planning Policy (SPP2.6)

The State Coastal Planning Policy (SPP2.6) is WA's policy for making decisions within the coastal zone as well as determining the coastal hazards, and strategies to manage identified hazards.

SPP2.6 provides rigorous outlines for the calculations of coastal hazards, specifically inundation and erosion. Whilst different parties may utilise different methods to assess coastal hazards, all studies must fall under the guidelines of SPP2.6.

SPP2.6 aims to avoid future development within areas identified to be at risk within the planning timeframe, generally 100-years. For areas at risk, all potential adaptation options will be identified under the risk management categories of avoid, managed retreat, accommodate and protect to manage the unacceptable risks. The ultimate aims of the policy are to ensure all future development considers coastal hazards, climate change, and landform stability.

SPP2.6 provides detailed information to evaluate the risk of coastal inundation and erosion and has specified the storm events to be considered for these analyses.

5.1.4 Coastal Hazard Risk Management and Adaptation Planning Guidelines

The CHRMAP Guidelines (WAPC, 2019) provide a comprehensive guideline for the process of CHRMAP development. The Guidelines detail the anticipated project scope, as well as standard approaches to undertake the hazard assessment, adaptation option development and implementation. This CHRMAP will be developed in accordance with the CHRMAP Guidelines.

5.1.4.1 Planned or Managed Retreat Framework

Appendix 4 of the CHRMAP Guidelines provides guidance on how to implement a policy of planned or managed retreat for 'brownfield' or 'greenfield' locations that are currently, and increasingly in the future, vulnerable to coastal hazards with limited opportunities to introduce less vulnerable forms of use or development *through planning control*.

The policy adheres to the principles for sustainable land use and development on the coast and adaptive risk management as required by the *Planning and Development Act 2005* (P&D Act) and SPP2.6, namely;

- To ensure the ongoing responsible and sustainable management of the coastline for the benefit of the whole community. It ensures ongoing protection and provision of a coastal foreshore reserve and beach amenity and continuing and undiminished public access to beaches.

The document details the following principles:

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

Aligned with and in accordance with SPP2.6, it provides that a comprehensive CHRMAP process be undertaken to inform and enable the adoption of a planned or managed retreat policy to guide implementation. The planning mechanisms outlined to enact planned or managed retreat are:

- Structure planning – where comprehensive redevelopment of land remains an option, structure planning takes into account risks identified in the CHRMAP process to feed into subdivision conditions which may, for example, address land requirements to accommodate coastal risks.
- Local planning scheme (LPS) amendment – the LPS can be amended for the provisions of SPP2.6 to apply as if they were part of the scheme and to inform the classification of vulnerable areas as Special Control Areas (SCAs); as applicable.
- SCA – establishing an SCA enables land use and development at risk to be identified in the SPP2.6 100-year planning timeframe, establish intention to retreat from the area and provide the special planning instrument required to implement the approach.
  - An SCA classification can be included in an LPS. Part 5, Schedule 1 of the *Planning and Development (Local Planning Schemes) Regulations 2015* provides the template for local governments to follow when amending their LPS to include an SCA.
- Taking of land – triggers for initiating this process should be included in any policy arising from the CHRMAP process to support implementation of the planned or managed retreat.
  - The policy also speaks to the cost of taking land needing to be in agreement with the requirements under section 168 of the *Land Administration Act 1997.*

Finally, the document speaks to special circumstances for state government control. This would be enacted through mechanisms set out in the P&D Act and including the relevant Region Scheme, a Planning Control Area declaration and/or an Improvement Plan and Scheme.

5.2 Regional Planning Strategies

The following regional documents have been reviewed. Information relevant to the CHRMAP has been included below and in Appendix A-2:

- South West Regional Planning and Infrastructure Planning Framework
- Draft Bunbury-Geographe Sub-regional Strategy
- Greater Bunbury Region Scheme 2003
- Great Bunbury Strategy

5.2.1 South West Regional Planning and Infrastructure Planning Framework

The vision for this framework is "a region that generates high standards of social amenity, diverse economic activities and high-quality food, supported by effective and efficient infrastructure and at the same time preserving and enhancing the natural environment". One of the key themes is sea level rise/storm surge.

The document outlines climate change as a major issue for the South West, and promotes adaptation as a way of preparing for a changing climate to manage the risks and maximise opportunities. The proximity of towns and cities to the coastline means they are vulnerable to the impacts of sea level rise and storm surge.

A response to this issue has been sea level rise and storm surge modelling for Bunbury by Geoscience Australia through the state planning agency.

The framework speaks to the formation of the PNP to provide a regional mechanism to facilitate effective and timely adaptation responses to climate change. Any proposed policy changes will be assessed by the Western Australian Planning Commission (WAPC) and, where considered appropriate, will be reflected through the relevant planning policies and statutory framework.

The WAPC will continue to support planning that mitigates and adapts to the probable impacts of climate change in the South West through, amongst other things, assessing the region's coastal vulnerability to determine the risk to coastal settlements and infrastructure from sea level rise and storm surge, and minimising potential impacts of sea level rise through planning policies and controls in vulnerable areas.

The document also speaks to natural disasters, stating that the South West is subject to a range of potential natural disasters such as flood, cyclones (though rare), storm surge, coastal erosion, severe storms, landslide and bushfires. It states that one of the most effective strategies for reducing the long-term impact of natural hazards is to integrate mitigation measures into the land use planning process.

5.3 Local Planning Strategies, Schemes and plans

The following local documents have been reviewed. Information relevant to the CHRMAP has been included in Appendix A-3:

- Shire of Capel Coastal Strategy 2005
- Shire of Capel Local Emergency Management Arrangements (2016-2021)
  - No specific coastal information
- Shire of Capel Draft Local Planning Strategy 2021
- Shire of Capel Draft Local Planning Scheme No.7 (8 is currently out for public comment)
- Peppermint Grove Beach Land Use Strategy 2013
- Peppermint Grove Beach Management Plan 2010
- City of Bunbury Local Planning Strategy 2018
- City of Bunbury Local Planning Structure Plans
- Koombana Bay and Casuarina Drive Master Plan
- Leschenault Inlet Master Plan
- Shire of Harvey Local Planning Strategy 2020
- Shire of Harvey District Planning Scheme No. 1 2019
- Shire of Harvey CHRMAP
- Ridley Place CHRMAP (summarised in Section 3.3)
- Shire of Dardanup Local Planning Strategy 2015
  - Currently no specific CHRMAP relevant information
- Collie River Erosion Management Plan 2020
  - Incorporated into coastal hazard assessment

5.4 Other Relevant Planning Documents

The following local documents have been reviewed. Information relevant to the CHRMAP has been included in Appendix A-4:

Bunbury Port Development Plan:

- Bunbury Port Development Long Term Monitoring and Management Plan
- Bunbury Inner Port Structure Plan

South West Development Commission

- Koombana Bay CHRMAP

Department of Water & Environmental Regulation Existing Plans:

- DWER Lower Collie River Master Plan

DBCA Regional Park Establishment Plan:

- Leschenault Regional Park Establishment Plan 2017
- Kalgalup Regional Park Draft Management Plan 2020

5.5 Planning Controls Summary

The study area contains a large array of planning documentation. As presented in this section and Appendix A, most of these documents make mention of coastal hazards, or values which will provide input into the CHRMAP process. With the exception of the Shire of Harvey however, none of the existing documents contain planning instruments that can be used to adapt to coastal hazards. This CHRMAP will consider what planning controls (existing or required) may be appropriate as adaptation measures within each management unit. Existing actions and controls appropriate to maintain will be identified along with required changes, updates or amendments or new controls required. The implementation plan will identify these and include proposed wording, implementation methods/process and supporting information.

Based on a review of the existing planning controls, the statutory planning mechanisms that may be available to address coastal hazards within the study area are summarised in Table 5-1.

Table 5-1 Summary of Potential Planning Controls

Planning Mechanism	Content	Comments
Structure planning	Where there is potential for comprehensive redevelopment of land, structure planning can take into account risks identified in the CHRMAP process to feed into subdivision conditions which may, for example, address land requirements to accommodate coastal risks	This may be an option considered in the development of the CHRMAP, in accordance with the provisions of the respective LPS.
Local Planning Scheme (LPS) amendment	LPSs can be amended for the provisions of SPP2.6 to apply as if they were part of the scheme and to inform the classification of vulnerable areas as Special Control Areas (SCAs); as required and deemed appropriate.	If an SCA is deemed an appropriate planning control for a section/s of the study area, a recommendation will be made for the relevant LPS to be amended including proposed wording, method and related information.
Special Control Area (SCA)	Establishing an SCA enables land use and development at risk to be identified in the SPP2.6 100-year planning timeframe, establish intention to retreat from the area and provide the special planning instrument required to implement the approach. An SCA classification can be included in an LPS. Part 5, Schedule 1 of the Planning and Development (Local Planning Schemes) Regulations 2015 provides the template for local governments to follow when amending their LPS to include an SCA.	The use of an SCA for a portion/s of the study area will be determined as part of the CHRMAP development process. The project team will work with the PNP and relevant local governments to establish likely level of support for use of this option.
Taking of land	The power to compulsorily acquire land is provided for under the Land Administration Act 1997. In accordance with the CHRMAP Guidelines, triggers for initiating this process should be included in any policy arising from the CHRMAP process to support implementation of the planned or managed retreat. The cost of taking land needs to be in agreement with the requirements under section 168 of the Land Administration Act 1997.	The use of this option will need to be discussed with the PNP, relevant local governments and state government. It will only be contemplated as an option in the event erosion or inundation hazard risks require the acquisition of such land.

6 EXISTING PHYSICAL CONTROLS

Physical controls have been implemented primarily along Casuarina Drive, inside Koombana Bay (including inner Harbour) and Leschenault Inlet. A list of physical controls has been prepared to establish the context and to progress the hazard assessment and development of adaptation options. These are presented in Table 6-1 and Figure 6-1.

Table 6-1 lists some major physical controls in Bunbury region and may not provide a complete list of physical controls over the entire study domain. The table will be updated at the completion of the coastal asset and value identification.

The influence of existing physical controls may affect the risk (consequence and/or likelihood), vulnerability, tolerance or appropriateness of risk management measures. Their ownership, available funding, design life, condition and level of management (monitoring and maintenance) will be considered throughout the CHRMAP stages. Following identification of vulnerable assets, the role of existing physical controls in influencing the level of risk and subsequent risk management measures can be considered further.

Table 6-1 Physical Controls

Location	Physical Controls	Structure Type	Material	Jurisdiction
Leschenault Inlet	Pat Usher Foreshore	Seawall	'Limestone Block and Mortar'	COB
	Rowing Club	Seawall	'Basalt and Concrete'	COB
	Queens Gardens	Seawall	'Basalt and Concrete'	COB
	Stirling Street	Seawall	'Limestone Block and Mortar'	COB
	Frank Buswell Foreshore	Seawall	'Limestone Block and Mortar'	COB
	Richmond Reserve	Seawall	'Coffee Rock and Concrete'	COB
	Koombana Boardwalk	Seawall	'Sheet Piling and Rock Armour'	COB
	Sykes Foreshore	Seawall	'Rock Armour'	COB
	Power Boat Club	Seawall	'Limestone Block'	COB
	The Plug – Les D Vorak	Seawall	'Rock and Mortar'	COB
	The Plug – Youth Precinct	Seawall	'Rock Armour'	COB
Ocean Drive	FMB outfall	unclear		TBC
	Ocean Drive Spur Groyne	Groyne	'Rock'	TBC
	Casuarina Drive Outer Harbour Breakwater	Breakwater	'Rock'	TBC
	Ocean Drive – Hungry Hollow	Revetment Wall	'Unknown'	COB
	Ocean Drive – Hayward Street	Revetment Wall	'Unknown'	COB
Koombana Bay	Jetty Road	Breakwater	'Rock'	DoT
	Marlston Waterfront	Seawall	'Rock Armour'	COB
	Ski Beach Groyne	Groyne	'Rock'	TBC

Location	Physical Controls	Structure Type	Material	Jurisdiction
	Storm surge barrier	Storm Surge Barrier		DoT
	Koombana Bay Sailing Club Groyne	Groyne	'Rock'	TBC
	Koombana Foreshore – Sailing Club	Revetment	'Unknown'	COB
	Koombana Foreshore – Dolphin Discovery	Revetment	'Unknown'	COB
	Koombana Beach Eastern Seawall	Seawall	'Rock Armour'	SPA
	Point Busaco Groyne	Groyne	'Rock'	SPA
	Point Hamilla Groynes	Groyne	'Rock'	SPA
Pelican Point	Pelican Point – Taylor Foreshore	Seawall	'Limestone Block and Mortar'	COB
Turkey Point	the Cut seawall	Seawall	'Rock Armour'	TBC
Inner Harbour	Inner Harbour Berth	Berth	Rock	SPA?
Rivers	Weirs/gates/riverbank protection			TBC

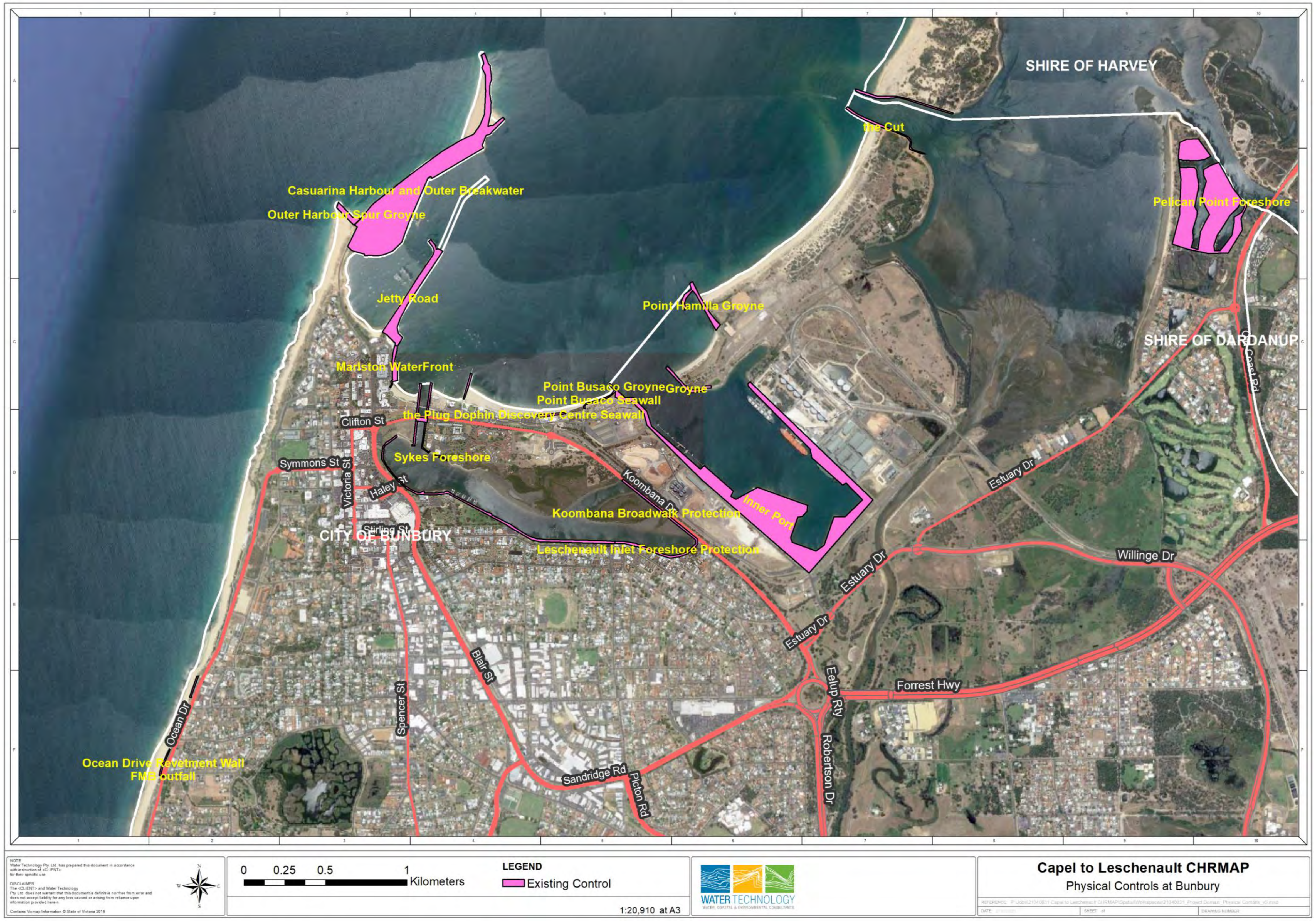

Figure 6-1 Physical Controls at Bunbury

7 MANAGEMENT UNITS

To facilitate the coastal hazard assessment and development of adaptation options, the study area is delineated into several management units which are determined according to a set of factors:

- Jurisdiction boundaries
- Presence of coastal assets and relevant stakeholders
- Coastal processes and potential hazard types.

For Shire of Capel, the shoreline can be divided into three primary management units:

- MU1 - Peppermint Grove Beach
- MU2 - Dalyellup Beach
- MU3 - Capel Coast (coastal reserve and farmland)

For City of Bunbury, the shoreline can be divided into five primary management units:

- MU4 - Bunbury S
- MU5 - Bunbury (including Five Mile Brook district, Koombana Bay, Leschenault Inlet)
- MU9 - Bunbury Inner Harbour (Bunbury Port)
- MU10 - The Cut
- MU11 – Bunbury E

Shire of Dardanup does not have an open coast. Primary hazards are potential riverbank erosion and inundation of lowlands along the Collie River. The area is defined as an individual management unit – MU7 - Collie River S.

For Shire of Harvey, the shoreline can be subdivided into two primary management units:

- MU6 - Leschenault Estuary
- MU8 - Collie River N, consisting of lands on the northern side of Collie River and along the Wellesley River and Brunswick River

Open ocean coast within Shire of Harvey is excluded from the scope of this CHRMAP.

Risk Assessment Zones have been considered for assessment of coastal erosion risks which will be discussed through consultation with Steering Group and stakeholders.

Table 7-1 Management Units with Shoreline Type(s)

Management Unit	Risk Assessment Zones	Shoreline Type	Comments
MU1-Peppermint Grove	Peppermint Grove Beach	Sandy	Town site with public assets e.g., playground, carpark, holiday park etc. Straight open coast
MU2- Capel Coast	Capel Coast including Forrest Beach, Stirling Estate (north of Capel River), Stratham Coast etc.	Sandy	Sandy beach, scattered assets, Stirling Wetlands connected to coast via Capel River and Muddy Lakes connected to coast via Five Mile Brook Diversion
MU3-Dalyellup	Dalyellup Beach	Sandy	Straight open coast, sandy beach Populated town site with public assets such as playground, lookout, beach, car parks etc.
MU4-Bunbury S	Mindalong Beach	Sandy	Straight open coast, sandy beach backed by coastal reserve (Maidens Reserve) Populated town site with public assets such as playground, lookout, car parks etc.
MU5- Bunbury	The Hollow Beach Back Beach	Sandy	Populated coast at Bunbury Straight open coast, sandy beach
	FMB & Big Swamp Wetland	Drainage Channel	Inland area with a low elevation.
	Point Casuarina	Mixed	Low rock outcrops Presence of numerous assets
	Casuarina Drive (South of the Spur Groyne)	Sandy	Backed by Casuarina Drive, sandy beach
	Casuarina Drive (outer Harbour breakwater, Casuarina Harbour)	Physical Control	Bunbury Outer Harbour Berths, breakwater and Casuarina Harbour Key protection for Koombana Bay Casuarina Harbour is currently under development
	Jetty Baths Beach Ski Beach Koombana Beach	Sandy	Protected beach backed by Casuarina Drive Small sandy beach under protection of the Plug breakwater Key public space and assets; Significant developments and recreational facilities
	Marlston Waterfront	Seawall	
	Koombana Bay Sailing Club	Sandy (potential breakwater protection)	Small sandy beach under protection of the Plug & Koombana Beach breakwater

Management Unit	Risk Assessment Zones	Shoreline Type	Comments
	Leschenault Inlet	Foreshore protection + mangrove habitats	Enclosed water Storm surge barrier Protection on southern side Shallow water
MU6-Bunbury Port	Port Area on Eastern Koombana Beach	Seawall	Presence of seawall control Port land
	Inner Port Berths	Seawall	Erosion allowances are not directly relevant.
	Point Hamilla	Sandy	Short stretch of sandy beach between two groynes
	Port Area at South of the Cut	Sandy	Short stretch of sandy beach
	Lower Preston River (North of Australind Bypass)	Riverbank	River flood plain
MU7-The Cut	Turkey Point	Sandy	Unprotected on both the seaside and estuary side
	the Cut	Seawall	Some segments are not built to the design standard
MU8-Bunbury E	Vittoria Bay	River delta	
	Pelican Point	Sandy & man-made Canal	Sandy shoreline on western side Houses connected by canal with physical protection
	Upper Preston River	Riverbank	River flood plain
MU9-Leschenault Estuary	Leschenault Peninsula Conservation Park Cathedral Ave Foreshore	Sandy, tidal flat	Sandy shoreline; No physical controls Sand foreshore backed by vegetated flat and road; No physical controls
	Australind Foreshore	Sandy	Sand foreshore backed by vegetated flat and road. Ridley Place, Leschenault Waterways Discovery Centre & Jetty Walk.
	Point Douro	River mouth	Tidal flat, sandy
MU10-Collie River S	Lower Collie River Nth (Clifton Foreshore) Upper Collie River Nth Wellesley River Brunswick River	Riverbank	River flood plain
MU11-Collie River N	Lower Collie River Sth (Eaton Foreshore) Upper Collie River Sth	Riverbank	River flood plain

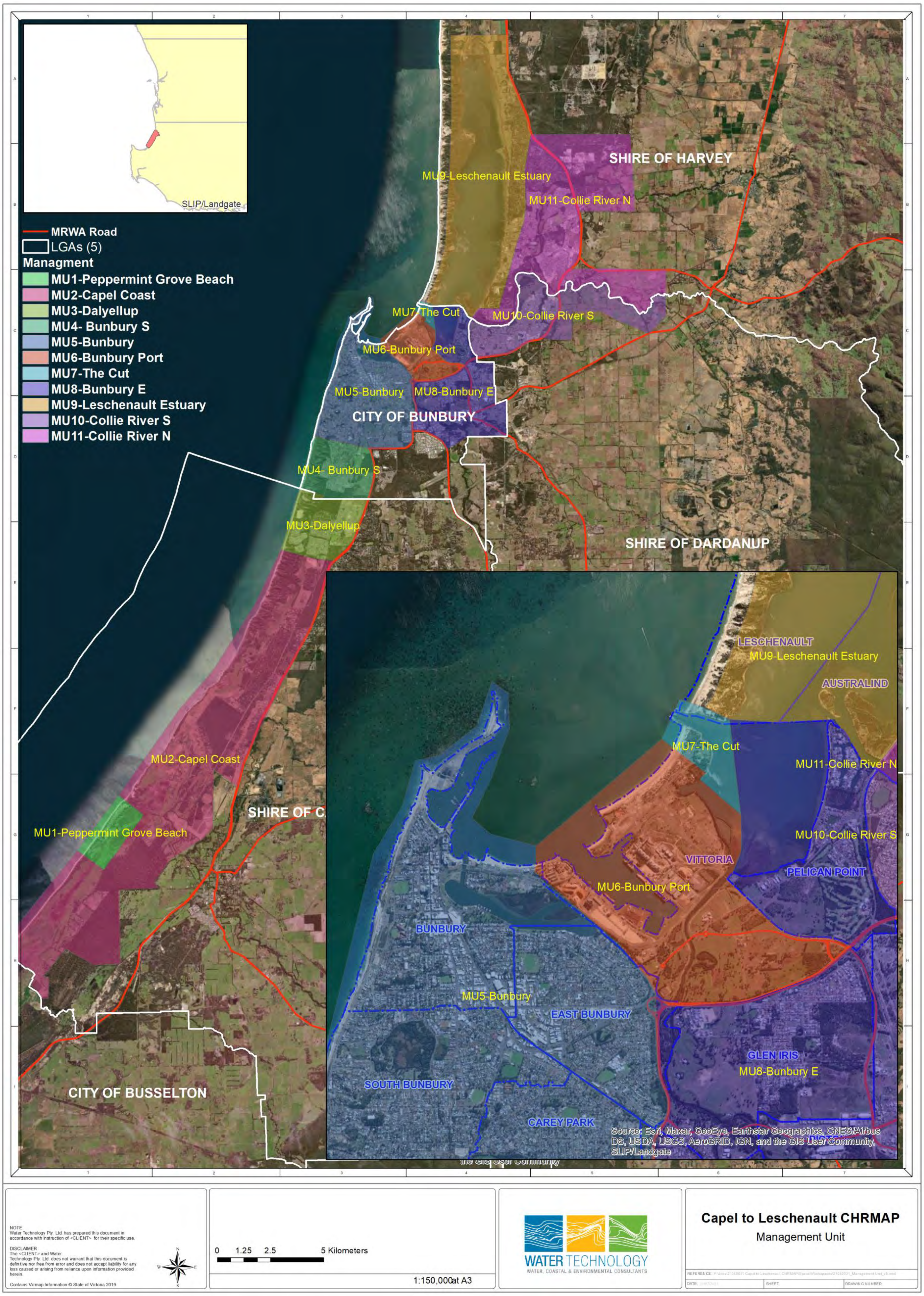

Figure 7-1 Study Area and Management Units

8 COMMUNITY AND STAKEHOLDER ENGAGEMENT

Key to the success of the CHRMAP project will be to ensure that the plan is underpinned by community and stakeholder values and knowledge. To this end, a Community and Stakeholder Engagement Plan has been developed in order to identify relevant stakeholders and determine the structure and pathways for their engagement throughout the CHRMAP process. The plan is intended to be fit-for-purpose, and commensurate with the size and scope of the CHRMAP – so as to avoid consultation fatigue within the community.

This plan has been prepared in accordance with the requirements of, and for consistency with, the following documents:

- Capel to Leschenault Communications Framework (PNP, 2020)
- The International Association of Public Participation (IAP2) documentation

The overarching objectives of the community and stakeholder engagement plan for the CHRMAP are:

- Establish strong working relationships with community networks and stakeholders which are built on mutual trust and respect.
- To ensure all stakeholders have up to date information about the CHRMAP, and the broader coastal management framework that supports the project.
- To provide the community and relevant stakeholders the opportunity to have direct input into the development and delivery of the CHRMAP.
- To understand community goals and aspirations for the coastal zone and community views on values, assets, opportunities and priorities.
- To aid in the identification of key issues and the selection of site-specific CHRMAP management actions to address them. Stakeholders on the ground will have knowledge of the site developed over years of interaction. This provides invaluable information that can be applied to generate innovative CHRMAP measures.
- Increased community and stakeholder understanding of, and support for, actions and priorities in the CHRMAP.

The engagement plan activities for the CHRMAP are outlined below in Table 8-1. The community values and success criteria will be developed during Stage C of the project. These will then be utilised to conduct the risk assessment and development of adaptation options. Additional engagement activities may be required if identified over the course of the project.

Table 8-1 Summary of Engagement Activities

CHRMAP Stage	Engagement Activity	Description	Timing
Stage C: Coastal Assets and Community Values	Prepare for launch of project	Establish Social Pinpoint mapping page for integration with PNP website portal - Social Pinpoint is a customisable community engagement platform which will be used to create a space to share information and keep the community engaged and informed. Provide tailored information for project communications (website content, media release, project information sheet, letter/email content, FAQs) Launch project – live project webpage, social media posts, launch of Coastal Assets and Values Survey to commence engagement phase of the project	29th July 2021
Stage C: Coastal Assets and Community Values	Coastal Assets & Values Survey	Water Technology will prepare a digital survey for PNP's use, to provide the community, and stakeholders with the opportunity to identify areas / assets of value. Values will be categorised to aid the identification process.	29th July 202
Stage C: Coastal Assets and Community Values	Community live-online workshop	Confirm the local community's values, and their perceptions of the key issues facing the study area. In this session, community members will have an opportunity to provide information regarding: ▪ Community uses, and areas of high social, environment and cultural value; and/or ▪ Community concerns regarding potential issues (including their priorities) to be addressed in the CHRMAP. This can also ascertain feedback regarding the current management plans and opportunities for improvement.	2nd September
Stage G: Risk Treatment	Adaptation Options Survey	Survey of community's adaptation preferences and tolerance to different funding alternatives.	TO BE CONFIRMED
Stage G: Risk Treatment	Briefing session	Open house style drop-in session for community members to view proposed adaptation options and confirm preferences.	TO BE CONFIRMED (at mid-point of adaptation options survey)
Stage I: Draft CHRMAP	Public Advertisements of CHRMAP Reports	Draft CHRMAP will be placed on the CHRMAP website for public comment. The document will be emailed / mailed to stakeholders identified as not having access to the CHRMAP website.	TO BE CONFIRMED ~March 2022

9 REFERENCES

City of Bunbury (2013), Leschenault Inlet Master Plan Report

DoT (2015) Coastal Sediment Cells for the Vlamingh Coast Between Cape Naturaliste and Moore River, Western Australia

DoT (2021), Bunbury Waterfront Development Options

Damara (2016), Harvey Coastal Hazard Risk Management and Adaptation Plan – Coastal Hazard Assessment

Damara (2020), Ridley Place Coastal Hazard Risk Management and Adaptation Plan, Australind

DWER (2018), DWER Collie River Master Plan

Intergovernmental Panel on Climate Change (IPCC, 2014). Climate Change 2014: Synthesis Report, Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva, Switzerland, Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)], IPCC, Geneva, Switzerland, 151 pp.

RPS (2015), Section 38 Environmental Referral Document-Koombana Bay Marine Structures

Seashore (2003), Bunbury Coastal Protection – PartA Koombana Beach Coastal Erosion and Design Report

Seashore (2019), Assessment of Coastal Erosion Hotspots in Western Australia

Seashore (2020), Lower Collie River Erosion Management Plan – Easton Scout Hall to Old Traffic Bridge

Western Australian Planning Commission (WAPC, 2006). State Planning Policy No. 2.9 – Water Resources, prepared under the Planning and Development Act 2005.

Western Australian Planning Commission (WAPC, 2013). State Planning Policy No. 2.6 – State Coastal Planning Policy, prepared under the Planning and Development Act 2005.

Western Australian Planning Commission (WAPC, 2017). WA Coastal Zone Strategy, Department of Planning, Lands and Heritage.

Western Australian Planning Commission (WAPC, 2019). Coastal Hazard Risk Management and Adaptation Planning Guidelines.

APPENDIX A
SUPPORTING PLANNING CONTROLS / INFORMATION

A-1 State Planning Documentation

A-1-1 State Planning Policy 3.4: Natural Hazards and Disasters (SPP3.4)

The purpose of the State Natural Hazards and Disasters Policy (SPP3.4) is to encourage local governments to adopt a systematic approach to the consideration of natural hazards and disasters when performing their statutory or advisory functions.

It considers the following hazards:

- Floods - the 100-year average recurrence interval flood should be used as the defined flood event. The floodplain of a defined flood event should be used as the area over which controls on land use and development need to recognise the impacts of flooding. All habitable, commercial and industrial buildings should have their floor levels above the level of the defined flood event.
- Severe storms and cyclones
- Storm surge - where storm surge studies have been undertaken and show that inundation may occur, new permanent buildings should be constructed to take account of the effects of storm surge (including wind and wave set-up). In areas where storm surge studies have not been undertaken, but evidence is available to demonstrate vulnerability to inundation, any development proposals should be supported by studies that demonstrate inundation will not occur.
  - SPP3.4 also makes reference to the need for hazard planning to refer to SPP2.6 for assistance in determining appropriate setbacks in coastal locations.
- Coastal erosion - development in areas affected by coastal processes, especially erosion, should take into account the requirements contained in SPP2.6.

A-2 Regional Planning Documents

A-2-1 Draft Bunbury-Geographe Sub-regional Strategy

The draft Bunbury-Geographe Sub-regional Strategy provides planning guidance for six local government areas (including the City of Bunbury and Shires of Dardanup, Capel and Harvey) and sets out a coordinated, contemporary and considered approach to future growth and development.

Two of the strategy's strategic principles are:

- Protect and enhance environmental values
  - Support the proposed creation of the Preston River to Ocean Regional Park and Leschenault Regional Park, and the protection of the greater Bunbury bushland corridor connecting the two.
  - Preserve and enhance ecological linkages, including a presumption against further fragmentation of these linkages.
- Protect people and property from natural hazards
  - Adopt a presumption against planning proposal within areas identified to be affected by coastal hazards

The strategy discusses coastal vulnerabilities, advising that settlements in close proximity to the coast are vulnerable to possible impacts from a changing climate including coastal erosion, coastal and fluvial flooding and inundation.

Increased population puts rising pressures on coastal and marine environments including those associated with:

- Tourism and recreation, including 4WD access to beaches
- Increased use of the foreshore
- Sewage disposal
- Nutrient run-off and other pollutants
- Climate change and sea level rise
- Erosion, inundation and sediment transport
- Marine debris
- Invasive species.

A-2-2 Greater Bunbury Region Scheme

The aims of the Greater Bunbury Region Scheme include to protect as regional open space the region's coastal foreshores, the foreshores of the Harvey, Brunswick, Collie, Preston and Capel Rivers, and the Leschenault Estuary and Inlet, as well as other areas of regional conservation significance and areas for regional recreational facilities.

The purpose of Reserves Waterways includes to recognise permanently inundated inland and coastal lands below the high-water mark, and existing and proposed water canals.

Schedule 3 of the scheme states that for schemes, subdivisions and developments which impact on Regional Open Space, Crown conservation or nature reserves, Environmental Management Plans may be required in accordance with specifications in Attachment 1 of the Minister for the Environment's "Statement that a Scheme may be implemented" No.000697 published on 31 October 2005, and subsequently implemented in accordance with the provisions of the Management Plan (to the satisfaction of the WAPC).

A-2-3 Greater Bunbury Strategy

One of the key challenges for the area is to protect and enhance biodiversity by:

- Identifying and protecting the health of the Greater Bunbury sub-region's rivers, wetlands, underground water sources, and the Leschenault Estuary and Inlet, and quality remnant vegetation from inappropriate development.
- Seeking and securing funding in conjunction with relevant stakeholders so that appropriate land for conservation and biodiversity can be identified, acquired and managed in the long-term.
- Effectively engaging with and resourcing community groups.
- Ensuring that development occurs in a way that safeguards and enhances the existing environmental, biodiversity and scenic assets.
- Better managing natural hazards within new developments, including flooding, coastal erosion and inundation, bushfire hazard and acid sulfate soils.

Two key delivery areas are:

- Regional open space and areas of environmental significance - Comprehensive assessment and implementation and ongoing funding and management of potential regional open space and areas of environmental significance to protect natural resources and support the growth of a compact and connected Greater Bunbury, including:

  - Estuary coastal dune systems;
  - Remnant vegetation;
  - Long term management responsibilities and funding;
  - Identification of priority areas that could be considered for rehabilitation and ongoing management as part of an environmental offsets program; and
  - The finalisation of the Preston River to Ocean Regional Park and an equivalent regional park established to the north of Bunbury city.
- Coastal management - Preparation and implementation of a coastal management plan including:
  - Taking into account the anticipated impacts of climate change such as rising sea levels, storm surge, effect on biodiversity; and
  - Establishing means of ongoing funding and management, especially opportunities for local community groups.

A-3 Local Planning Documents

A-3-1 Shire of Capel Coastal Strategy 2005

The Capel Coastal Strategy identifies several principles relevant to the ongoing management of the Shire's coastline. These have been based on the various coastal management policies and position statements released by the State Government over the past 20 years, culminating in the release of SPP2.6.

The principles cover issues such as environmental protection, public interest and community participation and guidelines for coastal development.

The strategy advises that an understanding of the environmental and social characteristics of the Shire's coastlines is essential for effective coastal management and provides a technical framework for the preparation of management strategies and recommendations.

Consultation with the community and relevant Government agencies provided significant input into the strategy. A range of coastal management strategies have been identified to provide a context for more detailed, location-based recommendations. The strategies provide a broad direction for coastal management over the entirety of the Shire's coastal areas. They provide guidance on issues such as coastal administration and tenure, environmental management, access and use conflict, facilities and signage/design.

Relevant recommendation strategies include:

- Support the development and implementation of an Education Strategy to focus on coastal and environmental management.
- Support the preparation of a Weed Strategy for the entire Capel Coastline.
- Consider supporting a driver education program for off-road vehicle use on the Shire's beaches.
- Evaluate and monitor the impacts of 4WD vehicles and general beach access on nesting habitats and migratory bird species in dune areas.
- Continue rehabilitation works on dunes at the main Peppermint Grove Beach.
- Maintain the pedestrian access paths at the Hardey Terrace car park.
- Fence the vehicle access track at the Hardey Terrace car park.

- Close and rehabilitate informal access tracks over the dunes, and install periodic signage directing pedestrians to formal tracks.
- Prepare a detailed Foreshore Implementation/Action Plan for the Peppermint Grove area that consolidates, updates and provides a mechanism for ongoing management of the foreshore, based on the preliminary foreshore management plan.
- Upgrade signage at Forrest Beach car park to clearly delineate zones for land uses.
- Delineate a vehicle and boat launching exclusion area along the main section of the Peppermint Grove Beach.
- Consider the closure of the vehicle access track at the main Peppermint Grove Beach as part of a future Foreshore Implementation/Action Plan for this area and following further consultation with the community. In the interim, install better signage and directions at this location to ensure that illegal vehicle use of the beach adjoining the boat launching area is reduced.

These and all other strategy recommendations will be considered as part of the development of the CHRMAP's adaptation options.

A-3-2 Shire of Capel Local Planning Strategy 2021

A few of the key land use planning issues outlined in the Shire's Local Planning Strategy relate to the CHRMAP. These are:

- Protection of environmental and coastal assets.
- Protection of the community from natural hazards such as bushfire and flooding.
- Protection and enhancement of essential infrastructure.
- Protection and enhancement of community infrastructure.
- The strategy outlines five primary objectives derived from the above, one of which is to preserve and enhance the natural and built environment.

In addition, the strategy seeks to promote measures to reduce the impact of development on climate change and promote greater resilience within communities to the effects associated with climate change such as sea level rise and water supply. An according strategy to manage coastal areas requires identified land along the coast to be reserved as Regional and Public Open Space in the local planning scheme and for CHRMAPs to inform the local planning scheme.

A-3-3 Shire of Capel Local Planning Scheme No.7 (LPS7)

The Shire's LPS7 has a Foreshore Protection Area zone and speaks to the protection of its coastal area.

Development is controlled within the Foreshore Protection Area. The Council's objectives in controlling development are to:

- Protect the foreshores of the ocean, rivers, watercourses and lakes from development which may cause land degradation, including that resulting from wind and water erosion; and
- Permit the use of land in a manner consistent with the long-term stability of the foreshore land.

This includes preserving and protecting against development which may or could destroy the existing physical characteristics and flora adjacent to the coast, except:

a. A public road.

b. A public footpath.

c. A building for the use or convenience of the general public.

and for which Council approval has been given. This shall be permitted generally within 100 metres of the seaward crest of a stable sand dune, which is undisturbed by wave or wind erosion.

Notwithstanding the above, the Council may approve of a use and/or development with a greater or lesser setback where in an adopted Coastal Management Plan or Outline Development Plan approved in accordance with clause 5.10 of the Scheme text.

A-3-4 Peppermint Grove Beach Land Use Strategy 2013

Engagement undertaken in 2012 to prepare the strategy established that characteristics that are valued and considered important to the community were:

- Sleepy village character
- Seaside hamlet
- Ocean/coast views
- Quiet, uncrowded
- Connected community
- Relative isolation
- Natural environment
- Native flora and fauna
- Access to beach
- Capel River
- Boating and fishing
- Diverse built form.

The coastal values survey will confirm and update these values, and consideration of adaptation option for Peppermint Grove.

The Foreshore Precinct includes the existing foreshore conservation reserves, recreation reserves and community purpose areas between the beach and the developed residential areas. Ongoing development and population growth, combined with the popularity of the beach during the holiday period has placed increased pressures on the foreshore from land use conflicts and environmental degradation.

The impacts of informal access tracks across the vegetated dunes and feral rabbits require ongoing management to address erosion and vegetation removal.

Strategies for the precinct include:

- Improving pedestrian path connectivity to the beach, recreation areas and community focal nodes.
- Ensuring the ongoing conservation and integrity of the foreshore dunes and the beach environment generally.
- Managing and, where necessary, controlling access to the beach via informal tracks across the vegetated foreshore.
- Addressing the ongoing management of any identified fire risk on the foreshore.

- Implementing the relevant remaining actions of the Peppermint Grove Beach Management Plan subject to available funding.

The values and strategies from the document will help inform the preparation of the CHRMAP and potential adaptation options. These values and strategies will be updated as required based on community feedback.

A-3-5 City of Bunbury Draft Local Planning Strategy

The Draft Local Planning Strategy (2017) speaks to priority focus areas, one of which is the Natural Environment.

Strategies include the facilitation of planning, regulation and works to address processes that pose a threat to the condition and abundance of living native organisms in Bunbury, the promotion of ecologically sustainable development and the investigation of further opportunities to support the protection of the natural environment through land use planning.

A-3-6 Koombana Bay and Casuarina Drive Master Plan

The project has the following high level design objectives:

- Improve social spaces along the foreshores supporting the development of the marine components
- Improve the tourism appeal of Bunbury
- Create an accessible and connected waterfront
- Connect with and respond to adjacent development plans
- Assess and plan for coastal vulnerability
- Establish sustainability and resilience design principles to minimise environmental impacts
- Plan for future development through provision of services

The Koombana Master Plan sets out to create a regionally significant coastal precinct within the Greater Bunbury region. The Master Plan presents the opportunity to reinforce the existing beach character within the project areas by:

- Improving Koombana Bay's foreshore amenity areas and reducing coastal vulnerability.
- Improving Casuarina Boat Harbour beach by increasing the quality of the sandy beach.
- Strengthening the natural character of BP Beach by a natural approach to vegetation, access and landscape interventions.

A-3-7 Leschenault Inlet Master Plan

The Leschenault Inlet Master Plan provides an overarching framework and strategic direction to the development of the public space around the Leschenault Inlet (The Inlet) for the next 20 years. The Master Plan includes consideration of the impact of climate change and potential future development.

The vision for the Master Plan is:

'*To plan, develop and manage the Leschenault Inlet and its environs to become an attraction of National and International quality and significant contributor to the continuous improvement of the character, amenity and economic viability of the Bunbury City Centre*.'

The objectives are:

- Protect and enhance the natural attributes of the Inlet environment.
- Provide for a diverse range of accessible activity areas that promote and facilitate community engagement, active and passive recreation and civic and cultural activities.
- Promote the Inlet as a major attraction to support investment and growth of the tourism industry in particular, and City Centre business generally.

The community vision is for Leschenault Inlet to be natural, clean, accessible and fun. It is recommended as a gathering place for the community and should tell the Bunbury story. From this vision the broad objectives for the Inlet are to:

- Clean and green the Inlet and surrounds
- Improve the facilities
- Keep it low cost
- Maintain it for the public
- Provide practical solutions.

There is a desire to improve the access to and around the Inlet, stage its roll out, get community support for projects and consider multiple sources (possibly commercial) to fund it. There is a risk that the influence of climate change will impact the Leschenault Inlet and the surrounding low-lying urban area. Risks that have been identified include:

- Increased risk of inundation of urban areas through sea level rise and increased storm surge.
- Increased salinity of the Inlet through decreased rainfall.
- Reduced groundwater quality and availability.
- Decreased rainfall.

The document states that planning and management will need to be responsive into the future as knowledge improves. Consideration will need to be given to other strategies beyond coastal defences in the future.

Inundation is considered to be a threat to Bunbury due to extensive low-lying urban areas around the Leschenault Inlet. However, the risk of flooding is largely mitigated by the Bunbury storm surge barrier constructed at the western end of the of the Inlet. The CHRMAP will not model the inclusion of this barrier however, as it is modelling a "worst case" scenario from a coastal inundation perspective.

The flood mitigation management is an important aspect of Leschenault Inlet. The key aims of the management strategy are to:

- Protect the natural systems.
- Protect people and property from the potential of flooding.

The potential threat of inundation is mitigated by two factors:

- Local mitigation through a system of seawalls, levees and revetments (ranging in height from +1.5 - +1.7m AHD); and
- Management of coastal flooding through the use of Bunbury storm surge barrier within the 'Plug'.

Based on an evaluation of the condition of the sea walls and the operation of the barrier, the following priority areas have been identified:

- Monitor barrier management to ensure it is operated to maximise the stormwater runoff holding capacity in the Inlet water body during a storm event.

- Raise the seawall/revetment/ levee around the Inlet to minimum of +1.7 AHD.
- Upgrade the stone revetment on Koombana Drive.
- Upgrade the seawall along Frank Buswell Reserve.
- Introduce a terrace behind the Waterfront Promenade seawall to achieve the +1.7m AHD levee height.
- Ensure the flood escape routes along Blair Street and Stirling Street are maintained.
- Planning and management will need to be responsive into the future as knowledge improves. Consideration will need to be given to other strategies other than the construction of sea walls.

These action recommendations will be investigated as part of the CHRMAP development.

A-3-8 Shire of Harvey Local Planning Strategy

The Shire's Local Planning Strategy recognises the issue of climate change and the potential for sea level increases as identified under SPP2.6. In this regard, the Shire commits to working with the PNP with a goal of establishing an appropriate planning framework to adequately deal with these matters into the future.

The Shire completed its CHRMAP for the entire open ocean coastline in 2016 and the CHRMAP was adopted in February 2017. Appropriate scheme provisions will be included within LPS2 to provide guidance on the best way to manage (defend or retreat) coastal infrastructure and areas of future development.

The Shire will spatially define coastal areas which are prone to sea level increases and include provisions within LPS2 to ensure development is undertaken accordingly. An SCA is to be included in LPS2 and appropriate scheme provisions are to be established for development.

The Shire also acknowledges that in certain locations within the Shire, rural land parcels possess significant environmental values which reduce their capacity to be utilised for agricultural purposes. In particular, the existence of remnant native vegetation, conservation status waterways, ecological linkages and lots in coastal areas are most affected.

A-3-9 Shire of Harvey District Planning Scheme No. 1

The Shire's District Planning Scheme objectives include to preserve and enhance places of natural beauty particularly along the coast, the rivers and inlets and the scarp, and to preserve historic buildings and objects of historical and scientific interest.

A-3-10 Shire of Harvey CHRMAP

The CHRMAP supports long-term coastal management and planning for the Shire's coastal assets. The Plan has been developed following SPP2.6 requirements and guidelines, with consideration of local attributes. The CHRMAP considers the Shire of Harvey open coast, which extends from the southern tip of Leschenault Peninsula to the northern Shire boundary, approximately 11 kilometres south of Preston Beach. The town centres at Binningup and Myalup are included.

Key coastal planning and management issues that may result from potential coastal hazards were identified through consideration of stakeholder values. Identification of values included community liaison through workshops and discussion with the project steering group, in their roles as representatives of key stakeholder interest groups.

The Plan acknowledges present-day coastal management issues faced by the Shire and considers how possible coastal change may affect town site and strategic planning over the next 100 years. Adaptation strategies are recommended to mitigate adverse consequences related to future coastal hazards.

The CHRMAP suggests that a substantially greater degree of planning assessment and dialogue with the State Government is required to develop a fully functional approach, and that further refinement of the planning approach is recommended over the next few years.

The CHRMAP recommends a two-level approach to planning, policy and tenure be adopted by the Shire.

1. Regional Planning: Regional Open Space
   a. The Regional Open Space Reservation of the Greater Bunbury Region Scheme needs to be more extensive along the Harvey coast, recognising its regional significance and the implications that actions outside the Shire can have on this section of coast. The actual extent of reservation needs to be agreed between the Shire, affected landowners and the WAPC, however it is recommended that as a minimum the mobile dune is reserved.
2. Local Planning: Local Planning Scheme
   a. The Shire has significant ability to influence land use planning at a local level. the Shires Local Planning Scheme may consider the following mechanisms to provide the appropriate planning response:
      i. Coastal Management Zone to cover all lots with frontage to the coast.
      ii. Coastal management Special Control Area within Binningup and Myalup to a line 150m landward of the existing coast; and
      iii. Specific requirement for Structure Plans prepared in accordance with Scheme Provisions to consider coastal processes.

A-4 Other Relevant Planning Documents

A-4-1 Bunbury Port Inner Harbour Structure Plan

The Bunbury Port Inner Harbour Structure Plan has been developed to guide development and decision making within the Inner Harbour. It contains the Leschenault Estuary immediately north of the Port and a remnant of the estuary to the south with both these water bodies connected to Koombana Bay via man-made channels.

Technical studies undertaken for the preparation of the structure plan included flood management and hydraulic modelling, dredge management planning and oceanographic studies.

The current position of the lower Preston River channel from the Australind Bypass Bridge to the estuary is highly modified from its original alignment prior to European settlement having been excavated and realigned over the last 50 years following several serious flood events and with the construction of the Inner Harbour.

The technical study reports that the existing Preston River channel is flanked by levees on its left and right banks along its length through the Inner Harbour area. These levees are designed to contain the 100-year Average Recurrence Interval (ARI) flood event. The final one kilometre of the river channel is flanked by the Inner Harbour where land on its northern bank has been filled and raised and is considered to be resilient to a 500-year ARI flooding event.

Realignment of the Preston River is proposed to increase the capacity of conveying the 500-year ARI flow through to Vittoria Bay and reducing the flood risk to East Bunbury residents compared to current day.

Figure A-1 Bunbury Port Inner Harbour Structure Plan Area

A-4-2 Bunbury Port Development Long Term Monitoring and Management Plan

This document describes the Long-Term Monitoring and Management Plan (LTMMP) for continued maintenance dredging and potential capital dredging programmes associated with future harbour expansion projects, for the period 2012 to 2022.

It is the intention of this LTMMP to guide the management and monitoring of maintenance and possible capital dredging and ocean disposal activities over a period of ten years (approximately three maintenance dredging cycles). A dredging cycle may incorporate multiple dredging campaigns depending upon the availability of dredges and the size and complexity of the programme and the extent to which harbour areas are subject to sediment and sand accumulation due to seasonal variations.

A-4-3 Koombana Bay CHRMAP

The CHRMAP covers the Transforming Bunbury's Waterfront (TBW) project area, along the shorelines of southern and western Koombana Bay. The CHRMAP area is defined as the foreshore and infrastructure included in the TBW project, and is based solely on the ultimate development configuration of coastal structures at the completion of stage 3 as currently planned.

The coastal hazard assessment considers erosion and flooding hazards associated with different storm scenarios. Significant infrastructure has been delivered in the project area through urban renewal projects. This infrastructure has become key assets at risk from coastal erosion and inundation hazards.

Based on the hazard assessment and a subsequent coastal vulnerability and risk assessment, coastal erosion presents an immediate level of risk to Casuarina Drive and its associated values that is intolerable due to the access it provides to Casuarina Breakwater, the Southern Ports Authority Outer Harbour and the proposed Casuarina Harbour and mixed-use developments as part of the TBW project.

In addition, in the short-term, monitoring and ongoing maintenance are necessary to monitor and minimise the effect of coastal hazards on the key attributes that the community value. In the medium to long term, decisions regarding continued interim protection will need to be made.

The document and recommendations for coastal management will be considered in the development of the CHRMAP to establish if there have been any changes which warrant updating the coastal hazard assessment and coastal vulnerability and risk assessment components or whether the analysis undertaken in this project is still sufficient.

A-4-4 Leschenault Regional Park Establishment Plan (2017) and Kalgalup Regional Park Draft Management Plan (2020)

The Leschenault Regional Park Establishment Plan was prepared to define the land in the park, qualities of the park, propose a model for the vesting and management of the park and provide an overview of the future statutory processes applicable to the park such as vesting procedures, management plan preparation, region scheme amendments for the reservation of land to allow for additions to the park, and community consultation.

Subsequently Kalgalup Regional Park Draft Management Plan (DBCA, 2020) has been prepared and released for comment. The plan provides for the protection and enhancement of the conservation recreation and landscape values of the Park. The plan supersedes the Leschenault Regional Park preparatory work and aims to conserve the special features of the park and sustainably manage its values and community use. The park consists of Regional Open Space identified in the Greater Bunbury Region Scheme covering over 3,000ha across three separate locations:

- East and northeast of Bunbury mainly along the foreshores of the Leschenault Estuary and Inlet and the Collie and Brunswick rivers including the lands within the Leschenault Peninsula
- South of Bunbury about 5km from the city centre and mainly within the City of Bunbury
- Southeast of Bunbury along the foreshores of the Preston River

The estuary and rivers within the park provide a landscape value for the residents of Harvey, Dardanup and the surrounding region. Maintenance and careful management of the foreshore areas, which are likely to be subject to predicted future increases in storms and coastal erosion processes as a result of climate change, will assist in protection of surrounding developments.

The CHRMAP development will consider these social values and the extent of physical changes and impact on the estuary and rivers from storms and coastal processes.

Figure A-2 Koombana Bay CHRMAP Area

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Capel to Leschenault CHRMAP

Chapter Report: Coastal Hazard Assessment

Peron Naturaliste Partnership

14 April 2022

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14 April 2022

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Dear Joanne

Chapter Report: Coastal Hazard Assessment

We are pleased to present the Capel to Leschenault Coastal Hazard Risk Management and Adaptation Plan Chapter Report: Coastal Hazard Assessment. If you have any queries, please do not hesitate to contact me on (08) 6555 0105.

Yours sincerely

Joanna Garcia-Webb
Principal Coastal Engineer | Western Australia Regional Manager

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WATER TECHNOLOGY PTY LTD

EXECUTIVE SUMMARY

It is internationally recognised that the mean sea level has been rising globally since the nineteenth century and is predicted to rise at an increasing rate in the future (IPCC 2021). Rising sea levels and intensifying storm activity will increase the risk of coastal inundation (temporary coastal flooding), storm erosion and long-term shoreline recession. State governments across Australia have introduced statutory obligations that require local governments to consider and plan for these hazards. In Western Australia (WA), the governing policy is the Western Australian Planning Commission's (WAPC) State Planning Policy No. 2.6: State Coastal Planning Policy (WAPC, 2013, herein referred to as "SPP2.6"). SPP2.6 recommends management authorities develop a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for land use or development that is potentially vulnerable to coastal hazards. Specific guidelines have been developed to assist in this process (WAPC, 2019).

SPP2.6 requires adequate risk management planning is undertaken where existing or proposed development is in an area at risk of being affected by coastal hazards over the 100-year planning timeframe. SPP2.6 and the CHRMAP Guidelines provide the risk assessment framework to be applied to identify risks that are intolerable to the community, and other stakeholders such as local governments, indigenous and cultural interests, and private enterprise. Risk Management measures are then developed according to the adaptation hierarchy outlined in SPP2.6.

The Peron Naturaliste Partnership (PNP) comprises membership of nine local government authorities. The PNP's Coastal Adaptation Pathways Project identified the coastal areas of Capel, Leschenault and Greater Bunbury as being particularly exposed to coastal hazards and climate change, which triggered the need for this CHRMAP. The aim of the present study is therefore to investigate the nature and severity of coastal hazards which are likely to affect these regions from Capel to Leschenault over future planning horizons. Refer Figure 1-1 for locality and study area extent. Appendix A contains a suite of locality plans identifying specific beaches, features, locations etc noted within the report, as well as the designated management units (Water Technology, 2021).

The objective of this CHRMAP project is to increase knowledge and understanding of coastal hazard risks, and identify risk management and adaptation measures for implementation. The outcomes will be used to inform local and state government policies, strategies and plans, including (but not limited to); planning strategies, community strategic plans, drainage strategies, asset management plans, emergency management plans, and foreshore management plans. The project will adhere to the WAPC (2019) guidelines with scope and deliverables to be consistent with the objectives identified by these guidelines and SPP2.6. The project will identify the strategic direction for coastal adaptation scenarios from the present-day to 2120 (100 yrs. management time frame), and identify an implementation plan to achieve this direction. Overall, this CHRMAP will develop a flexible adaptation pathway for the region and serve as a key reference for management, planning and policy making for the short-term (0-15 years), medium-term (15-30 years), and long-term (100 years).

This report presents the Coastal Hazard Assessment Chapter Report, which identifies the coastal hazards in the study area that need to be considered in the CHRMAP. Hazard maps are produced defining the erosion and inundation extents for present day, 2035, 2050, 2120. The flow chart displayed in Figure 1-2 indicates where this component sits with reference to the greater study; the 'Coastal Hazard Assessment' phase corresponds to the top part of the bubble shaded in red, presented below.

A summary of the coastal hazards, erosion and inundation is presented in Table 6-1. The full hazard maps are presented online for interactive viewing at the following link:

https://watech.maps.arcgis.com/apps/webappviewer/index.html?id=d43c39fda97d426ea6192d1a7a8543cf

Coastal Hazard Assessment – to understand coastal processes & hazards & identify areas at risk

- TBC: Site Investigation (as required)
  - To gain greater understanding of coastal processes and issues identified during Establishing the Context.
  - Collection of georeferenced photographs and notes for future reference.
- Coastal Hazard Assessment
  - Inundation Hazards
  - Erosion Hazards
- Coastal Hazard Mapping
  - Mapping of all coastal inundation and erosion scenarios at appropriate scale.

Identification of Coastal Assets and Values

- Community Engagement and survey to identify key coastal assets and values
- Coastal asset Information provided by the PNP or from other organisations
- Incorporation of site inspection outcomes (if conducted)

The study area covers a complex shoreline with various types of coastal hazards present in this region. The presence of rivers, an estuary and inlet has increased the complexity of the study, in particular the assessment of inundation hazards where river flood plays a more dominant role than the intrusion of ocean water. **It is acknowledged that the hazard identification component of the present study has been undertaken to provide a broad understanding of exposure than can support government planning at a regional level - and will be superseded once site-specific studies become available, in particular at the estuary/inlet and along the river courses**. Results derived from this study should not be over-interpreted at a micro-scale due to the assumptions applied and the limitations in model resolution. More detailed risk assessments and analysis may be required for the development of detailed engineering measures for specific sites. No geophysical or geotechnical assessments have been undertaken across the study to date. Erosion response across the study area may differ in reality to the predictions of this study due to the lack of data. Further geophysical/geotechnical assessment will be a recommendation of this CHRMAP

ABBREVIATIONS

Abbreviation	Description
AEP	Annual Exceedance Probability
ARI	Average Recurrence Interval
CHRMAP	Coastal Hazard Risk Management and Adaptation Plan
DoP	Department of Planning (now part of DoPLH)
DPLH	Department of Planning, Lands and Heritage
DoT	WA Department of Transport
HSD	Horizontal Shoreline Datum (see SPP2.6)
IPCC	Intergovernmental Panel on Climate Change
HAT	Highest Astronomic Tide
LAT	Lowest Astronomic Tide
LGA	Local Government Area
MHHW	Mean High High Water
MLHW	Mean Low High Water
MSL	Mean Sea Level
MHLW	Mean High Low Water
MLLW	Mean Low Low Water
SLR	Sea Level Rise
SPP2.6	State Planning Policy No 2.6: State Coastal Planning Policy (2013)
WAPC	Western Australian Planning Commission

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1 INTRODUCTION

It is internationally recognised that the mean sea level has been rising globally since the nineteenth century and is predicted to rise at an increasing rate in the future (IPCC 2021). Rising sea levels and intensifying storm activity will increase the risk of coastal inundation (temporary coastal flooding), storm erosion and long-term shoreline recession. State governments across Australia have introduced obligations that require local governments to consider and plan for these hazards. In Western Australia (WA), the governing policy is the Western Australian Planning Commission's (WAPC) State Planning Policy No. 2.6: State Coastal Planning Policy (WAPC, 2013, herein referred to as "SPP2.6"). SPP2.6 recommends management authorities develop a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for land use or development that is potentially vulnerable to coastal hazards. Specific guidelines have been developed to assist in this process (WAPC, 2019).

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The Peron Naturaliste Partnership (PNP) comprises membership of nine local government authorities. The PNP's Coastal Adaptation Pathways Project identified the coastal areas of Capel, Leschenault and Greater Bunbury as being particularly exposed to coastal hazards and climate change, which triggered the need for this CHRMAP. The aim of the present study is therefore to investigate the nature and severity of coastal hazards which are likely to affect these regions from Capel to Leschenault over future planning horizons. Refer Figure 1-1 for locality and study area extent. Appendix A contains a suite of locality plans identifying specific beaches, features, locations etc noted within the report, as well as the designated management units (Water Technology, 2021).

The objective of this CHRMAP project is to increase knowledge and understanding of coastal hazard risks, and identify risk management and adaptation measures for implementation. The outcomes will be used to inform local and state government policies, strategies and plans, including (but not limited to); planning strategies, community strategic plans, drainage strategies, asset management plans, emergency management plans, and foreshore management plans. The project will adhere to the WAPC (2019) guidelines with scope and deliverables to be consistent with the objectives identified by these guidelines and SPP2.6. The project will identify the strategic direction for coastal adaptation scenarios from the present-day to 2120 (100 yrs. management time frame), and identify an implementation plan to achieve this direction. Overall, this CHRMAP will develop a flexible adaptation pathway for the region and serve as a key reference for management, planning and policy making for the short-term (0-15 years), medium-term (15-30 years), and long-term (100 years).

Delivery of this project will occur over 9 stages (as summarised in Figure 1-2), each of which represents a key hold point. The staged approached is developed according to the PNP's scope and is in line with the CHRMAP Guidelines (WAPC, 2019).

This report presents the Second Stage: The Coastal Hazard Assessment Chapter Report, which identifies the coastal hazards in the study area. Hazard maps have been produced that define the erosion and inundation extents of varying magnitude (severity) for present day, 2035, 2050, 2120. The flow chart displayed in Figure 1-2 indicates where this component sits with reference to the greater study; the 'Coastal Hazard Assessment' phase corresponds to top part of the bubble shaded in red.

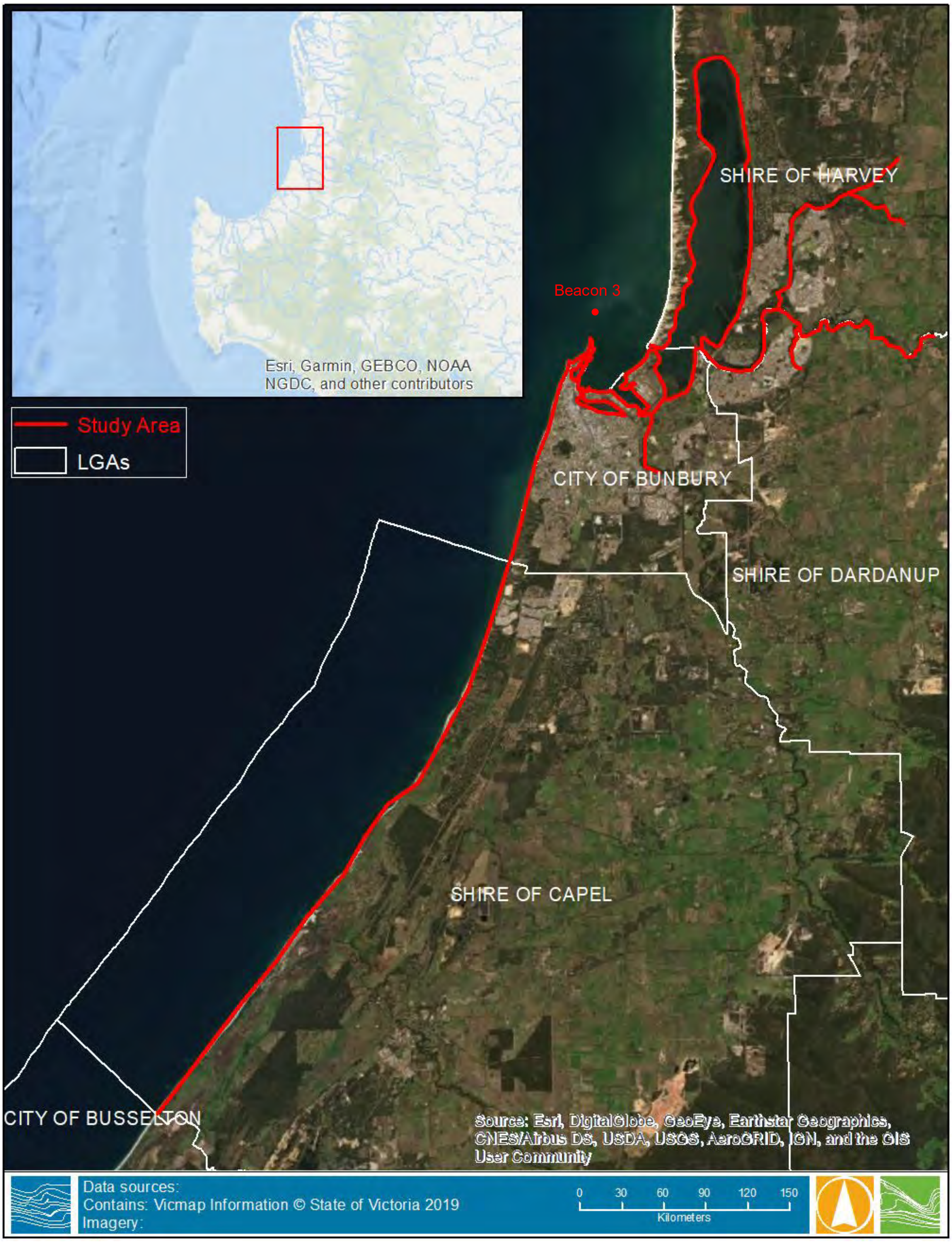


FIGURE 1-1 PROJECT AREA

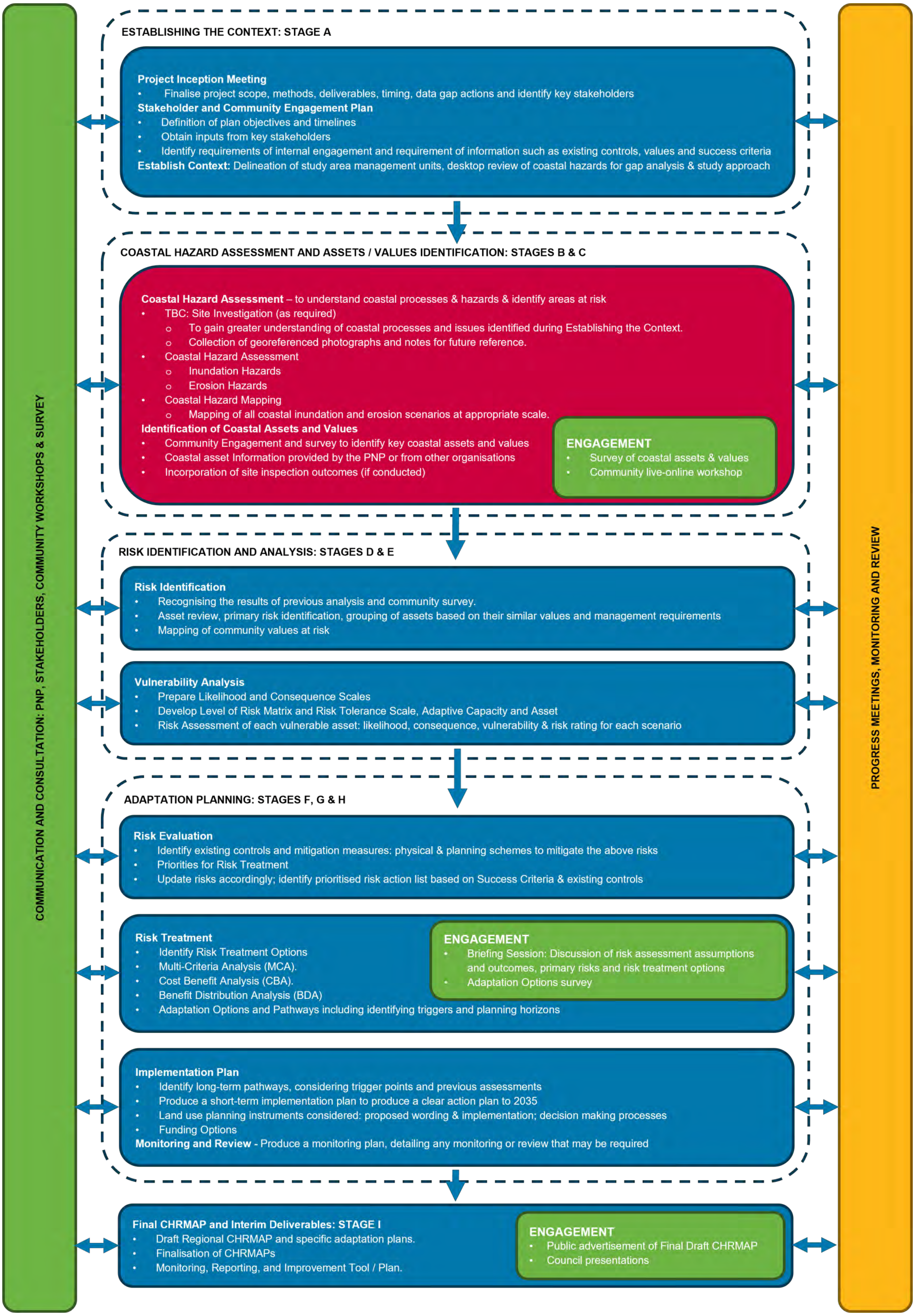


FIGURE 1-2 CHRMAP METHODOLOGY FLOW CHART (ADAPTED FROM WAPC, 2019)

2 DESKTOP REVIEW

2.1 Key Documents

Key documents and datasets have been reviewed to provide context for this coastal hazard assessment on metocean processes, coastal processes and existing coastal hazard information. Any sources of information identified as directly relevant to inform this CHRMAP have been utilised, referenced and reported below as well as subsequent chapter reports. As per Section 1, Appendix A contains a suite of locality plans identifying specific beaches, features, locations etc noted within the report.

2.2 Metocean Condition

2.2.1 Water Levels

Water levels over the project region comprise variations from astronomical tide, wind and wave setup, atmospheric pressure, seasonal and interannual anomalies, riverine discharge, and periodic impacts of tropical cyclones, coastal trapped waves and tsunamis.

The Bunbury tide gauge provides one of the longest water level records in WA, consisting of "paper trace" records back to the 1930s and digital records since 1985.

2.2.1.1 Tide Planes

Tidal planes at Bunbury are presented in Table 2-1 (from Austides 2018 and DoT 2010a). These have been calculated from over 30 years of tidal data recorded at the Bunbury tidal gauge. Tidal motion of the region can be characterised by a dominant diurnal tide, meaning one high tide and one low tide per day. Tidal range is approximately 0.8 m during spring tide and can be much smaller during the neap phase.

TABLE 2-1 TIDAL PLANES

Tidal Plane	HAT	MHHW	MLHW	MSL	MHLW	MLLW	LAT
AusTides 2018 (m AHD)	0.63	0.36	0.25	0.01	-0.23	-0.34	-0.58
DoT 2010a (m AHD)	0.67	0.39	0.28	0.04	-0.20	-0.29	-0.57

2.2.1.2 Non-tidal Water Level Variability

Variations in water level are caused not only by astronomical tides, but also by phenomena including wind and wave setup, atmospheric pressure, and oceanographic variations including seasonal heat budgeting, Leeuwin Current, coastal trapped waves, La Niña effects, pacific decadal oscillation etc.

Wave dissipation and breaking causes water to "pile up" against the coast (wave setup). Atmospheric pressure leads to local changes in sea level, with high pressure lowering the sea level and low pressure increasing the sea level, a process referred to as the inverse barometric effect.

Along the Western Australian coastline, it has long been recognised that oceanographic processes have a substantial influence on seasonal and interannual variability in coastal sea levels, which shows some correlations with the El Nino Southern Oscillation (ENSO) cycle (Pearce & Feng, 2013). Since the 1990s, the Pacific Decadal Oscillation (PDO), with its multidecadal time scale of 20–30 years, has also swung to a negative phase, sustaining positive heat content and more frequent cyclonic winds off the Western Australian coast. These large-scale ocean climate drivers are thought to have led to stronger La Nina over the past two decades. This process is recorded to have caused, for example, approximately 0.3 m water level increase during the 2011 La Nina event which is not related to either tide or local winds. Impacts from these oceanographic processes may be enhanced in the future due to the increased risk of extreme La Nina events under a warmer climate.

2.2.1.3 Storm Surge

Storm Surge

In the Southwest WA region, storm surges arise in relation to strong winter storms moving out of the Southern Ocean, as well as tropical cyclones travelling from the tropics south into the area.

- Winter low pressure storm systems have typical wind speeds of about 20 m/s. Winter storms are the main driver of frequent storm surge and erosion events recorded. Severe winter storms can generate water levels exceeding 1.5 m AHD, as recorded during a winter storm on 16th May 2003. This is about 0.9 m above the HAT level.
- Wind speed from tropical cyclones, even after extra-tropical transformation, may still reach 30 m/s or above. The highest storm tide (1.84 m AHD) level was recorded during TC Alby on 4 April 1978. This was about 1.2 m above HAT level. Tropical cyclones have the potential to generate greater storm levels than winter storms due to stronger wind gusts.

Desktop Review

Geoscience Australia (GA), the then Western Australian Department of Planning (DoP) and the Western Australian Planning Commission (WAPC) collaborated to develop a storm surge modelling methodology for Bunbury (Fountain et al 2010). The study provided the DoP and WAPC an assessment of inundation hazards based on a range of storm surge and climate change scenarios for Bunbury. Model results identified some vulnerable areas over the low-lying land proximal to Koombana Bay and around the Leschenault Inlet/Estuary. A storm surge level of over 2.3 m AHD was predicted for a worst-case synthetic cyclone event (modified from TC Alby track). Results provided in this study will be used to inform the preparation of the current CHRMAP study in terms of the inundation hazard assessment as they are considered fit for purpose.

Damara (2011) estimated the extreme water levels at Bunbury using over 20 years of water level data from the Bunbury tide gauge. Damara (2020) provided an update of this estimate (Figure 2-1). MPRA (2015, Section 2.5) undertook an extreme value analysis using 23 years of DoT data and 48 years of the former Public Works Department data (in total 71 years). Review results are summarised in Table 2-2:

TABLE 2-2 EXTREME WATER LEVELS AT BUNBURY TIDE GAUGE – DESKTOP REVIEW

ARI	1yr	5yr	10yr	50yr	100yr	500yr
Damara 2011 (m AHD)	0.94	1.25	1.32	1.44	1.49	
MPRA 2015 (m AHD)	1	1.2	1.3	1.6	1.7	2.0
Seashore 2018(m AHD)						2.9
Damara 2020 (m AHD)	0.93		1.23		1.55	2.6

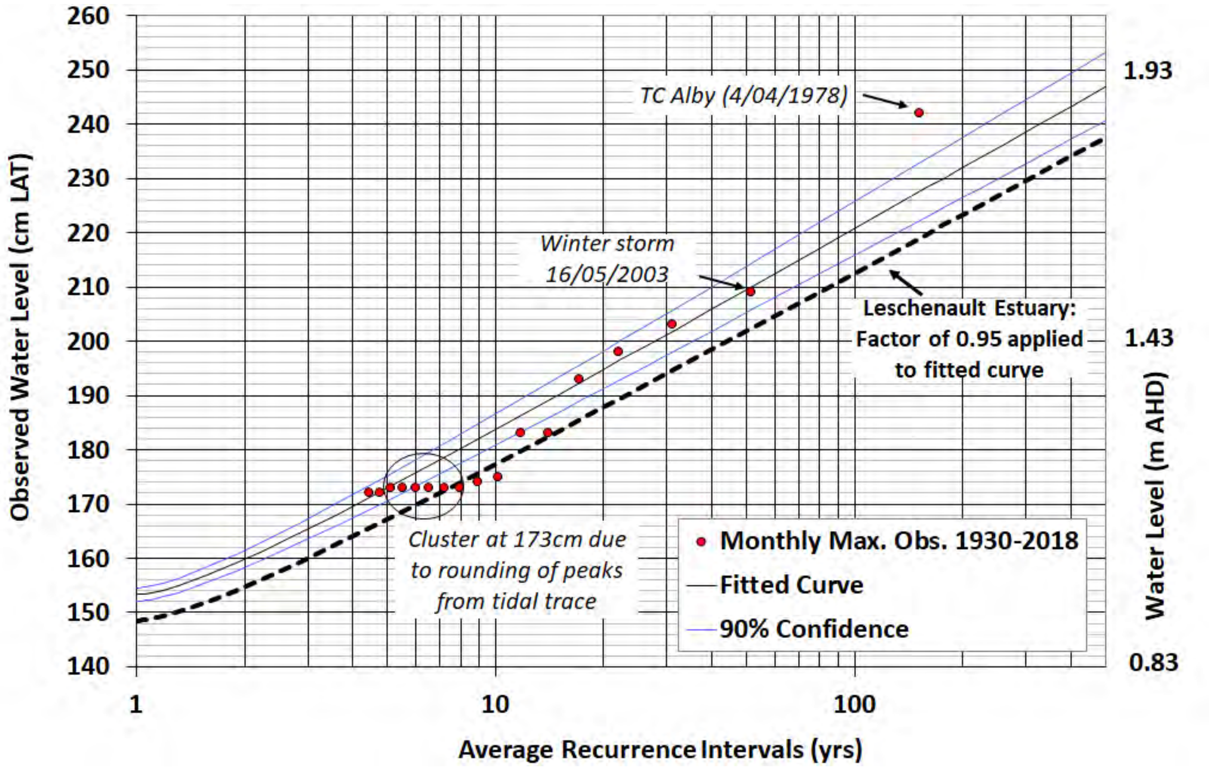


FIGURE 2-1 EXTREME WATER LEVEL ANALYSIS (DAMARA, 2020)

2.2.1.4 Tsunami

Tsunamis are often generated by earthquakes in subduction zones, where the earth's tectonic plates converge. Tsunami waves can propagate for thousands of kilometres across the ocean before dissipation. Burbidge (2008) identified that there have been at least three recorded major tsunami events affecting the Western Australian coast over the last few decades. These include the 1977 Sumbawa, 1994 Java and 2004 Sumatra-Andaman earthquakes. The strongest impacts were found along the northwest coast of Australia, with impacts reducing substantially towards the southwest region (see Figure 2-3). Tsunami hazard usually occurs at a lower frequency than storm surge and river flood events. Nonetheless it remains key information that should not be overlooked for any government planning policies.

Davies & Griffin, (2018) updated the 2008 assessment and produced results in finer detail around Australia. Figure 2-2 presents the results at the 25m contour offshore from the study area: a tsunami wave height of 1.6-1.8m is predicted for the 500 yrs. ARI. This translates to approximately 3.6-4m wave height nearshore if applying Green's Law, the tsunami wave shoaling theory. These values are significantly higher than the values predicted in the 2008 study. From this data the inundation levels are likely to be similar to that of the 500 yrs. ARI storm surge levels. However, the occurrence of earthquakes and tsunami waves are difficult to predict, and therefore there are large uncertainties associated with such estimations.

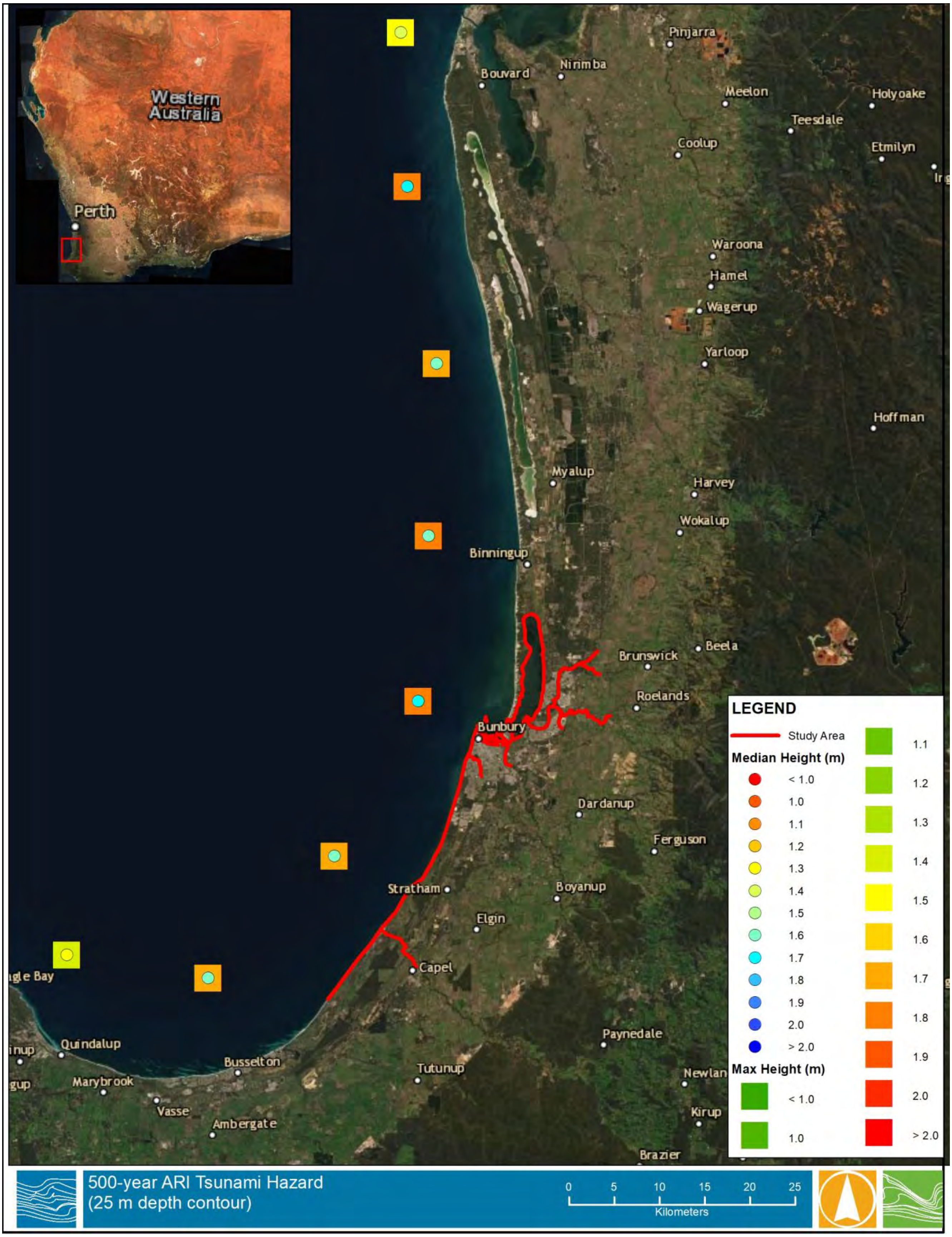


FIGURE 2-2 PREDICTED TSUNAMI MAGNITUDE AT 25M DEPTH CONTOUR: MAXIMUM (SQUARE) AND MEDIAN (CIRCLE) (DATA SOURCE: DAVIES & GRIFFIN, 2018, HTTPS://WWW.GA.GOV.AU/ABOUT/PROJECTS/SAFETY/PTHA)

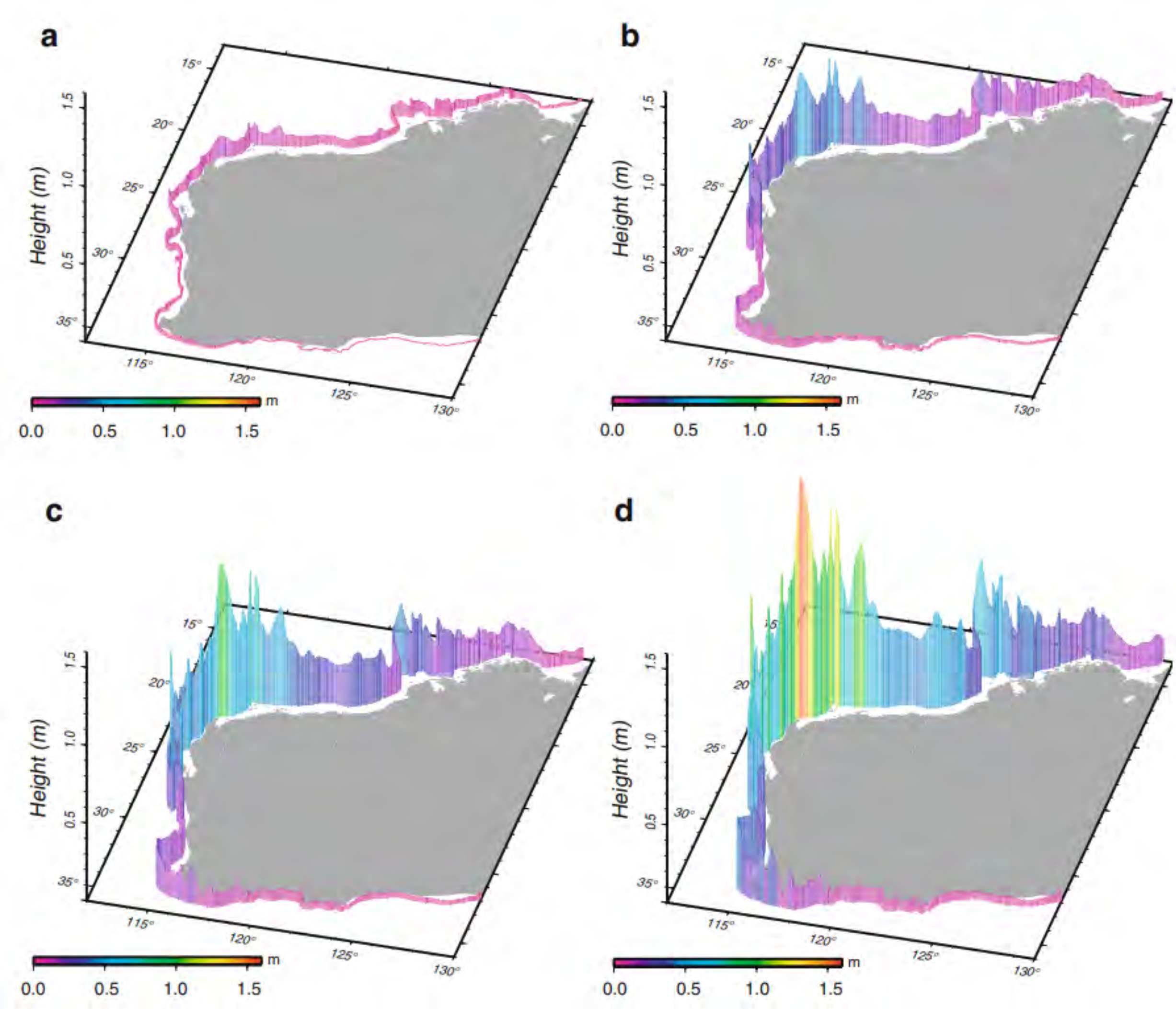


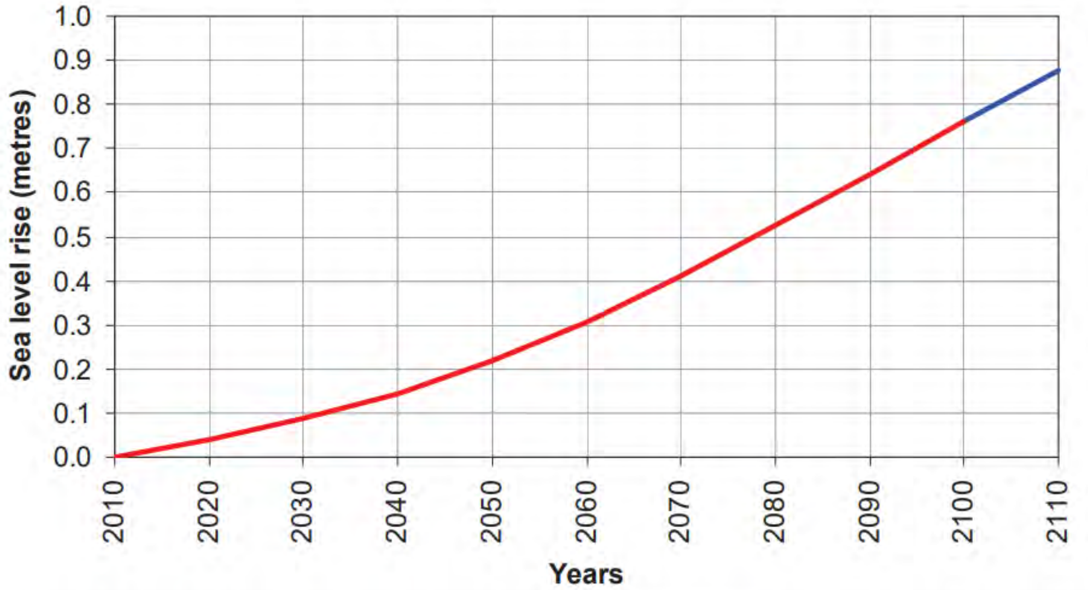
FIGURE 2-3 TSUNAMI HAZARD ASSESSMENT MAP AT 50M DEPTH CONTOUR (A-100YEARS, B-500 YEARS, C-1000YEARS AND D-2000YEARS, TAKEN FROM BURBIDGE (2008))

2.2.1.5 Sea Level Rise

Bicknell (2010) recommended allowances for sea level rise (SLR) application in coastal planning in Western Australia are presented in Table 2-3. The current recommended SLR for 2110 is +0.9 m above 2010 levels - with 0.01 m/year to be added for every year beyond 2110. It is noted that this SLR scenario is consistent with the latest projections provided in the Intergovernmental Panel on Climate Change (IPCC 2021) Sixth Assessment Report (AR6).

TABLE 2-3 SEA LEVEL RISE

Planning Time Frame (yrs.)	2010	2020	2030	2050	2070	2090	2120
Sea Level Rise (m)	0	0.04	0.08	0.22	0.42	0.64	0.98



2.2.2 Wind Climate

2.2.2.1 Wind Climate

In order to assess the local coastal wind climate, wind records from Bunbury Port Beacon 3 (Easting 374019.6, Northing 6315284.3, GD92 MGA 50, see red dot in Figure 1-1) anemometer have been assessed. Wind rose plots (Figure 2-4) show that the study area wind climate has both seasonal and diurnal characteristics:

- Wind conditions at Bunbury are moderate. Wind records at Beacon 3 show a median wind speed of ~5 m/s and a 95th percentile wind speed of ~10m/s (8 m height, 10 minutes' duration).
- The land-sea breeze cycle is a dominant feature of the region, typically with an easterly wind in the morning and a southerly to westerly wind in the afternoon.
- During the spring-summer (Oct-April) period, the typical wind is predominantly south-easterly to south-westerly. For winter months (May-Sep), however, wind conditions become more variable in terms of both speed and direction.
- Damara (2020) extreme wind analysis (based on 16 years of Beacon 3 wind data, wind speed adjusted to 10 m height, see Figure 2-5) shows the strongest storm winds tend to originate from the west, with wind speed varying from about 19.7 m/s for a 1 yrs. ARI event to over 26 m/s for a 100 yrs. ARI event. For easterly directions (0 - 180 $^{\circ}$N), extreme wind speeds are less than 20m/s for all investigated ARIs.
- These wind-rose plots are based on single point measurements. Wind conditions may vary along the coast due to the variation of shoreline orientation/formation; however, the general wind climate (moderate wind, seasonal and diurnal cycle) should be consistent within the project domain.

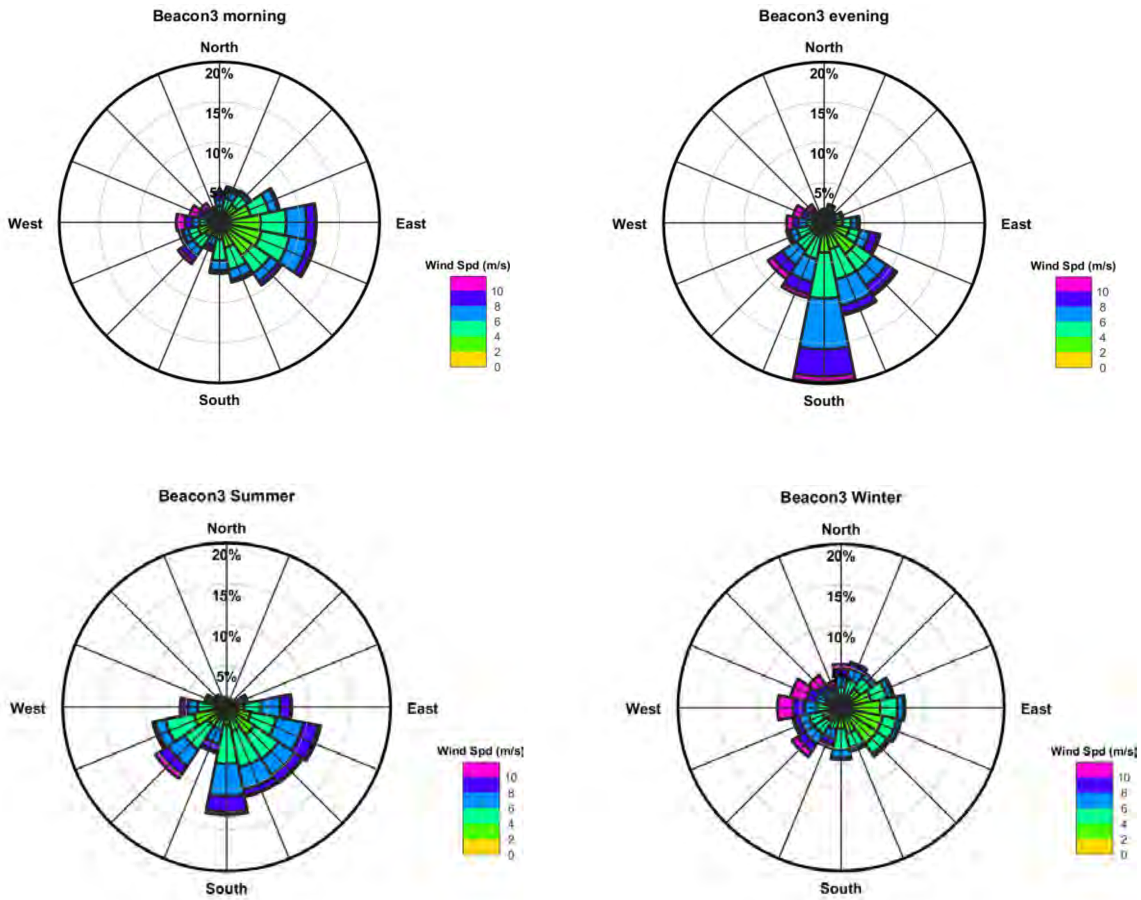


FIGURE 2-4 WIND ROSES AT BEACON 3 (JAN 2012- JAN2021)

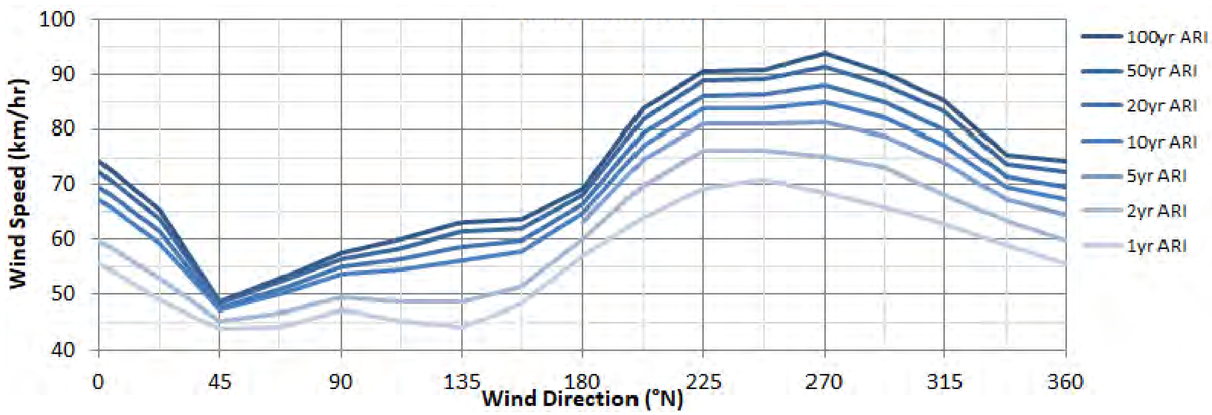


FIGURE 2-5 DIRECTIONAL EXTREME WIND SPEEDS (FROM DAMARA (2020))

2.2.2.2 Tropical/Extra-tropical Cyclones

Tropical Cyclones or extra-tropical transformation of Tropical Cyclones occur primarily between December and April, and occur much less frequently in adjacent months (e.g., TC Mangga in May 2020). Unlike northwest coast of Western Australia where tropical cyclone occurs at a regular basis, the southwest region does not experience cyclones frequently. Tropical cyclones can have a greater impact (in terms of coastal hazards) than winter storms due to the following factors.

- **Extreme Winds** – Maximum wind speeds are a function of the central pressure, the radius to maximum winds, the forward speed of the cyclone and local topographic effects. Cyclonic winds circulate clockwise in the southern hemisphere; however, wind fields are generally asymmetric such that the strongest winds are generally observed on the left-hand side of the direction of cyclone movement. A review of available cyclone track records indicates that a number of cyclones were reported to have gust speeds exceeding 50m/s, although these speeds were not measured over land. Typical cyclonic wind speeds on land have regularly exceeded 30 m/s. This is often beyond the range of the projected extreme wind speeds based on Extreme Value Analysis (EVA) of short-term wind records.

- **Extreme Waves** – Tropical cyclones generate extreme ocean waves as a result of energy transfer from the cyclone winds to the ocean surface. The growth of ocean waves is determined by water depth, wind speed, wind duration and the distance for winds to act over (fetch). Extreme waves can be much higher during tropical cyclones than regular winter storms.
- **Extreme Storm Surge** – A phenomenon of rising water commonly associated with low pressure weather systems (such as tropical cyclones and strong extratropical cyclones). It is driven by the combined action of wind setup, atmospheric pressure reduction and wave setup. Its severity is affected by the shallowness and orientation of the water body relative to the storm path and the magnitude of storm surge may be amplified in a semi-enclosed water body. The peak storm surge often only lasts for a few hours near the region of maximum wind speeds. Occurrence of extreme storm surge at high tide is relatively rare, however such a combination would have potentially catastrophic consequences particularly in semi-enclosed shallow waters, such as Koombana Bay.
- **Intense Rainfall** – The rain bands of a tropical cyclone can expand up to 1,000 km in diameter, with heaviest rainfall usually located at the eye wall. This implies a degree of correlation between extreme storm surge and rainfall during tropical cyclones which may amplify the inundation hazard for the low-lying Leschenault Inlet and Estuary regions.

Review of BoM cyclone database show two key cyclones that have affected the study area.

- **TC Alby** in 1978. TC Alby was one of the most devasting tropical cyclones to affect the southwest coast of Western Australia. It was first noted in the tropical region over 1,000 km to the north of the northwest coast where it started to form. Quickly it intensified and formed a Category 5 cyclone (estimated lowest centre pressure is about 930 hPa in the Indian Ocean and then moved southwards parallel to Western Australian coastline. It underwent an extra-tropical transition near Cape Leeuwin and gradually lost energy in the following days. As per the BoM report, the observed lowest pressure at Cape Leeuwin is about 972 hPa. During the 2nd and 3rd of April winds generated by the storm reached an estimated peak of 200 km/h. At Bunbury, winds were strongest during the period 04 April 10:00 to 04 April 13:30 GMT. Some wind gusts noted at the Bunbury Power Station exceeded 130 km/h (or ~36 m/s).
- **TC Bianca** in 2011. Bianca was a low-pressure system which developed over land near Wyndham on the 21st January. The maximum sustained wind speed recorded during TC Bianca was 96 km/h at Bedout Island at 10.30 am AWST (02:30 UTC) and at 11.20 am AWST (03:20 UTC) 26th January as the system passed to the north of the island. The maximum 3-second wind gust was 118 km/h at 10.30 am AWST (02:30 UTC), 11.20 am AWST (03:20 UTC) and 11.30 am AWST (03:30 UTC) 26 January. The system gradually dissipated over open water to the west of Perth. Although it did not land, strong wind gusts and hail damages were reported by local news.

2.2.3 Wave Climate

2.2.3.1 Wave Climate

Wave climate off the southwestern Australian coastline is dominated by the deep-water swell waves generated by large-scale weather systems over the Indian and southern Oceans. It shows little spatial variation for a large area extending from Perth to over 200 km south of Perth. The seasonal variation is however significant, which is determined by the regional meteorological climate. There are generally four sources of wave energy at Bunbury:

- Offshore swell (from west to southwest) from the Southern Indian Ocean with typical wave periods between 12 to 16 s. Typically, larger waves occur during the winter months (stormy season) than the summer months (calm season).
- Storm waves generated by winter storms associated with mid latitude depressions.
- Wind seas generated by the local sea breeze pattern from the west to southwest that are most dominant in Spring and Summer (October to April).
- Tropical/ extra-tropical cyclones that occasionally pass through Bunbury (e.g., TC Alby in 1978).

Along the Capel coast, nearshore wave conditions are to a large extent dominated by offshore waves.

At Bunbury, waves inside Koombana Bay are attenuated due to the sheltering from the Outer Harbor breakwater. The area is generally well-protected from westerly storms but shows is more exposed to northerly storms.

Wave conditions inside Leschenault Inlet and Leschenault Estuary are independent from offshore waves. For these confined water bodies, waves are primarily wind driven, subject to modulation of water depth, wind forcing and wind fetch. As storm winds are primarily westerly, stronger wind seas are more likely to be encountered on the eastern/south-eastern side of the estuary/inlet.

2.2.3.2 Extreme Wave Condition

Offshore

Lemm (1999) investigated the offshore wave climate on the southwest coast of Western Australia and noted that the offshore wave height can reach about 6.7 m and about 9.8 m for a 1 year and a 100 yrs. ARI event respectively.

ASR (2011) conducted an extreme value analysis of wave heights using 6 years of wave data obtained at Rottnest Island wave buoy. The predicted extreme waves were in general higher than Lemm (1999). The dominant extreme waves were either westerly or south-westerly with significant wave height (Hs) ranging from 9 m for 1 year ARI to ~11 m for 100 years ARI storms.

MPRA 2018 Design event selection provided a list of design storms for erosion hazard assessment which was selected using criteria of total wave power rather than extreme value analysis of highest waves. These events are used in this study for the purpose of erosion extent modelling.

Koombana Bay

Damara (2011) undertook an investigation into erosion and coastal processes affecting the eastern end of Koombana Beach as part of the preliminary design of the Point Busaco revetment. Analysis of Bunbury AWAC data (Southern Ports Authority, SPA) by Damara (2011), described in Seashore (2013), is shown in Table 2 4. The analysis is based on 14 years of data at Beacon 3 and 3.5 years of data at Beacon 10. It indicates over 55% reduction in wave heights between the two points as a result of the wave refraction and diffraction.

TABLE 2-4 EXTREME WAVE HEIGHTS AT SPA AWACS (SEASHORE, 2013)

	1 yr	2 yr	5 yr	10 yr	20 yr	50 yr	100 yr
Beacon 3	2.7	3.0	3.1	3.2	3.3	3.3	3.4
Beacon 10	0.9	1.1	1.2	1.3	1.4	1.5	1.6

Casuarina Harbour

DoT deployed two AWACs near the entrance and inside the Casuarina harbour (2015-2016). Data shows that the maximum of measured wave heights reduces from about 0.6 m near the entrance to about 0.2 m inside the harbour. Wave energy is thereby low for this semi-enclosed waterbody.

Leschenault Estuary

Damara (2020) has investigated the extreme wave conditions inside the estuary. A hindcast of wave conditions from 2011-2018 suggests a maximum significant wave height (Hs) of 0.6 m and that exceptionally strong winds are required to generate wave height above 0.7 m (>100 years ARI event). This implies a reasonably low wave energy environment for the estuary.

Leschenault Inlet

Wave information inside Leschenault Inlet is not available. The inlet is small and confined, and therefore the local wave climate is expected to be low energy and dominated by local sea waves.

2.3 Coastal Processes

2.3.1 Geomorphological Setting

Geomorphological processes drive the long-term landform evolution, and regional scale shoreline movement. The location of beach waterlines and vegetation lines changes over a range of time scales:

- At the geological scale (10,000-100,000+years), coastal change is dominated by long-term (eustatic) sea level change and large-scale geological processes primarily dealing with the location and movement of rock.
- At geomorphic scales (100-10,000 years), coastal evolution is determined by the sediment transport driven by regional and local metocean climate and sediment provenance and availability.
- Over planning scales (10-100years), sediment sources and sinks and pathways due to local landform changes and metocean climate and weather events.
- Over coastal management scales (days to 10 years), significant changes occur due to storms – generally cross-shore erosion, as well as seasonal shoreline variations that are linked to the seasonality of the local wave climate.

The geomorphological setting at the project site was described in detail in Searle and Semeniuk (1985) and Semeniuk et al. (2000). Stratigraphic profiles (Figure 2-6) show that the foreshore region consists of Safety Bay sand at the foredune, underlain by Leschenault Formation (typically below the elevation of MSL) / Becher Sand and a limestone/clay/sandy clay foundation underneath. This stratigraphic profile is generally representative for coasts between Busselton and Bunbury.

In the past 6,000 years, there have been significant shoreline variations (Semeniuk et al. 2000). At geological scales, this shoreline has a variable nature due to limited rock features and presence of mobile sand ridges.

The foreshore is generally characterised by simple offshore bathymetry, sand dunes parallel to the coast and depressions/wetlands/lakes between dune ridges. Studies have noted the presence of underlying limestone rock in some areas, but it is seldom observed above mean sea level. Outcropping basalt rock is present between Rocky Point and Casuarina Point above mean sea level at Bunbury. Beach sands are predominantly made up of quartz from re-working of Holocene deposits. Some calcareous sand is present from adjacent estuaries and seagrass beds and riverine inputs are minimal.

2.3.2 Sediment Cells

Sediment cells are spatially discrete areas of the coast within which marine and terrestrial landforms are likely to be connected through processes of sediment exchange, often described using sediment budgets. Sediment cells are used to assist coastal planning, management, engineering, science, and governance along the coast.

The project domain comprises multiple sediment cells including R06A-3(c, d), R06A-4 (a, b) and R06B-5a (Stul et al, 2015). A summary of sediment cells is provided in Table 2-5 below and in Figure 2-7 to Figure 2-9.

TABLE 2-5 SEDIMENT CELL SUMMARY (STUL ET AL, 2015)

Sediment Cell	Study Area	Geomorphological Feature
R06A-3d	Forrest Beach to the mouth of Capel River, up to -15 depth offshore	Broad shallow waters and sandy beaches; Parabolic dunes or frontal dunes; Land depression behind the dune.
R06A-4a, b	The mouth of Capel River to Bunbury Harbour, up to -15 m depth offshore	Narrow parabolic dunes or frontal dunes; Land depression behind the dune.
R06B-5a	Koombana Bay, up to -15 m depth offshore	Estuarine landforms, flood-prone land with installed mitigation works; Rock structure restricting sediment transport; Adjacent cells have a different shoreline aspect; Presence of engineered structures.

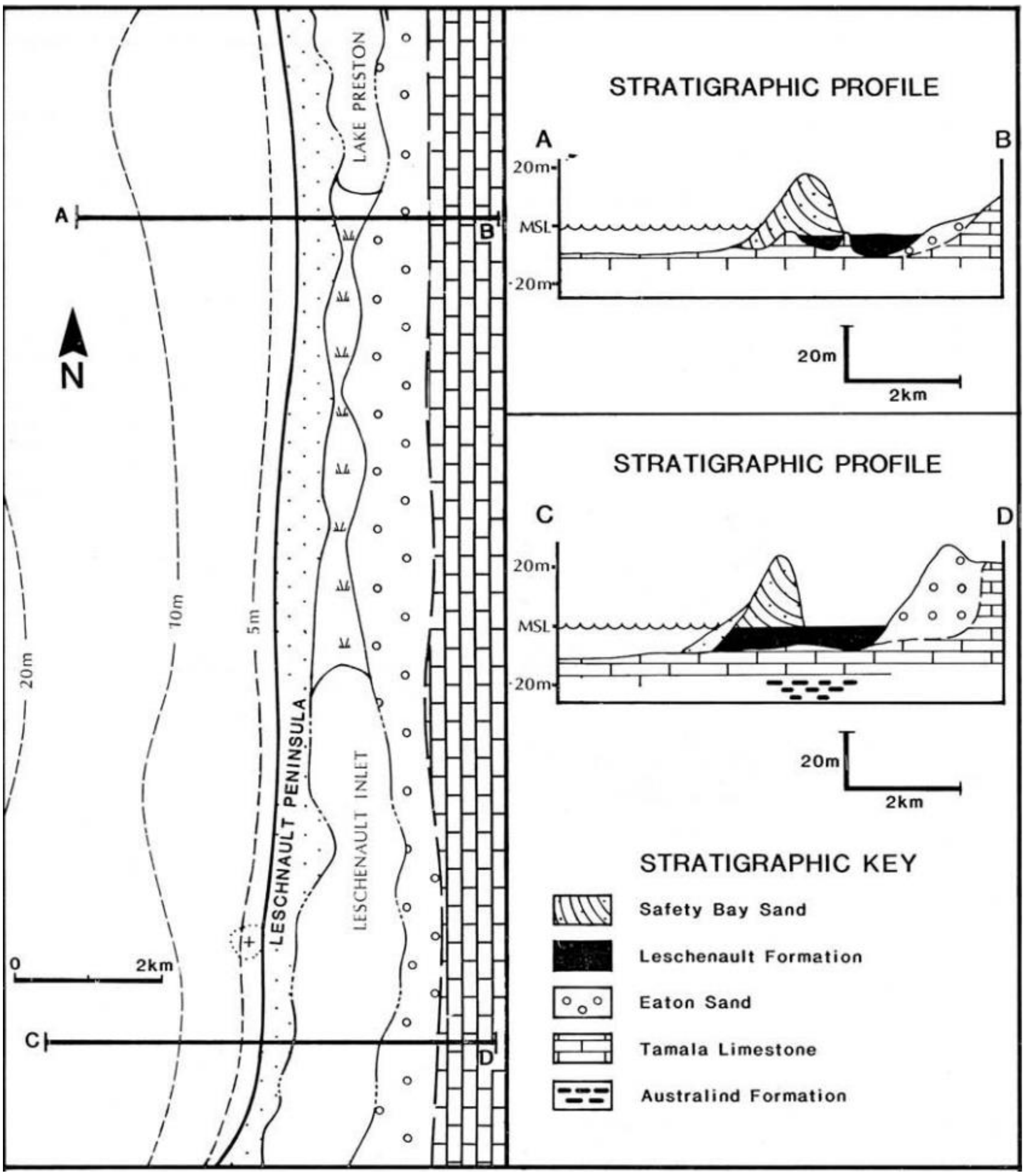


FIGURE 2-6 REGIONAL MORPHOLOGY AND STRATIGRAPHIC PROFILES (SEARLE AND SEMENIUK (1985))

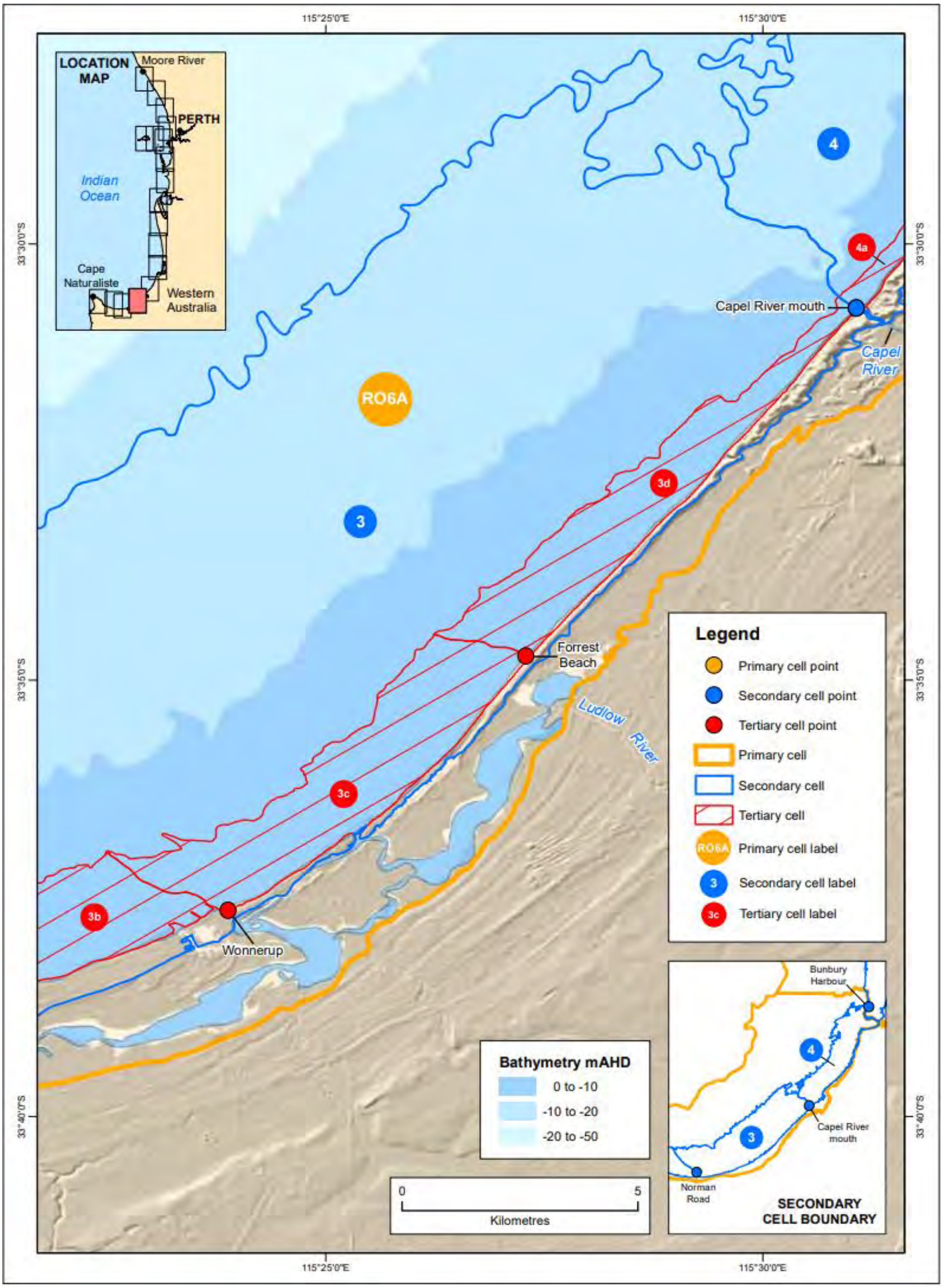


FIGURE 2-7 SEDIMENT CELL (WONNERUP TO PEPPERMINT GROVE BEACH). IMAGE SOURCE: STUL ET AL (2015)

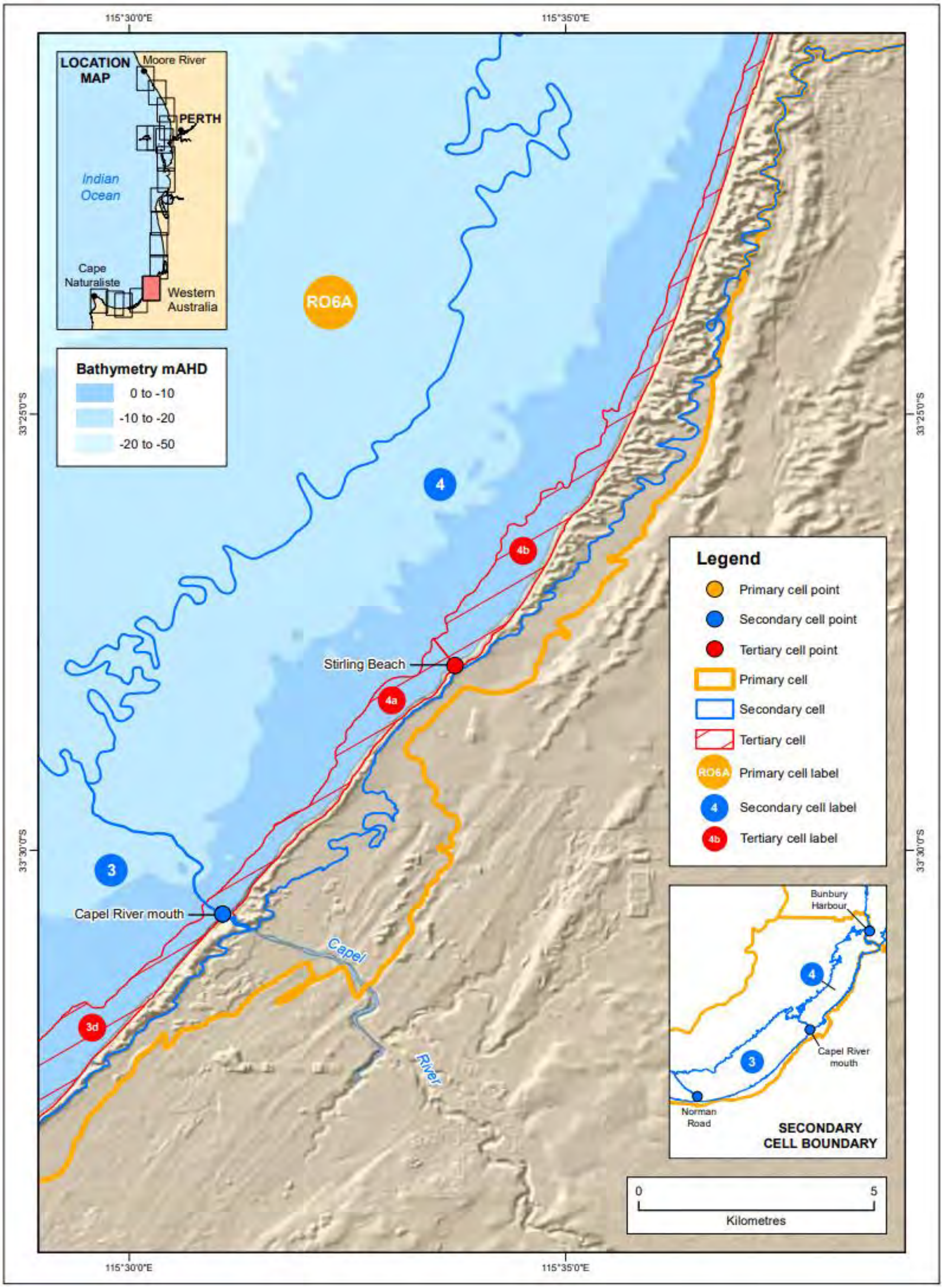


FIGURE 2-8 SEDIMENT CELL (CAPEL)). IMAGE SOURCE: STUL ET AL (2015)

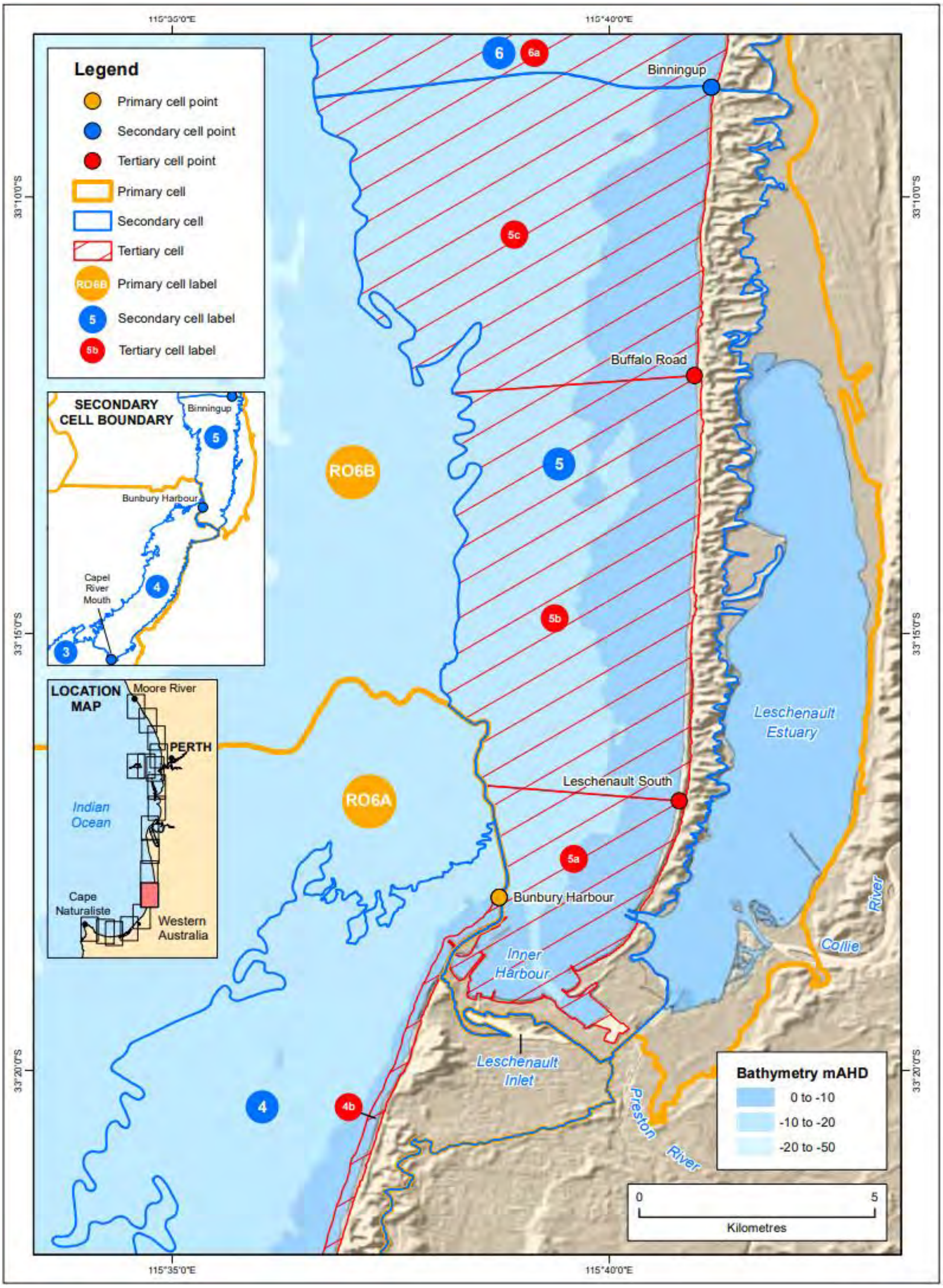


FIGURE 2-9 SEDIMENT CELL (BUNBURY TO LECHENAULT ESTUARY). IMAGE SOURCE: STUL ET AL (2015)

2.3.3 Sediment Transport and Local Morphology

The alongshore sediment transport within the project domain predominantly flows in a northwards direction, driven by the dominant westerly/south-westerly swells throughout the year. Temporary southwards longshore transport may be experienced during a storm generating northerly winds and waves – and these may occur in both winter and summer (less likely) months.

The dynamics of beach formation and local scale morphological changes have been assessed through the review of historic reports and aerial imagery sourced from Google Earth and Metro Map (high resolution) for key locations in the study area from south to north.

2.3.3.1 Peppermint Grove Beach

Morphological changes along Peppermint Grove Beach (Table 2-6) have been reviewed with results summarised as:

- Capel River mouth experiences occasional breaches. The location of the river mouth is generally stable, but this is understood to be influenced by occasional active management by the Water Corporation
- Beach width variation has been observed. Some significant storm erosion was experienced close to the river mouth as shown in 2005 image.
- In general, there was no clear observation of significant net long-term erosion or accretion. Vegetation line is stable and consistent over the past 16 years.

TABLE 2-6 SATELLITE IMAGES – PEPPERMINT GROVE BEACH

 2005	 2011

 2014	 2021

2.3.3.2 Dalyellup Beach

Review of satellite images (Table 2-7) shows variation in beach width likely associated with seasonal fluctuations. The current beach is wider than year 2017 and 2013 while slightly narrower than 2005. Land development has progressed in the last 16 years, while vegetation over the foredune was not affected.

TABLE 2-7 SATELLITE IMAGES – DALYELLUP BEACH

 2005	 2013

 2017	 2021

2.3.3.3 Bunbury

Ocean Drive, Casuarina Breakwater and the Outer Harbour

Sediment transport along Ocean Drive is similar in nature to Capel Coast due to its exposure to a similar wave climate.

Basalt rock outcrops at Point Casuarina have stabilised the shoreline and contributed to a wide beach along Bunbury Back Beach on the southern side of Wyalup Rocky Point. Sand has accreted against the spur groyne, north of Rocky Point, reflecting the northwards littoral drift. Some sediment has bypassed the groyne and deposited against the Casuarina Breakwater near McKenna Point. This has created a pocket of sand against the breakwater. Sediment within this pocket is relatively stable during calm periods, but can be mobilised by a southerly storm which may transport the sand further north and around the head of the breakwater. It is one of the main sources of sediment feeding into the outer harbour and Koombana Bay. The shipping channel and its associated maintenance dredging is likely to act as a barrier to net sediment movement from south to north in the outer harbour.

Satellite images show loss of beach width in 2010 by storm erosion (see Table 2-8). The beach face gradually recovers in the following years. The widest beach was evident in 2020 (slightly wider than year 2017 and 2005) while significantly wider than year 2010. There was no clear trend of shoreline movement in the past 16 years.

Several seawalls provide some additional protection to key assets along this section of coast, primarily at Bunbury Back Beach. This includes buried and exposed seawalls that are understood to be protecting the café, surf life-saving club and associated car parks. Design drawings have been provided by City of Bunbury which are factored into the development of erosion hazard lines.

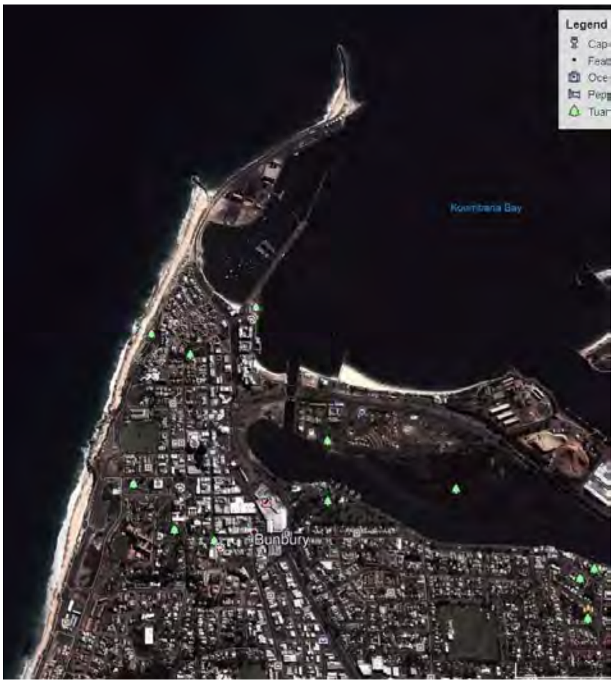
Jetty Baths Beach & Ski Beach

Jetty Baths Beach and Ski Beach have been stable according to the satellite imagery (Table 2-8). This is likely determined by:

- Lower wave energy environment when compared to Koombana Beach, Back Beach and other more exposed sites.

- These two beaches have been isolated by physical controls (Jetty Road, between Marlston Waterfront and the Plug groyne) and formed local scale sediment cells.
- Relatively coarse sediment grain size at Jetty Baths Beach and Ski Beach. GHD (2019) took four sediment samples from Ski Beach to assist a coastal stability and setback review for the Koombana North development. Sediment grain size were consistent at all sites with D_{50} values between 0.35 and 0.4 mm. This is coarser than sediment sampled at Koombana Beach (GHD 2019).

TABLE 2-8 SATELLITE IMAGES - BUNBURY

 2005	 2010

 2017	 2020

Koombana Beach

Sediment transport along Koombana Beach has been investigated by Seashore (2013) and then again reviewed by GHD (2019). Both studies suggest that the net sand transport along Koombana Beach was westwards. Review of these two studies suggests:

- Significant accretion was observed along the western portion of the beach. This has been concluded based on monitoring programs undertaken during 1991-2009 and 2009-2012. There was weak erosion at the western side during 2009 and 2012 which is not considered significant.
- The eastern portion experienced continuous erosion as also noted by the monitoring program.
- The estimated littoral drift rate is in the range of 1000-2000 m^3/yr, with rates varying by chainage along the beach and also by year.
- Storm erosion was investigated by GHD (2019) which has identified some erosion potential (6 to 20 m of horizontal erosion for a 100 yrs. ARI storm relative to the current shoreline).

Koombana Beach has been heavily engineered, consisting of groynes on both ends of the beach, the Point Busaco Revetment protecting the eastern side of the beach, a buried rock revetment protecting the Dolphin Discovery Centre in the centre of the beach, as well as various concrete and limestone edge treatments along the western portion of the beach as part of the 2017 foreshore redevelopment. All these coastal structures had and will influence the morphology of Koombana Beach into the future.

Koombana Beach forms a local scale sediment cell for which beach sands are trapped between groynes for most periods of the year. Sediment may be lost through cross shore sediment transport during storms and bypass of sands across the groynes.

Leschenault Inlet

Within Leschenault Inlet, the shoreline is either protected by rock revetment (on southern, eastern and northern sides) or mangroves habitats (on the north-eastern side of the inlet). Segments of sandy coast are present in the vicinity of Bunbury Boat Ramp (near the plug training wall). Review of satellite images show minimal changes in landforms in the inlet.

For such a low wave energy environment, sediment mobility is low even during the stormy season. The City of Bunbury undertakes minor maintenance of the Sykes Foreshore beaches through sand replenishment and is currently considering future management options. Other than this, no severe erosion has been reported according to document review.

2.3.3.4 Leschenault Estuary

A number of historic studies (Semeniuk et al. 2000, Damara, 2020) have been undertaken to evaluate the changes of the foreshore in Leschenault Estuary. Findings are summarised below.

- Human activities and engineering works have substantially affected the estuary environment (mostly done before 1970s). These activities have formed the base of the current landform, particularly on the southern side near the inner harbour.
- Construction of the Cut entrance in the 1950s, with substantial influx of marine sediment to form a flood sill (Colman 1983), an ebb sill and more recent breach of training wall (MP Rogers & Associates 2015).
- Division of the estuary basin into Leschenault Inlet and Leschenault Estuary (1970s).
- Activities associated with mineral sands processing and disposal of pigment plant by-products to the Leschenault Peninsula area via pipeline over the estuary.
- Capital and maintenance dredging of Collie River through to the Cut.
- Construction and development of canal estate subdivisions toward the southern end of Leschenault Estuary.
- Morphological changes after 2000s: Damara (2020) has undertaken a detailed review of Leschenault Estuary morphology using both survey information and aerial images (refer Figure 2-10), showing that:
  - Very limited changes on land.
  - Accretion at the northern extent of the estuary.
  - Some significant changes adjacent to the channels, the Cut, Collie River and Preston River. Weak accretion was found near Preston River Delta and the mouth of Collie River due to riverine sediment inputs. Light erosion was found immediately to the south of Collie River mouth. Bed level changes near The Cut are rather complex, comprising a mixture of erosion and accretion of the channel and flood/ebb sills.
  - Small bed level changes along the riparian boundary in order of 0.2 m-0.4 m for the southern portion of the estuary over the period of 2005-2018. Note that this difference is in the same order of magnitude as the uncertainty level of LiDAR Survey (band error in the range ±0.2 m).
  - Some changes may have been influenced by activities such as maintenance dredging and spoiling of sediment.

Overall landforms of the Leschenault Estuary have not changed much since the early 2000s. Some areas were identified to have weak accretion (northern side), while others were found to experience weak erosion. The changes are not significant enough to draw a conclusive erosion/accretion pattern of the region. Overall sediment transport rate is low inside the estuary, except near the mouth of Collie / Preston River (riverine inputs) and at The Cut entrance.

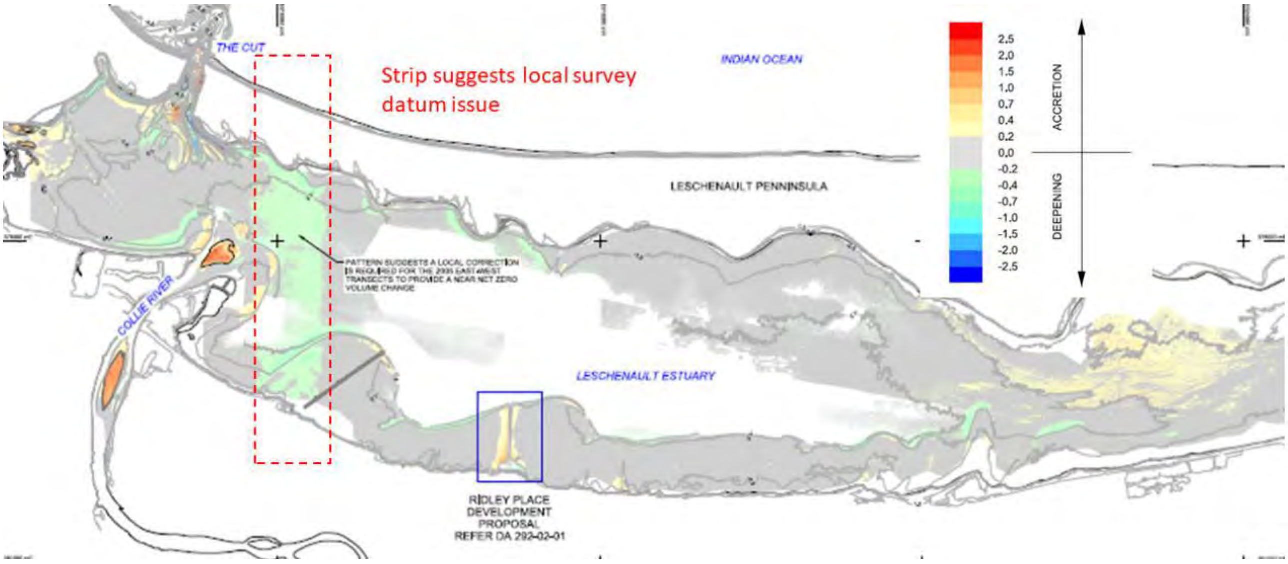


FIGURE 2-10 LESCHENAULT ESTUARY BATHYMETRY DIFFERENCE (2005-2018, PLOT SOURCED FROM DAMARA, 2020)

2.3.3.5 Riverbank Erosion

Preston River

Satellite images show a generally consistent river course (Table 2-9). Kalgulup Regional Park has been established by DBCA and includes the banks of the Collie and Brunswick Rivers, the Leschenault Peninsula, Maidens Reserve and associated nearby reserves, and also along the course of the Preston River bounded by soil embankments/roads located at up to 200 m distances from the riparian boundary.

Preston river has been historically re-aligned will flood levees constructed up to the South-Western Highway. Riverbank/Riparian zone condition summaries were not presented in literature provided.

Collie River and Catchment Area

Seashore (2020) has investigated the riverbank condition along the lower section of Collie River (affected by both riverine and oceanic forcing). As per their site inspection, most of the foreshore is in moderately degraded condition. While there is a broad range of foreshore management works, many areas have not been engineered.

Further upstream, riverbank morphology is dominated by riverine processes. Healthy vegetation growth is found along the middle and upper riverbank including both primary and secondary branches, forming a barrier to prevent riverbank erosion. Riverbank condition is however unknown due to lack of reported information. Satellite images show that the location of riparian zone did not change significantly in past 20 years, indicating generally low energy along the course of Preston, Wellesley and Brunswick Rivers.

TABLE 2-9 SATELLITE IMAGERY – PRESTON/COLLIE RIVER

2005	2018
	
	

2.4 Existing Coastal Monitoring and Management

2.4.1 Coastal Monitoring

Coastal monitoring activities in the study area include the following:

- Beach width measurements
- Dune measurements

- Oblique aerial photos
- Field photographs

Beach width and dune measurements

The PNP currently undertake annual monitoring of primary dune positions in a number of locations, and monthly beach width monitoring across the study area. Dune monitoring is undertaken within the local government area (LGA) of Bunbury (commenced in October 2017) and some data was gathered in the Harvey and Capel LGAs. Previous studies note the dynamic nature of the local sand dunes and the role of unvegetated dune blowouts in shaping the local foreshore landforms.

PNP coordinate the undertaking of beach width monitoring at several locations within the LGAs (https://www.peronnaturaliste.org.au/projects/monitoring-project/): Harvey (11 sites), Bunbury (8 sites) and Capel (6 sites) at approximately monthly intervals and have done since March 2017 (Figure 2-11). The beach widths are measured by LGA officers using handheld GPS or tape measure from the dune toe. This location is determined by observing the waves for several minutes and locating the approximate mid-point between the highest level on the beach that the water reaches and the lowest level that the water recedes. This method does not correct for water levels (i.e., during the periods of higher water levels the beach appears narrower although sand may not have eroded) but is undertaken at low tide (if practicable) for consistency and is useful to monitor long term behaviour of the beach and to compare between sites. As per Figure 2-11, beach widths have varied by between 10-120m at the sites between March 2017 and March 2021, but typically are constrained to changes within a 10-30m envelope seasonally and intra-annually.

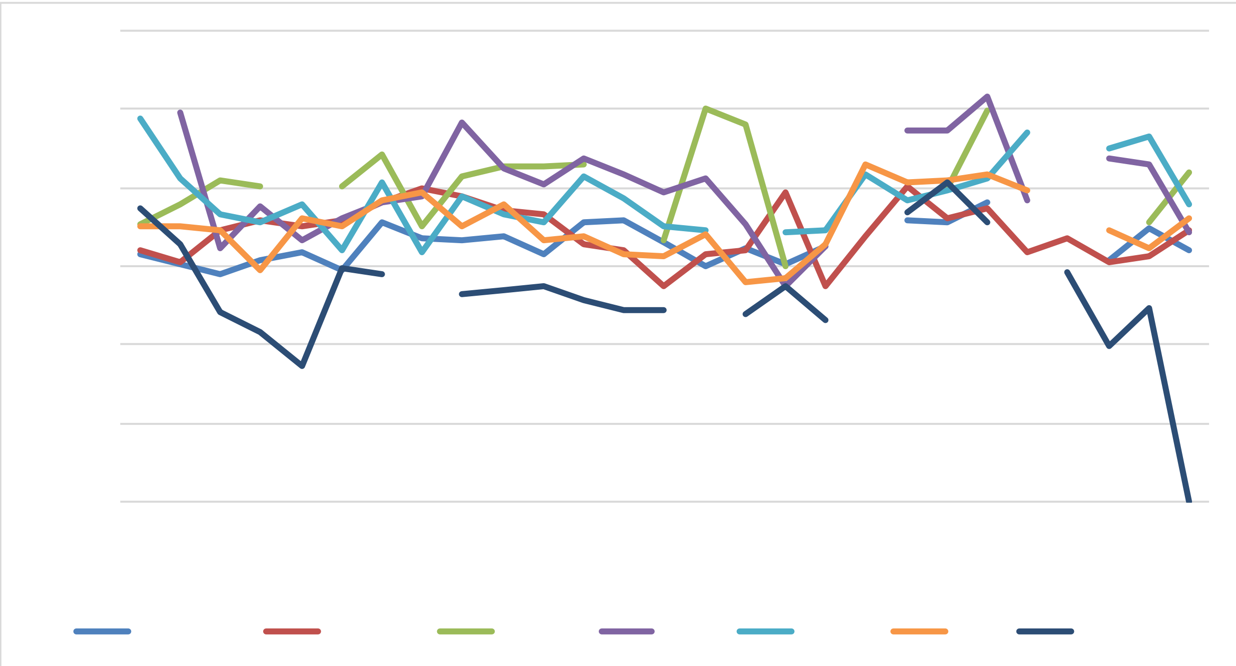


FIGURE 2-11 AVERAGE (BY LGA) OF BEACH WIDTH MEASUREMENTS COORDINATED BY PNP FOR MARCH 2017 TO MAY 2019 (SOURCE: PNP)

Oblique aerial photos

The University of Western Australia (UWA) in collaboration with the PNP collect oblique aerial photos approximately twice per year and have done since December 2014 (UWA, 2021; Figure 2-12). The bi-annual photos provide a qualitative means of assessing seasonal and longer-term coastal change. With more advanced processing the photos may also be able to be used to derive quantitative information. Prior to 2017 the photos were taken using a point-and-shoot camera by PNP staff from a helicopter. Beginning in 2017 the photos were taken by UWA as geo-tagged photos collected from a helicopter flying at approximately 300 m elevation and 300 m offshore.

FIGURE 2-12 EXAMPLE OBLIQUE AERIAL PHOTO COLLECTED BY UWA FOR PNP AT PORT OF BUNBURY INNER HARBOUR - JUNE 2020.

Beach field photos

PNP coordinate the collection of approximately monthly field photographs whilst undertaking beach width measurements (described above) and at the same locations. In general, four (4) photos are collected at each site – one in each direction at the mid-point (between waterline and dune toe) and at the dune toe (Figure 2-13).

FIGURE 2-13 EXAMPLE BEACH FIELD PHOTOS FROM SEDIMENT CELL R06A4A IN SHIRE OF CAPEL 20/5/2021, COLLECTED AT SAME TIME AS BEACH WIDTH MEASUREMENTS.

CoastSnapWA is a coastal monitoring program which uses photos taken by community members on smart phones from fixed marker points which determine their field of . These photos are then uploaded, shared via social media and / or emailed to a database where, in addition to providing qualitative information of the along-coast morphology and beach state, beach width measurements and shoreline position are extracted. (UWA, 2021; Figure 2-14). There are three (3) CoastSnapWA sites in the study area at Dalyellup, Koombana Bay and the Collie River foreshore.

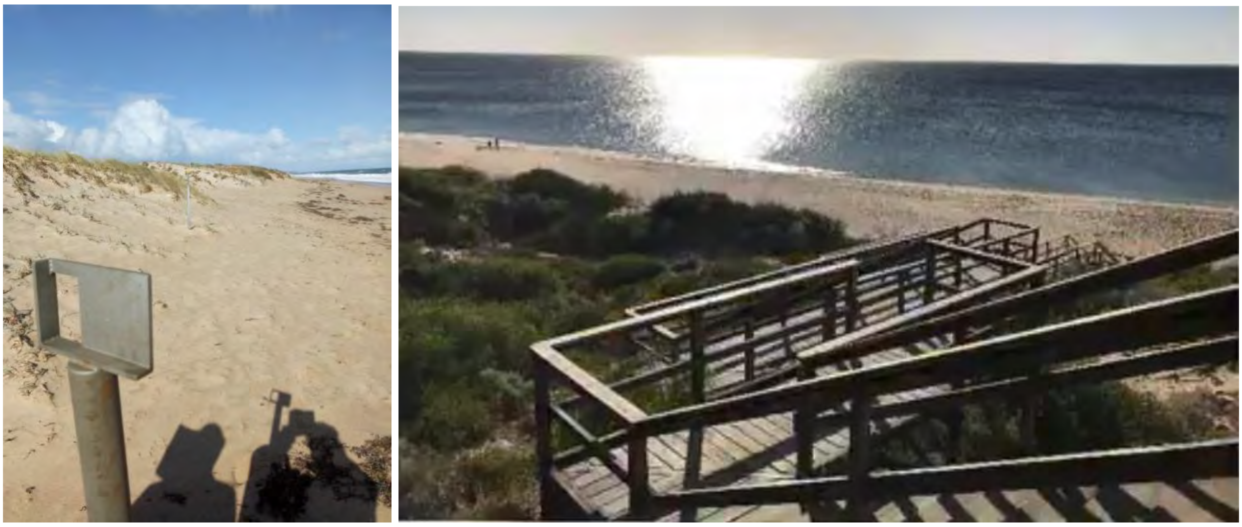


FIGURE 2-14 EXAMPLE COASTSNAPWA PHONE CRADLE (LEFT) AND EXAMPLE PHOTO FROM THEIR DALYELLUP SITE

2.4.2 Coastal Management Activities

The land managers currently care, control and maintain the foreshore and the assets within it by undertaking the following:

- Management of the foreshore amenities, car parks, boat ramps and associated infrastructure including dual use paths. This includes maintenance, rubbish removal, cleaning.
- Coastal monitoring activities in collaboration with PNP and subcontractors – outlined earlier in this document.
- Patrols by LGA Rangers of foreshore area and beaches.
- Coastal revegetation programs depending on sourcing grant funding and support from community groups and members such as local schools.

- Operation and maintenance of the Bunbury Storm Surge Barrier.
- Beach replenishment of heavily eroded sections of beach via occasional sand renourishment (e.g. via City of Bunbury).
- Management and maintenance of coastal structures (breakwaters, groynes, seawalls).

2.5 Existing Coastal Hazard Documentation

2.5.1 Coastal Erosion

2.5.1.1 Coastal Erosion Hotspots

There are two known erosion hotspots of state significance along the study area's coastline according to the WA Department of Transport (DoT) state-wide assessment (Seashore Engineering 2019):

- Koombana Beach
- The Cut

Koombana Beach was substantially re-formed in the 1970s as part of the inner harbour and estuary works. The beach was created from dredged sand and has a history of erosion at its eastern end and accretion at its western end (i.e., clockwise rotation) (Seashore Engineering 2019). There is a partially buried rock revetment at the eastern end of the beach to protect SPA infrastructure. There is a buried seawall in front of the Dolphin Discovery Centre. The beach itself is at risk from ongoing erosion and severe events as are the sections of foreshore not protected by revetments. The medium to longer-term risk is that no dry beach will be available for recreation for large parts of the years and erosion of foreshore infrastructure.

The Cut is a drainage channel excavated in the 1950s by the then Public Works Department to provide drainage from the estuary and associated rivers to the ocean (Seashore Engineering 2019). Rock revetment training walls were constructed in subsequent decades to stabilise the channel. In 2012 the northern training wall failed allowing sand from the northern beach to migrate into the channel. DoT undertook emergency repair works in 2014 but this is an orphaned asset from the Public Works Department and the management responsibility for the structure and channel have never been resolved. The beach to the north has a net erosion trend so in future years sections of the northern training wall will become impacted by wave action from the northern side – not what the wall was designed for. The channel is used for boating despite this never being the intent of the structure because of the presence of navigation hazards (mobile sandbars).

There are also three watchlist locations in the study area, W24 at Ocean Drive in Bunbury from Hastie Street to Scott Street; W25 at Peppermint Grove Beach and W26 at South Forrest Beach, both in the Shire of Capel (Seashore Engineering 2019). There is only a narrow beach and dune buffer seaward of infrastructure in these locations.

2.5.1.2 Other Coastal Erosion Hazard Information

Damara (2012) prepared regional erosion hazard lines to 2110 under contract to the Peron Naturaliste Partnership to consider the potential economic impact of coastal hazard risk. The lines were not prepared in accordance with SPP2.6, instead utilising a geological regional recession study which focused on sediment transport between the coast and continental shelf. As such they are not directly comparable hazard lines determined by other methods. They do however provide useful background information and represent what erosion could be possible over the next 100 yrs.s and the variability associated with these types of projections.

More recently GHD (2019) determined erosion hazard lines for the sandy sections of Koombana Bay, as well as Casuarina Beach, in accordance with SPP2.6. Hazard lines were determined for present day (2018), 2030, 2070 and 2120. This information will be used to compare and cross-check erosion hazards for the broader study area.

Damara (2020) assessed the erosion hazard risk for part of the Leschenault Estuary's eastern shoreline using a local case conceptual model based upon observations at the Ridley Place study area and expectations of future behaviour for similar low-energy estuary beaches.

2.5.2 Coastal Inundation

In 2012 Damara prepared mapping depicting the potential extents of coastal inundation for the Peron Naturaliste Partnership to consider the potential economic impact of coastal hazard risk. The inundation determinations were broadly prepared in accordance with SPP2.6 and have been included as extreme water level information in Section 2.2.1 of this report.

Inundation extent was considered for Koombana Bay by GHD (2019) and mapped for sections of Koombana Bay and Casuarina Beach. Damara (2020) reviewed extreme water levels to inform hazard characterisation of the Leschenault Estuary shoreline. The relevant extreme water level information from both studies has been included in Section 2.2.1 of this report and considered when determining the inundation hazard for the broader study area.

There were two potential inundation hotspots identified along the study area's coastline according to the DoT's state-wide assessment (Seashore Engineering 2019):

- Australind town
- Bunbury CBD

The assessment was not systematic or exhaustive as the study's focus was on erosion.

3 COASTAL HAZARD ASSESSMENT METHODOLOGY

3.1 Study Framework

The coastal hazard identification approach has been developed based on the following policies and guidelines:

a. State Planning Policy 2.6 State Coastal Planning Policy (SPP2.6)

b. Coastal Hazard Risk Management and Adaptation Planning Guidelines (CHRMAP Guidelines)

c. State Planning Policy 2.9 Water Resources (SPP2.9)

3.2 Study Limitations

The study area covers a complex shoreline with various types of coastal hazards present in this region. The presence of rivers, an estuary and inlet has increased the complexity of the study, in particular the assessment of inundation hazards where river flood plays a more dominant role than the intrusion of ocean water.

It is acknowledged that the hazard identification component of the present study has been undertaken to provide a broad understanding of exposure than can support government planning at a regional level - and will be superseded once site-specific studies become available, in particular at the estuary/inlet and along the river courses. Results derived from this study should not be over-interpreted at a micro-scale due to the assumptions applied and the limitations in model resolution. More detailed risk assessments and analysis may be required for the development of detailed engineering measures for specific sites e.g., erosion control along a riverbank that requires geotechnical investigation. Also, the Department of Water and Environmental Regulation (DWER) may have their own additional planning policies implemented over river courses, for which a CHRMAP study does not usually cover. Outcomes of this coastal hazard assessment should not affect the implementation of any existing polices. Water Technology will be cognisant of the limitations of this assessment in the development of adaptation options, and highlight the trigger points for which options should be implemented in the CHRMAP implementation plan, rather than relying on the timeframes indicated by the coastal hazard assessment results.

No geophysical or geotechnical assessments have been undertaken across the study to date. Erosion response across the study area may differ in reality to the predictions of this study due to the lack of data. Further geophysical/geotechnical assessment will be a recommendation of this CHRMAP.

3.3 Horizontal Shoreline Datum

The horizontal shoreline datum (HSD) is defined as the active limit of the shoreline under storm activity. It is the line from which the erosion hazard allowance will be applied from. In this assessment HSD has been determined by:

- Present day vegetation lines which often characterise the upper limit of seasonal storm impacts. The vegetation line can be difficult to establish within a reach where there are seasonal beach variations.
- Elevation of the 100-year ARI Peak Steady Water Level (about 1.7m AHD for 100-year ARI storm). For open coast, a 2 m AHD elevation is generally appropriate to outline the potential unimpacted area for typical winter storms if vegetation lines are deemed too conservative for hazard mapping.
- For estuary environments with the presence of large tidal flats and vegetation growth, a conservative approach is used to define the HSD as the limit of storm inundation or riparian boundary as the HSD boundary.

The HSD line is included in the erosion hazard maps.

3.4 Erosion Hazard Study Approach

SPP2.6 (WAPC, 2013) has provided a clear guideline for evaluation of erosion hazards within the reach of tidal impacts. It stipulates the following components be considered when evaluating the coastal erosion risk:

- Storm erosion in response to storm waves and loss of beach material.
- Historic shoreline movement that highlights the chronic/long term evolution of the coast. This could be contributed by littoral drift processes, larger scale morphological movements, long-term water level/wave dynamic variations (~18.6 yrs. tidal cycle, interannual climate oscillations e.g., La Niña effects, Pacific Ocean decadal Oscillation etc.) and climate change impacts (SLR, more intense storms and rainfalls etc.).
- Direct response to future sea level rise.

SPP2.6 indicates the methods for determining the allowance for erosion for a sandy coast are derived principally for open coastlines. For erosion on tidal reaches of inland waters, allowance should be assessed in a site-specific context, with the methodology to be developed appropriately for each site.

Model tools are demonstrated in Appendix C and Appendix D.

3.4.1 Open Coast

For open coast sections of the study area, the assessment of erosion risk was undertaken as per SPP2.6, which has documented a standard approach to undertake the coastal hazard assessment. This includes a clear definition of the Horizontal Shoreline Datum (HSD), erosion allowances as well as storm scenarios to be modelled.

- As per SPP2.6, HSD is defined as the active limit of the shoreline under storm activity. More practically, this will be defined by topographic contours (upper limit level of wave action) and compared to the vegetation line (area not constantly affected by storms) in aerial photographs to ground-truth this value.
  - This is roughly 2m AHD, with some manual adjustments to the vegetation whenever considered appropriate across the study area.
- Allowance for the current risk of storm erosion (S1) estimated by use of the SBEACH storm erosion program, with consideration of longshore processes contributing to storm erosion risk.
- Allowance for historic shoreline movement trends (S2) estimated by analysis of historic vegetation lines.
- Allowance for erosion caused by sea level rise (S3) through application of the Bruun Rule, as per SPP2.6
- Uncertainty allowance as per SPP2.6
- Additional consideration for landform stability in accordance with larger scale sediment mobilisation
- Consideration to erosion controls in place whenever appropriate

There may be some local effects of occasionally exposed rock outcrops at some beaches in the study area including Peppermint Grove Beach, Dalyellup Beach, and Bunbury Back Beach. These local effects are considered at a broad scale through review of landform stability in accordance with larger scale sediment mobilisation. A conservative approach is used in the absence of detailed geotechnical investigations, and we believe this is appropriate for the purpose of planning projects. A recommendation of geotechnical investigations will be provided as an outcome of this CHRMAP.

3.4.2 Leschenault Inlet

The shoreline within Leschenault Inlet has a secondary risk of erosion due to the presence of foreshore controls and small wind fetch for development of erosive storm waves (less than 0.3 m for typical winter storm).

At present day, wave induced erosion is relatively minor, given the small waves inside the inlet even during severe storms. Under future SLR, the area will likely still be sheltered unless the entire foreshore of Koombana Bay is eroded. It is therefore not envisaged that there will be significant erosion risk inside the inlet, if the existing seawall was designed to standards with ongoing maintenance/management. It is possible that the existing seawall may require maintenance and upgrades to reduce overflow of flood water under the impact of climate change. Future erosion risk will likely be determined by overtopping of seawater over the crest and across the road which is investigated separately by the inundation hazard assessment. The mangrove habitat to the north of the inlet may encounter additional permanent inundation and shoreline retreat; and such impact is investigated in the context of coastal inundation as well. Due to the presence of the existing walls, and the proximity of development around the inlet, it is assumed these physical controls will remain in place for the planning timeframe. The existing seawalls (limestone /concrete) are designed for erosion protection under present day conditions, and will likely be suitable into the near future with minimal maintenance requirements, given the small storm waves in such a confined water body (about 200m in width and 2 km in length). Future seawall upgrades may be required to mitigate inundation risk under increasing sea level. These upgrades (no existing drawings) are not considered in inundation/coastal process modelling but will be re-evaluated in the development of adaptation options, together with the potential upgrade of the storm barrier.

The extent of erosion hazard is determined by the contour of permanently tidal inundated area relative to the current shoreline position (HAT plus future SLR, e.g. 1.5 m AHD in 2120).

3.4.3 Leschenault Estuary

The shoreline within Leschenault Estuary has a moderate risk of erosion due to the larger fetch (distance available for wind to blow over water and generate waves) and lack of physical controls. From literature review, wave heights inside the estuary can be up to 0.7 m high, subject to wind conditions and storm surge level. The extent of erosion hazard is assessed through a combined estimate of erosion potential (in line with S1 erosion allowance of the open coast) and increased frequently inundated zones from future SLR.

S1 is assessed in line with the SPP2.6 methodology. The approach is slightly modified to represent local conditions for S2 and S3:

- The assessment of S2 allowance is based on review of satellite images (high resolution images from Metro Map) rather than DoT vegetation lines (not available for the estuary). The review has shown much of the estuary foreshore is dynamic and subject to negligible changes, in particular on the northern side. For these areas, S2 allowance may not be considered.
- River mouths are treated separately. Dynamic areas at the delta are excluded from the existing shoreline.
- The Bruun Rule that applies to open sandy coast cannot capture landform/geomorphological effects in an estuary environment. The shoreline response to SLR is evaluated using a site-specific approach:
  - Excluding delta/tidal flat areas under active development from the present HSD.
  - A fixed erosion allowance for S3 as per SPP2.9 (WAPC, 2006) for S3 (i.e., a foreshore reserve of 50 m in 100 years for estuary water).

Refer Table 3-1 for summary of this process.

3.4.4 Riverbanks

Riverbank erosion is an important geomorphological phenomenon in the fluvial and estuary environment. It is often affected by river hydraulics, natural meandering of river courses, sediments, geotechnical conditions of the bank as well as presence of vegetation etc. Riverbank erosion generally starts as a slow process, however once accumulated it may cause detrimental impacts to the surrounding environment. Unfortunately, there is no established method to evaluate the risk of riverbank erosion in the CHRMAP context. In most cases, the assessment would depend on historic riverbank movements and geotechnical investigation(s).

Given these is no straightforward and universal approach for such assessment in relation to coastally affected waterways, and detailed site inspections are almost always required to address site-specific issues, it is reasonable to adopt existing policy allowances in the absence of complex assessments for this Coastal Hazard

Assessment (CHA). Detailed engineering studies are still required to identify site specific riverbank erosion issues and can be undertaken as outcomes of the CHRMAP.

Given all the above considerations, the erosion hazard assessment along the riverbanks is undertaken based on SPP2.9 (WAPC, 2006):

- For main waterways e.g., Collie River, Preston River, a 'foreshore reserve' width of 30 m by 2120 is applied.
- For secondary channels influenced by SLR (refer Section 3.5.2.3) e.g., upper Collie River and Preston River, a setback allowance of 15 m by 2120 is applied.
- Flexibility for site specific reasons e.g., topography, bank condition and protection.

The method demonstrated above is implemented to evaluate erosion risk along segments of river courses subject to the combined impact of riverine and coastal processes (or tidal reaches of inland waterways).

For river courses dominated by inland processes, riverbank erosion is dominated by river flows, sediment composition, riverbank slope and condition of vegetation etc. Literature review indicates that for rivers located in a micro tidal environment such as the study area, the main cause of erosion is from river flood discharge and sediment composition (clay/sand). Tide and ocean waves usually play a secondary role on riverbank erosion, in particular for the mid- and upper- stream channels of the Collie River, where both small tidal range and the sheltering provided by the Leschenault Estuary contributes to a weak dynamic environment for coastal processes. There are some levels of exposure to boat wakes, however such impacts area determined by human activities not climate change.

DWER has an existing Operational Policy 4.3 which requires a more comprehensive site-specific assessment based on biological and physical features. These inland waterways are identified through review of flood levels simulated by the DWER flood model. For inland waterways showing minimal impact from tide /sea level rise, the analysis for this CHRMAP is kept as broad-scale as possible to avoid unnecessary duplication of work in developing adaptation options for regions not covered by the CHRMAP scope. Essentially, if the 100 years SLR has only negligible impact to flood levels/currents in the river channel, the adaptation options should not be developed under the framework of CHRMAP, rather the analysis should be undertaken based on projection of future rainfall / evaporation rates under the framework of DWER Operational Policy. For inland river courses, simple guideline allowances provide no additional values to the management of erosion along riverbanks.

3.4.5 Land Depression along the Capel Coast

The land depression along the Capel coast is not directly affected by coastal processes at present due to the protection of foredune and embankment walls. With sea level rise, the area may be affected under storm surge conditions, assuming the culverts are opened. The shallow water depth and potential vegetation growth will likely mitigate any coastal erosion processes. It is not envisaged that these land depressions will be affected by coastal erosion, unless the entire foredune is eroded. The dune reserve is assessed as greater than 100m^3,. As per SPP2.6, this indicates the dune is unlikely to be removed during storm activity. This should continue to be monitored in the future.

3.4.6 Physical Controls

As per SPP2.6, variations for areas of industrial/public/commercial/defence development include.

- For temporary facilities with design life of less than 30 years, erosion allowances are considered assuming that no structures are in place.
- For permanent structures e.g., port structures and those structures inside Koombana Bay, it is assumed that these structures will be in place and remain functional during the 100-yea. planning period.

As discussed in Section 3.4.2, the defences around Leschenault Inlet are assumed to remain in place. It is however notable that future upgrades may be required to mitigate inundation risk (discussed in more detail within the inundation hazard assessment).

The buried seawall and discontinued revetment along Bunbury Back Beach were designed to stabilise the foreshore area. Review of design drawings show different specifications along different segment of the shoreline. Some areas have only one thin layer of revetment for which the protection is not considered as effective for erosion control, and are not considered to provide protection in the erosion hazard assessment. For some segments of buried/exposed seawalls (near the two carparks between Stockley Rd and William St and between Beach Rd and Hayward St) where two-layer 1-5 tonne armour rocks were used for erosion control, the design is considered as effective during their design life. As such, these sections, it is assumed that the seawall will prevent shoreline erosion.

Whilst beaches within Koombana Bay are assessed as open coast, it is assumed the physical controls in this area (the outer harbour breakwaters) will remain in place throughout the planning timeframe.

A spatial summary of the physical controls impacting the erosion assessment is provided in Figure 3-1.

3.4.7 Summary

A summary of the erosion assessment approach is provided in Table 3-1. This is presented pictorially in Figure 3-2.

TABLE 3-1 SUMMARY OF EROSION HAZARD ASSESSMENT METHOD

Shoreline Type	Erosion Assessment
Open Coast	Standard method as per SPP2.6. This considers erosion allowances relative to the present Horizontal Shoreline Datum. ▪ HSD is defined by topographic contours, ground truthed by vegetation line. ▪ Allowance for the current risk of storm erosion (S1) estimated by SBEACH model. ▪ Allowance for historic shoreline movement trends (S2) estimated by analysis of historic vegetation lines. ▪ Allowance for erosion caused by sea level rise (S3) through application of Bruun Rule ▪ Uncertainty allowance as per SPP2.6 ▪ Hazard lines are defined by HSD+S1+S2+S3+uncertainty Consideration of erosion controls: ▪ Physical controls such as Groynes, Port facilities, Outer breakwater and jetty road breakwater are considered as permanent structures assuming ongoing maintenance and management. These are key facilities that determines the overall landscape of Bunbury coast. ▪ Erosion controls that are designed with large armour rocks and proper toe protection are considered as effective for their design life e.g., buried seawalls along Ocean Drive, Ski Beach and Koombana Beach. ▪ Temporary protection such as thin layers of pavement are not considered as erosion controls. Consideration of landform stability in accordance with sediment cells and geomorphological features wherever appropriate. Rocky shoreline definition requires continuous rocky surface extending above the reach of storm waves plus SLR. If the rocky surface is lower than the active limit of waves, the shoreline should be defined as a mixed or sandy type. Our analysis shows no continuous rock cliff above the reach of storm impact. Unless otherwise notified by geotechnical assessments, the shoreline within the study domain is considered as 'sandy' type for the purpose of coastal planning and management.

Shoreline Type	Erosion Assessment
Estuary	For shallow foreshore with/without riparian boundary, hazard lines defined by HSD+S1+S2+S3+uncertainty with fine scale adjustment to define the HSD: ▪ HSD defined by the location of riparian boundary / inundation line (HAT level, 0.6m AHD, as boundary of tidal inundation) / physical controls. ▪ Allowance for the current risk of storm erosion (S1). SBEACH model used to evaluate the extent of erosion generated by the strongest possible waves in the Estuary. ▪ Allowance for historic shoreline movement trends (S2) estimated by review of historic vegetation lines/satellite images/historic reports. ▪ A fixed allowance of 50 m is assumed as a response to SLR (or S3) by 2120, as per SPP2.9 recommendations. The estimated erosion hazard lines are compared against the permanent inundation extent (HAT water level +SLR) in 2121. Both are reported to facilitate erosion hazard assessment. Tidal flats and dynamic river deltas are excluded from current shoreline.
Leschenault Inlet	Leschenault Inlet has a very limited impact from storm waves. Erosion of shoreline is largely contributed by increasing sea level and overflow of flood water. Shoreline movement is determined in context with tidal inundation from SLR and operation of the storm barrier. Total erosion allowance is estimated at 0.6m + SLR (eg 1.5 m AHD in 2120)
Riverbank	For riverbanks, methods derived for open coast by SPP2.6 are not applicable. SPP2.9 is used to guide the development of erosion hazard lines. ▪ a ‘foreshore reserve’ width of 30 m by 2120 for main waterways (Preston, Collie River, Capel River) ▪ a ‘foreshore reserve’ width of 15 m by 2120 for secondary channels (Branches of Collie River, Miller River, Henty River Brunswick River, Wellesley River etc.) We have noted several breaches through the coastal barrier near the Capel River mouth. This erosion is investigated at a broader scale by historic shoreline movement and also in the context of open coast erosion. Detailed analysis of breach activation is beyond the scope of current study. River courses dominated by in land processes are not investigated by this study. DWER has an existing Operational Policy 4.3 which requires a more comprehensive site-specific assessment based on biological and physical features.
Land depression behind the sand dune (Shire of Capel)	No erosion risk considered.

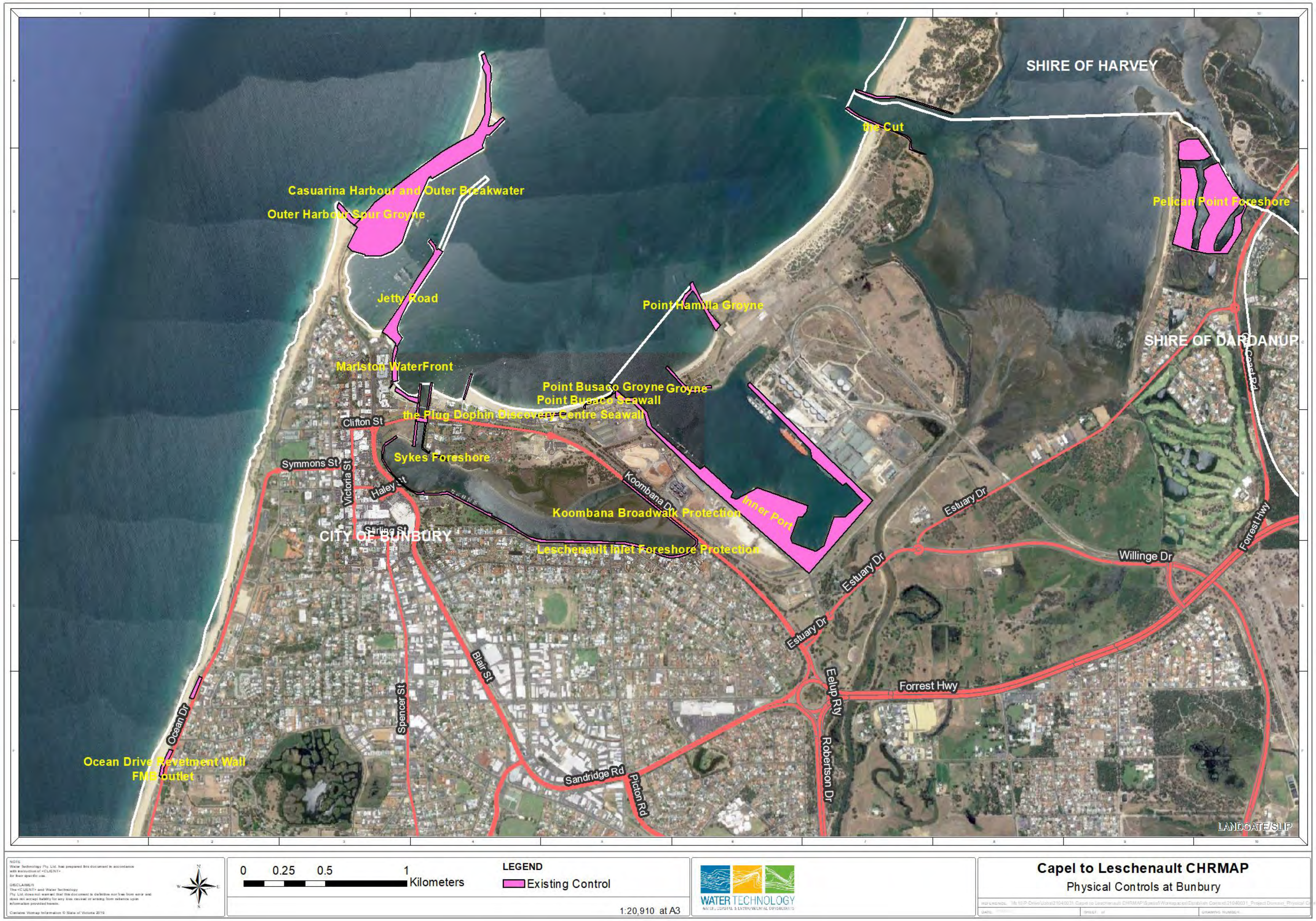


FIGURE 3-1 PHYSICAL CONTROLS

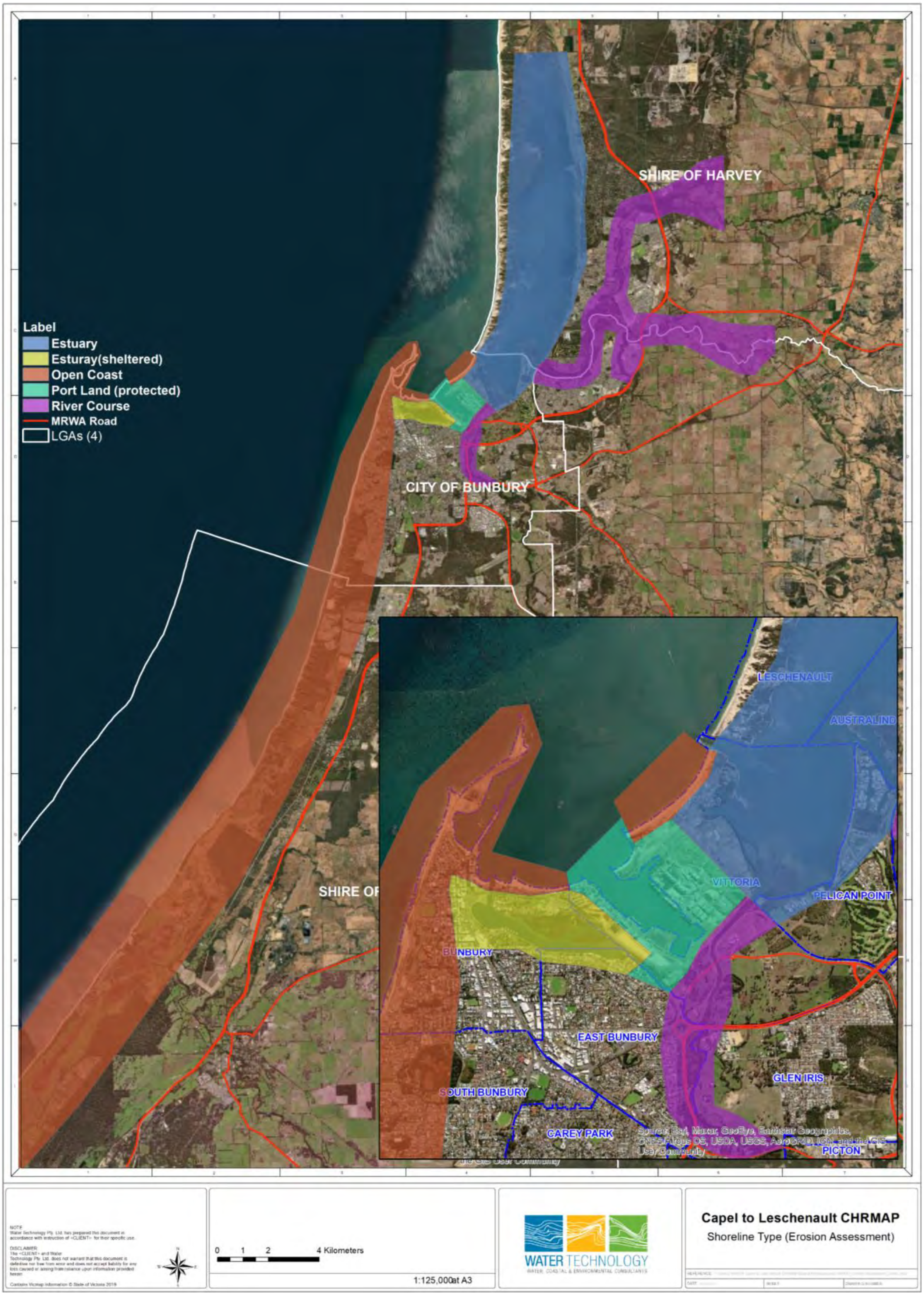


FIGURE 3-2 SHORELINE TYPES FOR EROSION HAZARD ASSESSMENT

3.5 Inundation Hazard Study Approach

Inundation is one of the primary coastal hazards of the region. Historic studies have identified multiple mechanisms that have contributed to the high-water levels along the coast and in the estuary.

SPP2.6 requires the allowance for inundation to be the maximum extent of inundation calculated as the sum of S4 Inundation plus the predicted extent of sea level rise. Being a coastal Policy, it does not apply to areas where inland processes dominate the inundation/flooding process.

3.5.1 Modelling Tools

The DHI MIKE storm surge model has been used to simulate the inundation extent in the study area coastal zone from Capel to Leschenault Estuary. The approach was proposed to account for the complexity of inundation processes in Leschenault Estuary, along river channels, and in the land depression of Capel which cannot be accurately assessed by a simple bathtub model approach, particularly with the inclusion of catchment flood impacts. The model however did not attempt to replace the existing riverine catchment flood model along the Collie River supplied by DWER which has been carefully calibrated through inclusion of MIKE11 network for rivers, drainages, bridges and culverts, all of which are crucial inputs to simulate accurate river hydraulics.

Although the storm surge model includes all major river courses, model results along the Collie River are limited to only cover areas affected by SLR. However, all major river courses are included in the model domain to provide river discharge inputs and flood storage, so that the inundation extents within the full tidal reach of the estuary (including future SLR) can be appropriately assessed.

A set of ARI storm events have been simulated for the assessment of coastal inundation hazards (Table 3-2). Refer to Appendix C for a detailed description of the modelling tools utilised in this assessment.

Inundation risk along the Collie River (for river courses beyond the impact of tide/SLR) is mapped directly from DWER flood model results.

3.5.2 Model Implementation

3.5.2.1 Open Coast

Inundation along the open coast is evaluated by Water Technology's Danish Hydraulic Institute's MIKE storm tide model which has been calibrated to hindcast the storm tide conditions during TC Alby. The model simulates the combined effects of peak steady water level as well as wave setup through a coupled Hydrodynamic and Spectral Wave model.

For the 500-year ARI event, the inundation level is modelled through simulation of a representative cyclone which is developed based on the existing TC Alby track, with modifications to locate the cyclone eye near the Bunbury region (peak surge lasts for up to 4 hours). The timing of the peak storm surge is shifted to match the timing of the MHHW level. Overall, a reasonably conservative storm tide is provided based on comprehensive modelling investigations.

For lower return period storms, the inundation levels from existing studies are adopted to drive the inundation model (see Section 2.2.1). A synthetic storm tide sequence is produced as a model boundary condition based on typical MHHW levels as well as a simple cosine function (about 4 days duration) to represent the process of storm surge.

TABLE 3-2 INUNDATION HAZARD MODELLING SCENARIOS (MINIMIUM 2 DAYS OF STORM DURATION)

ARI (years)	Model Domain (excluding Collie River)				Collie River
	Current Sea Level (2020)	2035 (0.12 m SLR)	2050 (0.22 m SLR)	2120 (0.98 m SLR)	Current Sea Level (2020)
1	1-year ARI water level + tide variation 1 year ARI river discharge	1-year ARI water level + tide variation 1 year ARI river discharge SLR	1-year ARI water level + tide variation 1-year ARI river discharge SLR	1-year ARI water level + tide variation 1-year ARI river discharge SLR	Rerun of DWER flood model using 1-year ARI flood
10	10-year ARI water level + tide variation 10-year ARI river discharge	10-year ARI water level + tide variation 10-year ARI river discharge SLR	10-year ARI water level + tide variation 10-year ARI river discharge SLR	10-year ARI water level + tide variation 10-year ARI river discharge SLR	DWER flood model results 10-year ARI flood
100	100-year ARI water level + tide variation 100-year ARI river discharge	100-year ARI water level + tide variation 100-year ARI river discharge SLR	100-year ARI water level + tide variation 100-year ARI river discharge SLR	100-year ARI water level + tide variation 100-year ARI river discharge SLR	DWER flood model results 100-year ARI flood
500	Tide variation, 500-year ARI cyclone 500-year ARI river discharge	Tide variation, 500-year ARI cyclone 500-year ARI river discharge SLR	Tide variation, 500-year ARI cyclone 500-year ARI river discharge SLR	Tide variation, 500-year ARI cyclone 500-year ARI river discharge SLR	DWER flood model results 500-year flood

3.5.2.2 Estuary and Inlet

The storm tide levels inside the estuary and the inlet are determined from the MIKE storm tide model (as per Open Coast section above). This process-based inundation model considers the following factors that may affect the inundation levels in the confined waters of Leschenault Estuary and Inlet:

- Storm duration and constrained water exchange through the estuary/inlet openings have significant impact to the storm tide levels inside the estuary. The small opening at the Cut behaves like a filter to dampen the signal of short peaks while withholding peaks with longer duration. Review of post-flood survey data has shown about 0.5 to 1 m of water level difference between Koombana Bay and Leschenault Estuary during TC Alby. This is based on simulation of a 3 to 4 hours peak surge during TC Alby, as once tide retreats, the peak surge level will drop accordingly.
- The Storm Surge Barrier is one of the key physical controls to mitigate the inundation hazard for the Bunbury townsite. As per discussions with DoT and the Steering Committee, this has been modelled as closed using the design parameters taken from the drawings supplied by DoT. Damage/ loss associated with malfunctioning of the storm barrier could be catastrophic from an inundation perspective. It is assumed that the storm barrier will be maintained to ensure it remains operational for the planning timeframe.
- River flows have significant impacts to water levels in the estuary and along the river which have been incorporated as model inputs.

3.5.2.3 River

River flood hazards occur at a higher frequency than storm surge hazards in Leschenault Estuary and along the river flood plain. This sets the current CHRMAP apart from many other CHRMAP projects where inundation hazard of tidal waters is primarily contributed by the coastal storm tide. Assessment of river flood and spreading of flood water requires comprehensive modelling of river flow (see Figure 3-4 for locations of river courses). Catchment flood inputs are used to simulate inundation extents along the river flood plain.

SPP2.6 does not provide a clear guideline to evaluate the risk of river flood, particularly in areas where river flood impact becomes more dominant.

Five Mile Brook

Five Mile Brook is connected to the ocean through two outlet pipes (with flip open valve). It shows no impacts from regular tide at current sea level and very limited impact even during extreme storms. This water body is included in the inundation modelling, given the potential impact of drainage discharge and its impact to the extent of coastal inundation. However, Five Mile Brook will not be considered in the erosion hazard assessment.

Five Mile Brook Southern Diversion

Review of DEM data shows the diversion drain heading south has a high ground level (bed level ranging from ~1 m AHD near the beach exit to over 4 m AHD upstream) and is bounded by either high dunes or vegetated embankments (crest level over 4 m AHD). It is unlikely that this diversion drain will be affected by coastal processes at present and in near future. In the 100-year period, the impact of SLR to water level may appear along the lower 1.5 km section of the drain. Inundation risk from the ocean is still low, as long as the embankment walls between the foredune and the Bussell HWY are maintained to standard. This diversion is not considered in our inundation model due to its negligible impact to inundation of coastal assets. Maintenance requirement of this drain will be included as a recommendation in future stages of the CHRMAP.

Collie River

A key objective of this study is to evaluate the inundation risk along the Collie River in response to future SLR and develop options/plans to adapt to the predicted inundation hazard. As per SPP2.6, the coastal zone is defined as the areas of water and land that may be influenced by coastal processes. Regions beyond the impact of tide and SLR are excluded from the scope of the CHRMAP study as no adaptation plan is required if not affected by SLR from climate change. Other climate change factors e.g., increasing/decreasing rainfall, should be investigated in detail by appropriate river flood risk assessment under DWER and other policies.

DWER provided Water Technology with a comprehensive flood model for Collie River and Leschenault Estuary (including model setup files and results). For this CHA, Water Technology has undertaken a review of modelled water level differences (per DWER 2014 report and model outputs) before and after 0.9 m SLR for a 100 yrs. ARI flood, in order to identify the areas under the influence of SLR. The modelled water level differences are presented in Figure 3-3 which show that:

- The water level within Leschenault Estuary will increase by the same amount as the projected SLR.
- The impact of SLR reduces with distance from the river month upstream. The modelled impact from SLR (100 yrs. Flood, 0.9 m SLR) reduces from 0.9 m in the estuary to less than 0.1 m in the river about 2 km upstream from the Old Coast Rd Bridge. This 0.1 m difference is within the range of numerical error for typical hydrodynamic simulations in coastal and estuary environment.

SLR has more profound impact to inundation level along the open coast and in Leschenault Estuary, significantly attenuated impact (10 to 40% of SLR) for the lower section of Collie River and almost negligible (<10% of SLR) impact to the middle and upper sections of Collie River. It is reasonable to exclude the river courses over 2 km upstream of the Old Coast Rd Bridge from this CHA, as inundation hazards along the upper river courses should be investigated by more comprehensive river flood analysis (e.g., DWER flood study).

Inundation extents beyond the impact of SLR are mapped as per DWER flood study results.

Preston River

Preston River envelopes the eastern boundary of Bunbury City and is directly connected to the Leschenault Estuary. Inundation hazard along Preston River is investigated through numerical simulation of storm surge and river flood. Riverbanks are implemented as line structures to prevent any calculation error from insufficient model resolution over the embankment walls. Flood water can still overtop over the embankments if water level is greater than the crest level of the embankments.

The current model did not consider any planned/proposal diversion of Preston River resulting from expansion of Bunbury Port.

Capel River

Capel River is one of the major waterways connecting to the ocean within the study area. The river is narrow near the townsite and gradually widens downstream of Bussell HWY crossing. It runs through a flat land depression and is bounded by embankments with culvert openings for the purpose of flood water drains. Capel River is included in the inundation model with embankments built in as line structures allowing overtopping of flood water over the crest. The culverts connecting the drainage paths to the Capel River are also included to evaluate coastal inundation impact at the land depression. Conservative culvert settings have been used to produce more conservative model results.

3.5.2.4 Physical Controls

Key flood/inundation controls are implemented in the model as follows:

FMB outlet

Review of current FMB outlet showing the following specifications:

- Two outlet pipes (1.8 m diameter) with pressure generated opening flaps. One is in operational condition while the other one is currently not being used (locked shut). The performance of the locked outlet (if in use) may be affected by the one in operation.
- The pipe valves are opened from the land side by water pressure if water level in FMB is higher than ocean water.

- Two pumps, each has capability to pump 540L/s so overall about 1.1 m^3/s pumping capacity. The pumps are for the purpose of using jets to flush the sand build up on the ocean side so the outlet can be opened by water pressure.
- Two pumps cannot work together with the outlet pipes.
- Pumps usually run for 20mins with 10 mins break.
- At the outlet, the peak flow could be up to 8.5 m^3/L as per Water Technology (2012). This requires a flow speed of about 3.3 m/s for one outlet pipe to be in operation, and about 1.7 m/s flow speed for two outlet pipes to be in operation.
- The performance of the outlet will be affected by the increased sea level. It is unknown whether this has been considered by the current design.

To be conservative, the outlet has been implemented in the model as:

- Two outlet openings each having 2 m diameter. This will allow inflow of ocean water within the model through the outlet pipes if ocean water level is higher than the creek. This configuration is more conservative than the current design which allows only one way flow.
- Assuming the road/outlet will be protected, given they are key coastal infrastructure. This is flagged as prerequisites for risk treatment options for the inundation hazard at Bunbury.
- The FMB flood discharge is modelled with the same timing as storm surge which is a conservative assumption.

Leschenault Inlet Storm Surge Barrier

This has been included in the model as a DIKE with a crest level of 2.1 m AHD as per supplied design drawings (refer Appendix B). The operation process of this storm barrier is not modelled, it is simply simulated as closed. This should have no impact on the results of the inundation hazard assessment, as this storm barrier will always be closed during the simulated storm events. For storm events with water levels below 2.1 m AHD, the model does not allow ocean inundation into Leschenault Inlet. For water levels above 2.1m AHD, water flows over the DIKE and can enter the inlet, similarly to the real life process.

Roads, Flood levees and Riverbanks

Dike structures have been used at multiple locations along the roads, riverbanks and along key flood barriers. This is particularly important to reduce the "leak" of flood water through grid points not fully resolved by the model.

Culverts

Culverts are included at multiple locations e.g., the two culverts downstream of Capel River, bridge openings/culverts near Preston River. Hydraulic performance of these culverts was checked, confirming acceptable performance. In the final simulations, these culverts were widened to produce more conservative results, regarding to the uncertainties of future operation, maintenance and upgrade.

Exclusions

Despite the efforts to include more hydraulic structures for more accurate inundation hazard mapping, it was not intended to include all inland flood controls/drainage networks for such a large study area CHRMAP study. Key flood controls are included as these have profound impact to the prediction and management of coastal inundation risk. Some controls are tuned to be relatively conservative to serve the purpose of regional planning and management.

For all investigated scenarios, rain on grid rainfall inputs and infiltration is not considered, nor are the various urban drainage networks, structures and paths.

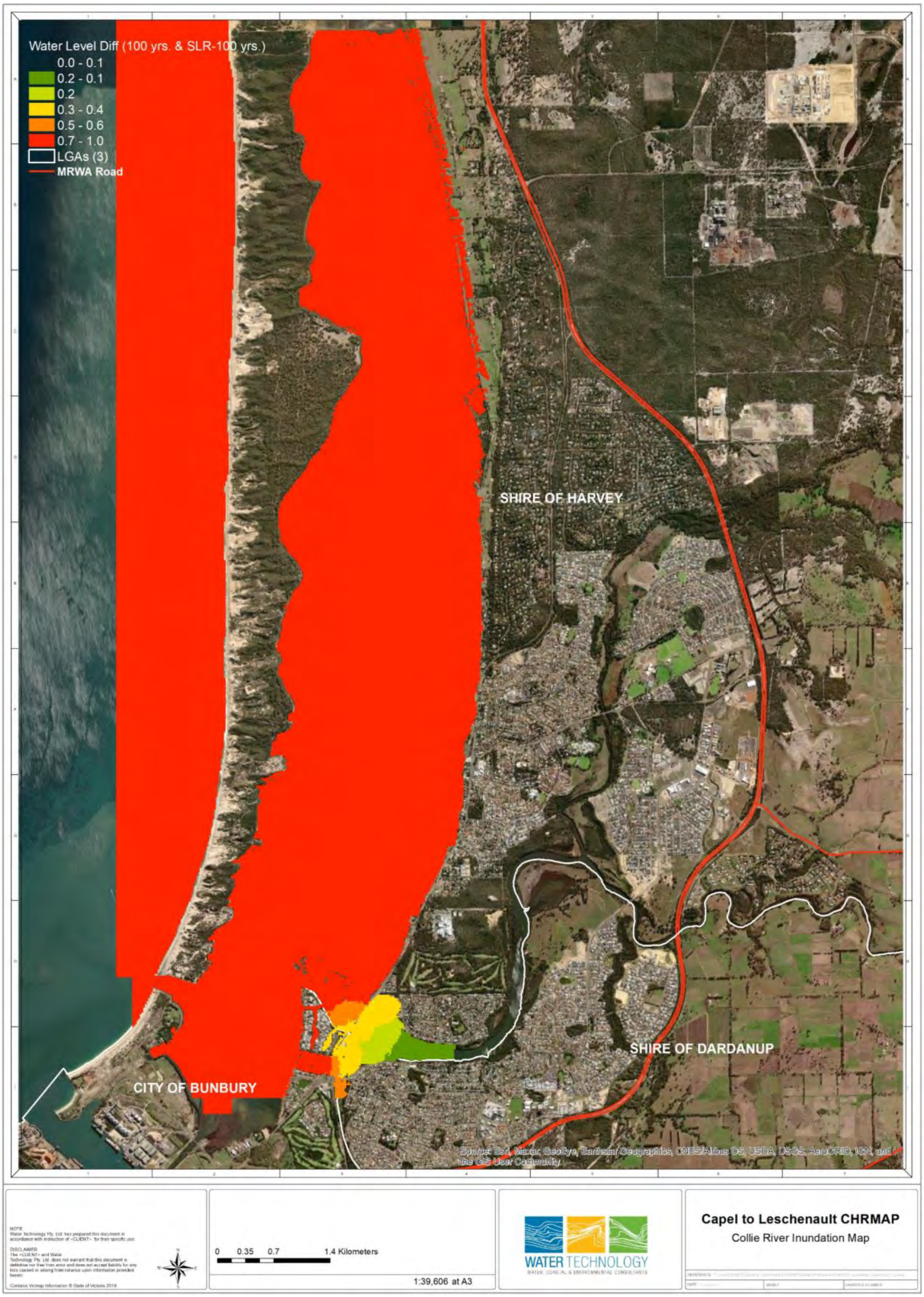


FIGURE 3-3 MODELLED WATER LEVEL DIFFERENCE (100 YRS. FLOOD WITH SLR – 100 YRS. FLOOD)

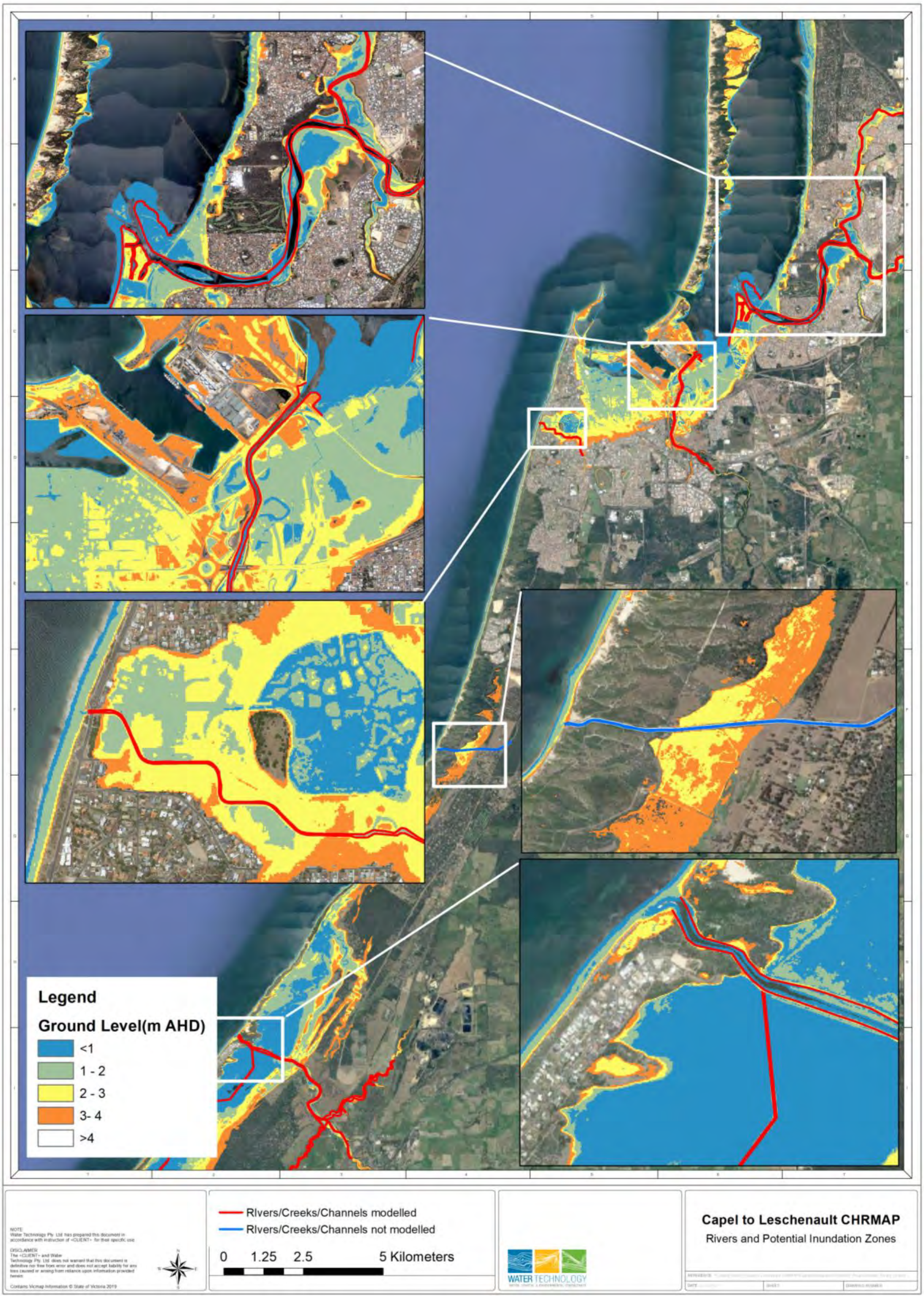


FIGURE 3-4 RIVER COURSES WITHIN THE STUDY DOMAIN

4 EROSION HAZARD ASSESSMENT

As per Section 3 study methodology, the erosion hazard study is carried out by the following steps:

- Simulate storm erosion for the 100 yrs. ARI storm (S1).
- Evaluate historic shoreline movement trends based on DoT vegetation lines (S2).
- Evaluate sea level rise impacts for present day, 2035, 2050 and 2120 (S3).
- Apply corrections for controlled shoreline segments.
- Evaluate total erosion values for each coastal management zones and for four different planning periods i.e., present day, 2035 (short term), 2050 (medium term) and 2120 (long term).
- Establish an erosion matrix considering both exposure levels and planning periods.
- Mapping of erosion hazard lines.

4.1 S1 Allowance

The potential for storm-induced erosion is assessed using the SBEACH numerical model by applying the MPRA (2018) storm. It is assumed that the subsurface of the shoreline within the study site is of a uniform uncemented sandy constituency. Complex geological features are beyond the capability of the SBEACH model framework and relevant impacts are factored in for the risk assessment component of the CHRMAP.

Refer to Appendix A and Appendix D for a detailed description of the wave modelling and simulation of storm erosion. The estimated S1 allowance is included in the total erosion hazard allowance table (Table 4-2, Section 4.4).

4.2 S2 Allowance

The historic shoreline trend is estimated through review of available historical shoreline changes (DoT vegetation lines from 1942 onwards). The approach is to analyse historical aerial imagery/shorelines and to use the horizontal change in the vegetation line as an indicator for historical shoreline changes. This approach is applicable on natural coastlines where vegetation is free to recede in response to erosion.

Refer to Appendix D for more detailed description of historic shoreline analysis using DSAS 5.0. The findings can be summarised as follows (see Figure 4-1 to Figure 4-3):

- The shoreline at Peppermint Grove Beach and to the south shows a slight trend of long-term accretion (0 - 0.4 m per year) over recent decades. The 2016 shoreline is about 0-8 m behind (landward) the 2008 shoreline, while still a few metres ahead (seaward) of earlier shorelines. As the observed variations in shoreline position is of the order of 10 m over a long-time frame, it is difficult to differentiate seasonal variations from the digitalised shorelines. The trend of accretion is not apparent and is uncertain for the future regarding the impact from SLR. It is envisaged that a 0 m shoreline movement would be appropriate to approximate the S2 allowance in this region.
- A weak erosion trend is observed at the mouth of Capel River (immediately to the north of Peppermint Grove residential area). Due to the dynamic nature of the river mouth, this section of shoreline is considered more vulnerable to storm erosion, and has less inherent ability to recover during periods of calmer summer waves. A modest nominal allowance (0.4 m per year erosion) is considered appropriate for the S2 allowance over this vulnerable section of coast.
- The shoreline between Capel River mouth and Dalyellup experience a similar historic movement, albeit with weak erosion at some sections of the coast (<0.2 m per year). We could however observe a trend of progressive erosion in the past 14 years at a rate of 0.4-0.8 m per year to the south of Dalyellup. The value is not included in Figure 4-1 as there are only two shorelines as inputs which lack statistical significance. For most areas of the coast, the current shoreline is still a few metres seaward of the 1991 and earlier shorelines. The reversed trend of shoreline movement following the 1990s likely reflects the

impact of climate change, which has become more apparent since the 1990s. As the net movement of shoreline is within 10 m for the most recent 20 years, it is difficult to differentiate the impact from seasonal beach variations (in order of 10-20 m as per PNP beach monitoring program).

- The shoreline north of Dalyellup to Bunbury Outer Harbour has been relatively stable with no clear trend of erosion/ accretion. This section of coast shows the natural shoreline variation of the order of ±10 m. It is reasonable to assume a stable shoreline over this section of coast, given the similar magnitude of variation showing by seasonal beach erosion. Slightly more accretion at the northern end is associated with the implementation of the spur groyne (in 1950s/1960s) as well as sand accumulation against the rock outcrops at Wyalup Rocky Point. Since the 2000s, the shorelines gradually converge showing up to 10 m variations across years.
- The shoreline inside the Casuarina Boat Harbour (or Bunbury Outer Harbour), along Ski Beach shows moderate accretion since 1941, mainly contributed by engineering works completed. In recent years, there has been almost no change in shoreline position. Koombana Bay Sailing Club shows a weak erosion of less than 0.2 m per year. Koombana Beach experiences overall weak erosion (<0.2 m per year) on the western side and a moderate erosion of up to 0.4 m per year on the eastern side. The shoreline within 200 m distance from Point Busaco Groyne is within the jurisdiction of Bunbury Port for which the shoreline has been stabilised by seawall structures (no trend of erosion observed).
- The beach connecting the port to Turkey Point (near The Cut) shows a clear trend of accretion at about 1-1.5 m per year since the construction of rock groynes at Point Hamilla and the cut opening. This has been interrupting the littoral drift process leading to accretion at the beach and reduced sand supply to the northern side of the Cut.

The analysis suggests most shorelines are either weakly accreting (for shoreline on southern side of Peppermint Grove Beach) or experience a weak erosion except Turkey Point where the shoreline accretes at an approximate rate of +1 m per year. Along the open coast, there is a general trend of recession since 2008. The 2016 line is almost always landwards of the 2008 shoreline. It is however unclear whether this is due to different methods used to derive the shoreline positions. Review of more recent satellite imageries shows the 2016 shoreline is very much in line with current shoreline indicating a pause/decline of such trend.

Looking at a broader time frame, all shorelines are considered to be reasonably stable. Water Technology considers a 0 m per year rate for shoreline on the southern side of Capel River and 0.2 m per year of erosion for shoreline to the north along the open coast is appropriate. Accretion within Casuarina Harbor is unlikely to continue for current landform settings (enclosed harbour). Koombana Beach has different shoreline movement rates on eastern (0.4 m per year) and western end (0.2 m per year). Due to the potential risk of beach breaching at Turkey Point under future SLR, the strong historic accretion (>1m per year) is unlikely to continue thereby not considered for erosion hazard mapping.

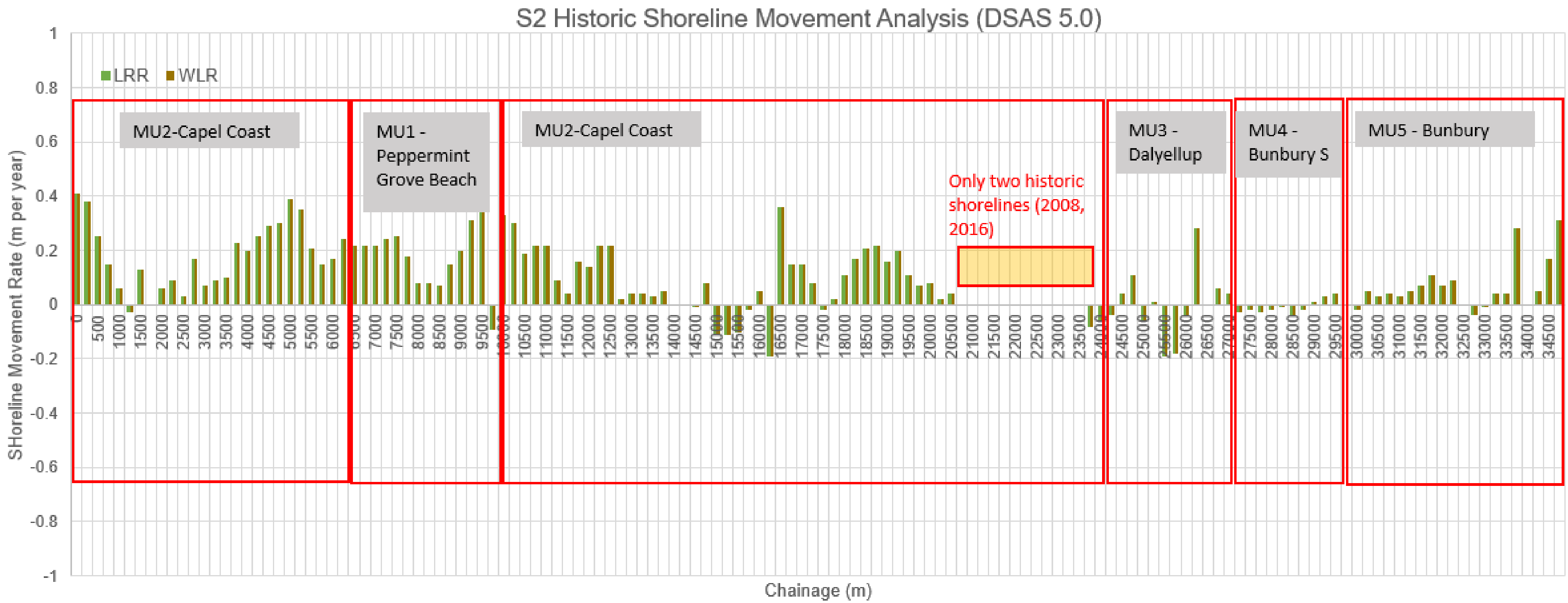


FIGURE 4-1 HISTORIC SHORELINE MOVEMENT (M PER YEAR) FROM CAPEL TO BUNBURY, (+) = ACCRETION AND (-) = EROSION, LRR DENOTES LINEAR REGRESSION RATE, WLR DENOTES WEIGHTED LINEAR REGRESSION RATE

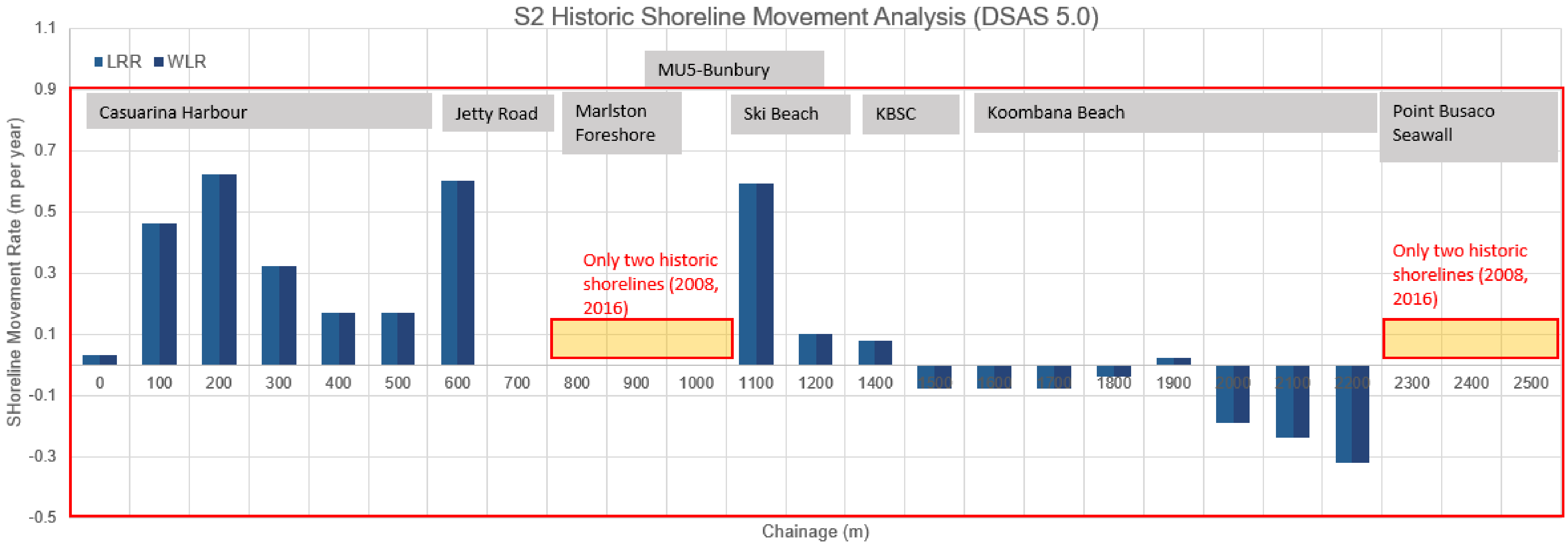


FIGURE 4-2 HISTORIC SHORELINE MOVEMENT (M PER YEAR) AT BUNBURY

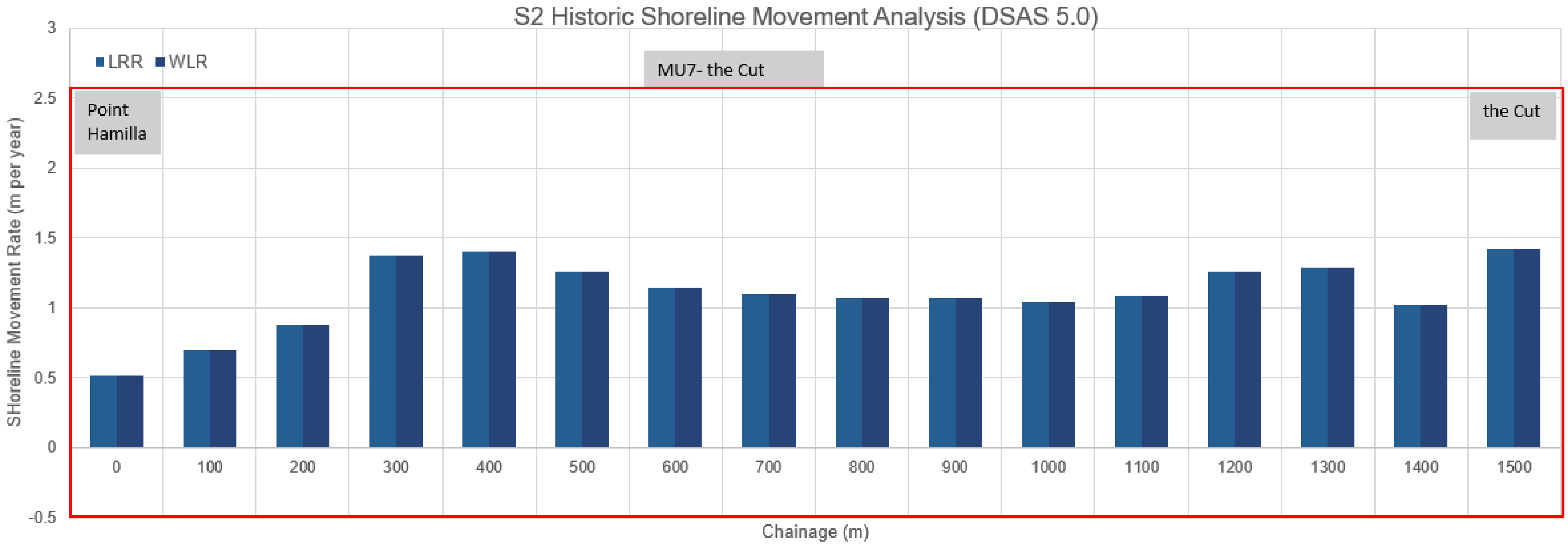


FIGURE 4-3 HISTORIC SHORELINE MOVEMENT (M PER YEAR) AT TURKEY POINT

4.3 S3 Allowance

Along the beach slope, rising sea level will cause additional inundation and retreat of the shoreline which is often characterised by the Bruun rule (Bruun, 1962). According to SPP2.6 and project applications, the shoreline recession due to future sea level rise can be estimated as being equivalent to 100 times the adopted sea level rise value (in metres) over the defined planning periods for sandy/mixed coasts. The multiplier of 100 is based on the Bruun rule (Bruun, 1962) over a mildly sloping shoreline.

SLR impact will be applied in context with local landform conditions which would be treated differently for open coasts and estuary environments (Table 4-1). Note S3 allowance will not be considered for locations where permanent physical controls (i.e., seawalls) are in place.

TABLE 4-1 SUMMARY OF S3 ALLOWANCES

Planning Time Frame (year)	Present day	2035	2050	2120
Sea Level Rise (m)	0	0.12	0.22	0.98
Open Coast S3 (m)	0	12	22	98
Estuary S3 (m)	0	7.5	15	50

4.4 Total Erosion Hazard Allowance

The total erosion hazard allowance is presented in Table 4-2. Erosion hazard maps can be viewed in high detail at the following link:

https://watech.maps.arcgis.com/apps/webappviewer/index.html?id=d43c39fda97d426ea6192d1a7a8543cf.

TABLE 4-2 EROSION HAZARD ALLOWANCE SUMMARY

Profiles	S1 (m from HSD)	S2 (m/year)	S3 (m/year)	Uncertainty (m/year)	Erosion Allowance (m from HSD)			
					2020	2035	2050	2120
1 (MU1)	14.0	0	1	0.2	14	29	42	132
2 (MU1)	12.0	0	1	0.2	12	27	40	130
3 (MU1)	23.0	0	1	0.2	23	38	51	141
4 (MU2)	14.0	0	1	0.2	14	29	42	132
5 (MU1)	17.0	0	1	0.2	17	32	45	135
6 (MU1)	10.0	0	1	0.2	10	25	38	128
7 (MU1)	23.0	0	1	0.2	23	38	51	141
8 (MU1)	28.0	0.4	1	0.2	28	49	68	186
9 (MU3)	26.0	0.2	1	0.2	26	44	60	164
10 (MU3)	29.0	0.2	1	0.2	29	47	63	167
11 (MU3)	24.0	0.1	1	0.2	24	40.5	55	152
12 (MU4)	21.0	0	1	0.2	21	36	49	139
13 (MU5)	19.0	0	1	0.2	19	34	47	137
14 (MU5)	19.0	0	1	0.2	19	34	47	137
15 (MU5)	17.0	0	1	0.2	17	32	45	135
16 (MU5)	27.0	0	1	0.2	27	42	55	145
17 (MU5)	30.0	0	1	0.2	30	45	58	148
18 (MU5)	8.0	0	1	0.2	8	23	36	126
19 (MU5)	14.0	0	1	0.2	14	29	42	132
20 (MU5)	39.0	0	1	0.2	39	54	67	157
21 (MU5)	4.0	0	1	0.2	4	19	32	122
22 (MU5)	10.0	0.1	1	0.2	10	26.5	41	138
23 (MU5)	9.0	0.1	1	0.2	9	25.5	40	137
24 (MU5)	12.0	0.3	1	0.2	12	31.5	49	160
25 (MU6)	14.0	0	1	0.2	14	29	42	132
26 (MU6)	21.0	0	1	0.2	21	36	49	139
27 (MU6)	21.0	0	1	0.2	21	36	49	139
28 (MU7)	15.0	0	1	0.2	15	30	43	133
29 (MU8)	3.0	0	0.5	0	3	10.5	18	53
30 (MU9)	5.0	0	0.5	0	5	12.5	20	55
31 (MU9)	3.0	0	0.5	0	3	10.5	18	53
32 (MU9)	3.0	0	0.5	0	3	10.5	18	53
33 (MU9)	3.0	0	0.5	0	3	10.5	18	53
34 (MU9)	5.0	0	0.5	0	5	12.5	20	55
35 (MU9)	5.0	0	0.5	0	5	12.5	20	55
Preston River	0.0	0	0.3	0	0	4.5	9	30
Collie River	0.0	0	0.3	0	0	4.5	9	30

5 INUNDATION HAZARD ASSESSMENT

5.1 Inundation Levels

The modelled peak steady water levels are presented in Table 5-1 and detailed in Appendix C-2-4. The Cut opening has some notable impacts for the surge peaks inside the estuary water. The water level differences are smaller for 1-year, 10-year and 100-year storms as duration of these storms were expanded to cover multiple tidal cycles. This is to represent the longer duration of winter storms compared to extratropical cyclones.

5.2 Inundation Extent

An overview of inundation extents within the study domain are presented in Figure 5-1 to Figure 5-5. The full map set is provided in Table 6-1 and at the following link:

https://watech.maps.arcgis.com/apps/webappviewer/index.html?id=d43c39fda97d426ea6192d1a7a8543cf

Inundation extents along the middle and upper Collie River (including branches) are mapped based on DWER river flood model (present day, not affected by SLR). Flood plain (low lying land along the river courses) is under consistent risk of river flooding. There is however a clear boundary where river flood does not reach further due to a rapid increase in ground elevation at the outer edge of this flood plain. Areas under flood risk are most likely limited within the envelope of the established foreshore reserve. Existing development activities were planned to be beyond the reach of the 500 yrs. ARI flood. SLR has very limited impact to the inundation extent mapped by Figure 5-1.

Inundation extents along the open coast, land depression at Capel, Bunbury coast and Leschenault Estuary/Inlet are simulated by the calibrated storm surge model for all required storms including 1 yrs., 10 yrs., 100 yrs. and 500 yrs. storms and planning timeframes including present day, 2035, 2050 and 2120. The model has considered impacts from river floods e.g., flood discharges at Five Mile Brook, Capel River, Preston River and Collie River, as well as some major controls such as riverbanks, flood levees, roads, main bridge openings, Leschenualt Inlet storm barrier (present day barrier level included in model), FMB drainage inlets and culverts. The model does not however simulate the on-grid rainfall/infiltration, nor flood flows through urban flood infrastructure (such as pipes and urban stormwater networks). Model results show that:

- At present day, the existing storm barrier is functional during a 1-year, 10-year and 100-year event. The Bunbury CBD area is predicted to be inundated in the present day 500-year cyclone. Differences in levels outside and inside the Leschenault Inlet are a result of the storm barrier – represented as a weir / dike within the model.
- The current design of the FMB outlet is sufficient to discharge 1-year and 10-year river floods (assuming 2 outlet pipes in operation). For more extreme events, coastal water may intrude into FMB and contribute to inland flooding. Modelling assumed a two-way flow through the outlet pipes (conservative settings to allow for potential malfunctioning of the pipes).
  - The modelled inundation (>100ARI) near Big Swamp Reserve is caused by river flood overflow from Five Mile Brook. Results were compared to Water Technology's 2012 detailed FMB flood model and noted consistent model results. The present study has a lower model resolution and more conservative inundation extent as infiltration/urban drainage networks were not modelled.
- In the present day, the land depression behind Peppermint Grove Beach is affected by both riverine and coastal flood, with different extents of impact for different ARI storms. Most coastal assets and occupied land at Peppermint Grove does not appear to be affected even by the greatest storm (500-year ARI) modelled as they are located well above the level of coastal inundation. A large area of land near the mouth of Preston and Collie River and land depression at Peppermint Grove Beach has a ground elevation of 2 m AHD or lower which is only slightly higher than the HAT level in 2120. These areas will be exposed to risk of consistent tidal flooding.
- In 2035 (short term) and 2050 (medium term), the inundation extents are quite similar to the present day. This is due to the small SLR allowance (0.1-0.2 m) considered for the short to medium term planning.

- In 2120, the 100-year ARI storm level (~2.7 m AHD) is predicted to be greater than the crest level of the existing Storm Surge Barrier (~2.16 m AHD). Most low-lying land (ground level 3 m AHD or lower) near Leschenault Inlet, Bunbury Port and Bunbury CBD is predicted to be affected by coastal inundation during the 100-year and 500-year ARI storms. The extent of impact is much smaller for a 100-year ARI storm. Due the protection of the Storm Surge Barrier, most urban land is not predicted to be affected by more regular storms (e.g., 1-10-year ARIs).
- For 2120, a greater extent of inundation is also found at the land depression behind Peppermint Grove Beach, the Big Swamp Reserve and Leschenault Estuary.

TABLE 5-1 MODELLED PEAK STEADY WATER LEVEL (M AHD)

Locations	Peak Steady Water Level (m AHD), various ARIs (years)															
	Present				2035				2050				2120			
	1	10	100	500	1	10	100	500	1	10	100	500	1	10	100	500
Leschenault Estuary	1.1	1.5	1.9	2.1	1.2	1.6	2.1	2.3	1.3	1.7	2.2	2.9	2.1	2.4	2.9	3.1
Koombana Bay	1.1	1.4	1.9	2.8	1.2	1.5	2.0	2.9	1.3	1.6	2.1	2.9	2.1	2.4	2.9	3.7
Leschenault Inlet				1.2				1.3				1.9		0.6	1.9	2.6
Open Coast (Bunbury)	1.1	1.4	1.9	3.0	1.2	1.6	2.0	3.1	1.3	1.7	2.1	2.8	2.1	2.4	2.8	3.9
Open Coast (Capel)	1.1	1.4	1.8	2.7	1.2	1.5	1.9	2.8	1.3	1.6	2.0	2.8	2.1	2.4	2.8	3.6
Land Depression	1.0	1.2	1.5	2.3	1.1	1.2	1.5	2.4	1.1	1.2	1.6	2.4	1.2	1.5	2.4	3.4

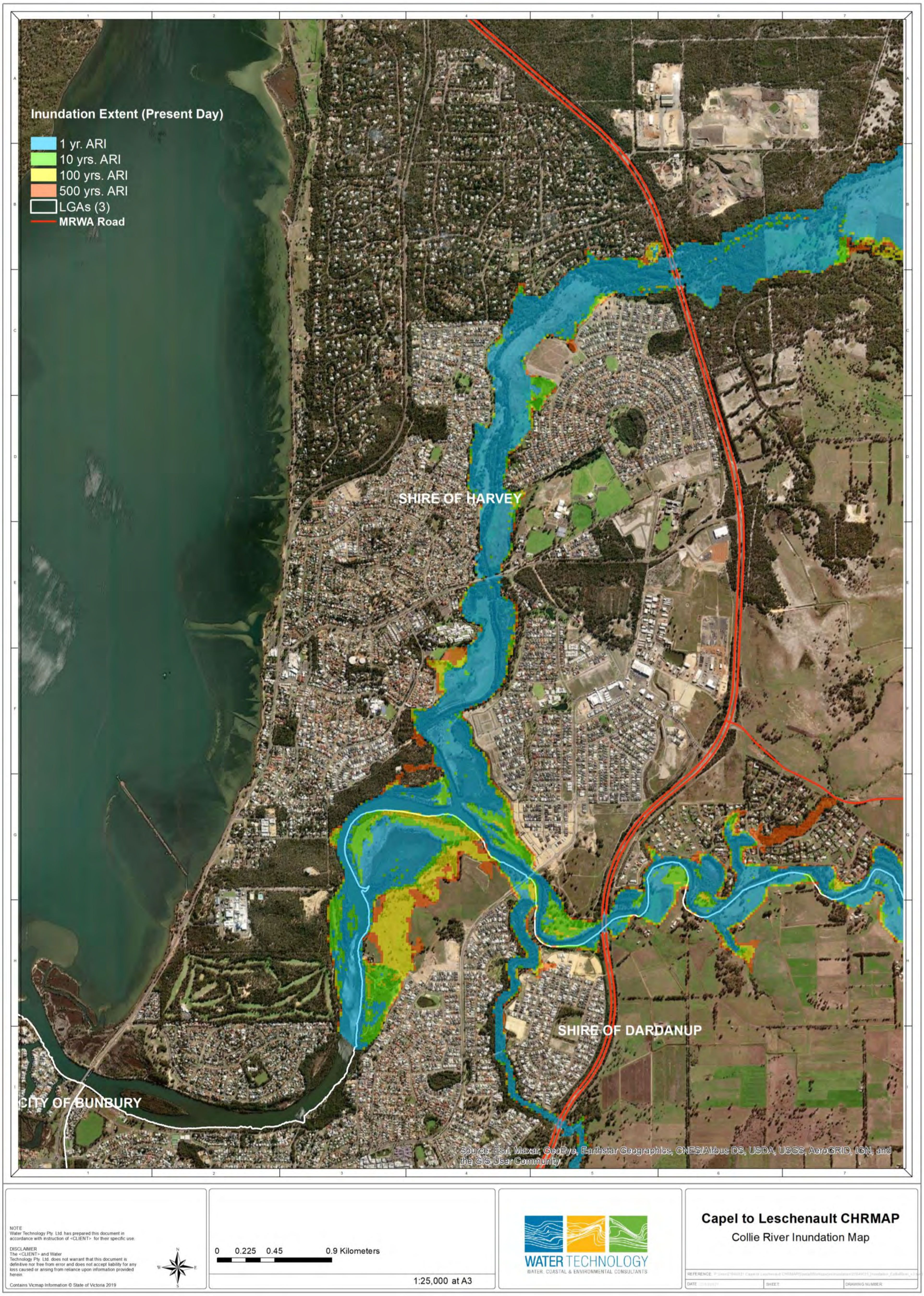


FIGURE 5-1 PRESENT DAY INUNDATION EXTENT AT COLLIE RIVER (1YR., 10 YRS., 100 YRS. AND 500 YRS. ARI PRESENTED IN BLUE, GREEN, YELLOW AND RED RESPECTIVELY)

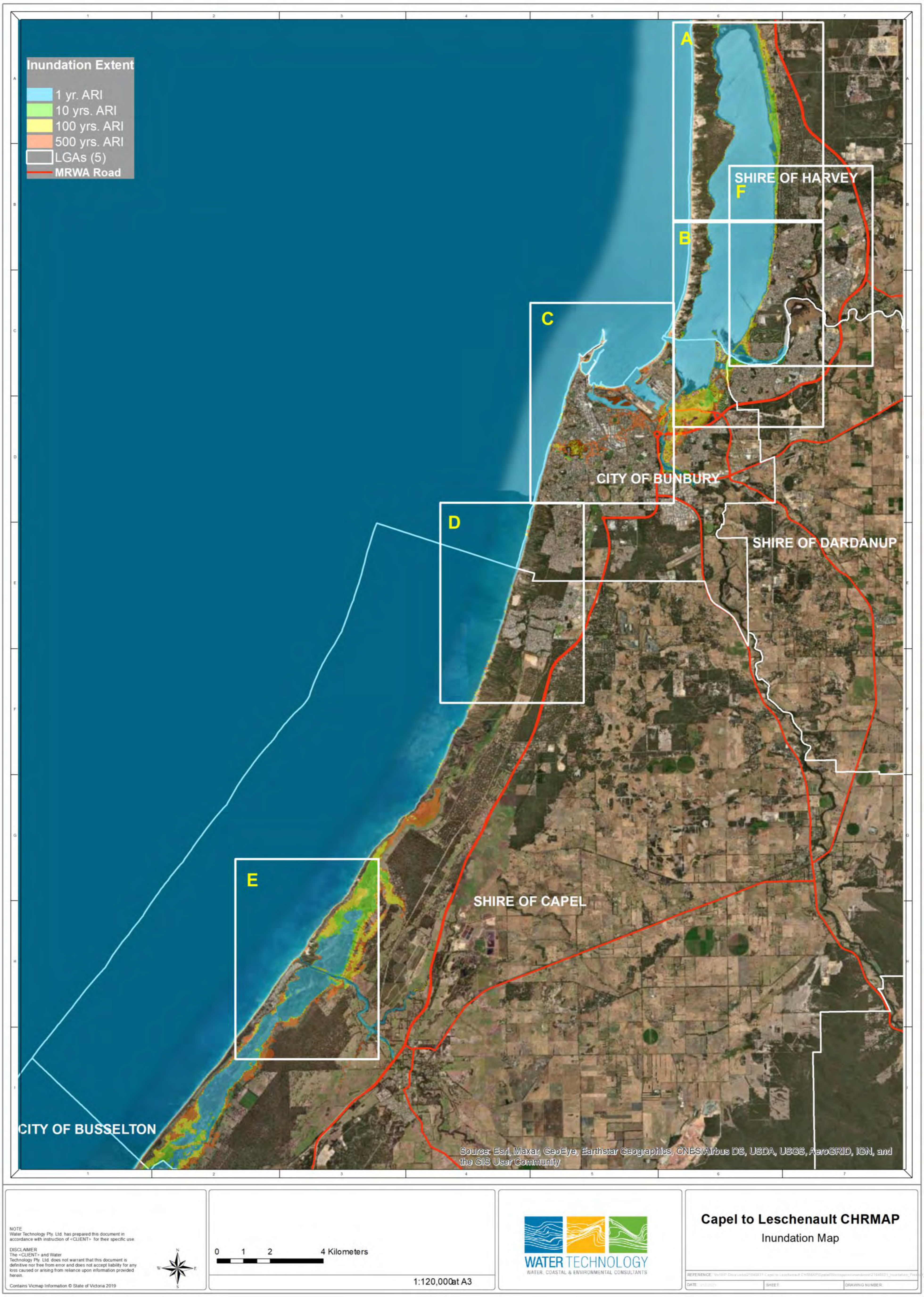


FIGURE 5-2 PRESENT DAY INUNDATION EXTENT (1YR., 10 YRS., 100 YRS. AND 500 YRS. ARI PRESENTED IN BLUE, GREEN, YELLOW AND RED RESPECTIVELY)

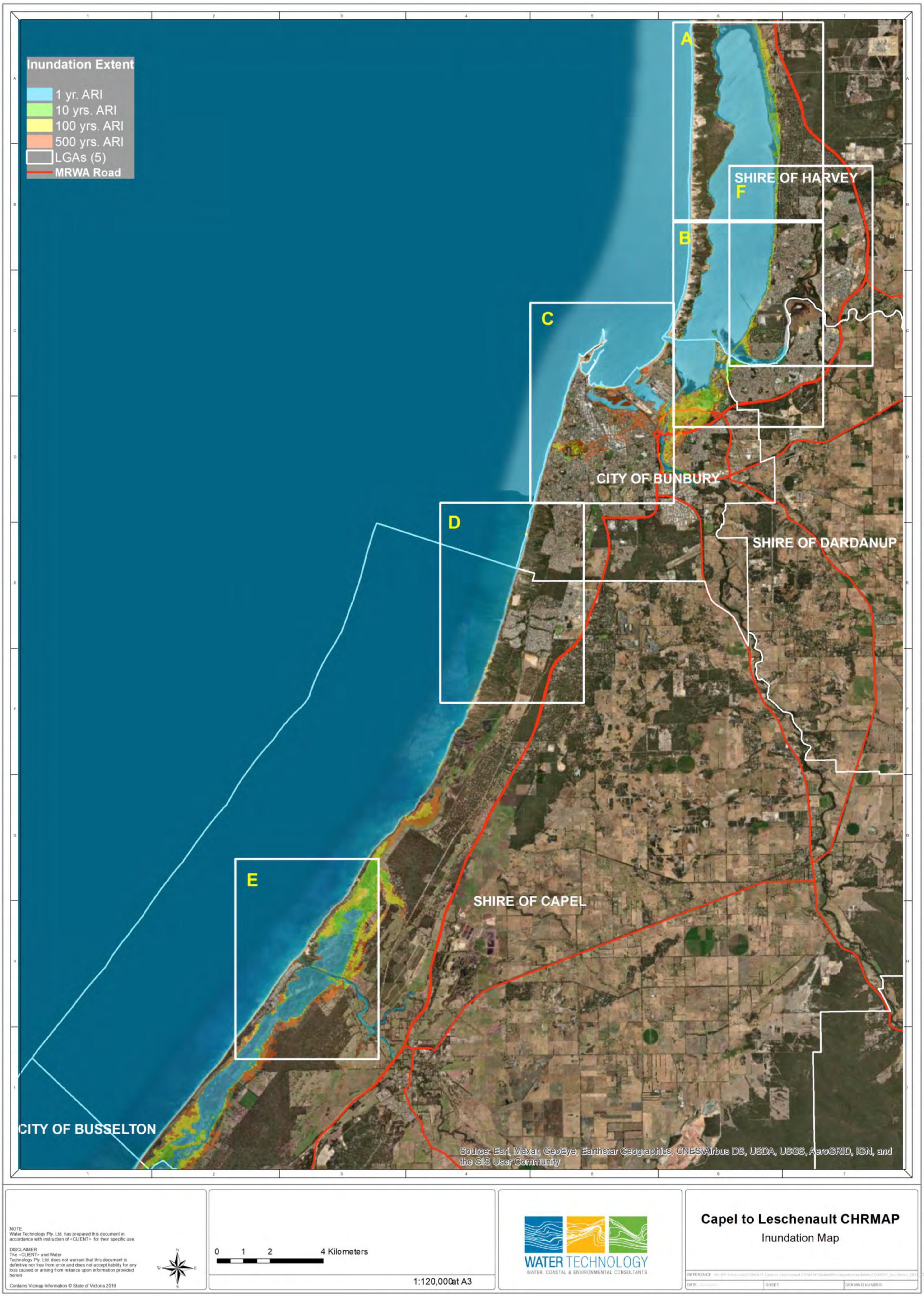


FIGURE 5-3 2035 INUNDATION EXTENT (1YR., 10 YRS., 100 YRS. AND 500 YRS. ARI PRESENTED IN BLUE, GREEN, YELLOW AND RED RESPECTIVELY)

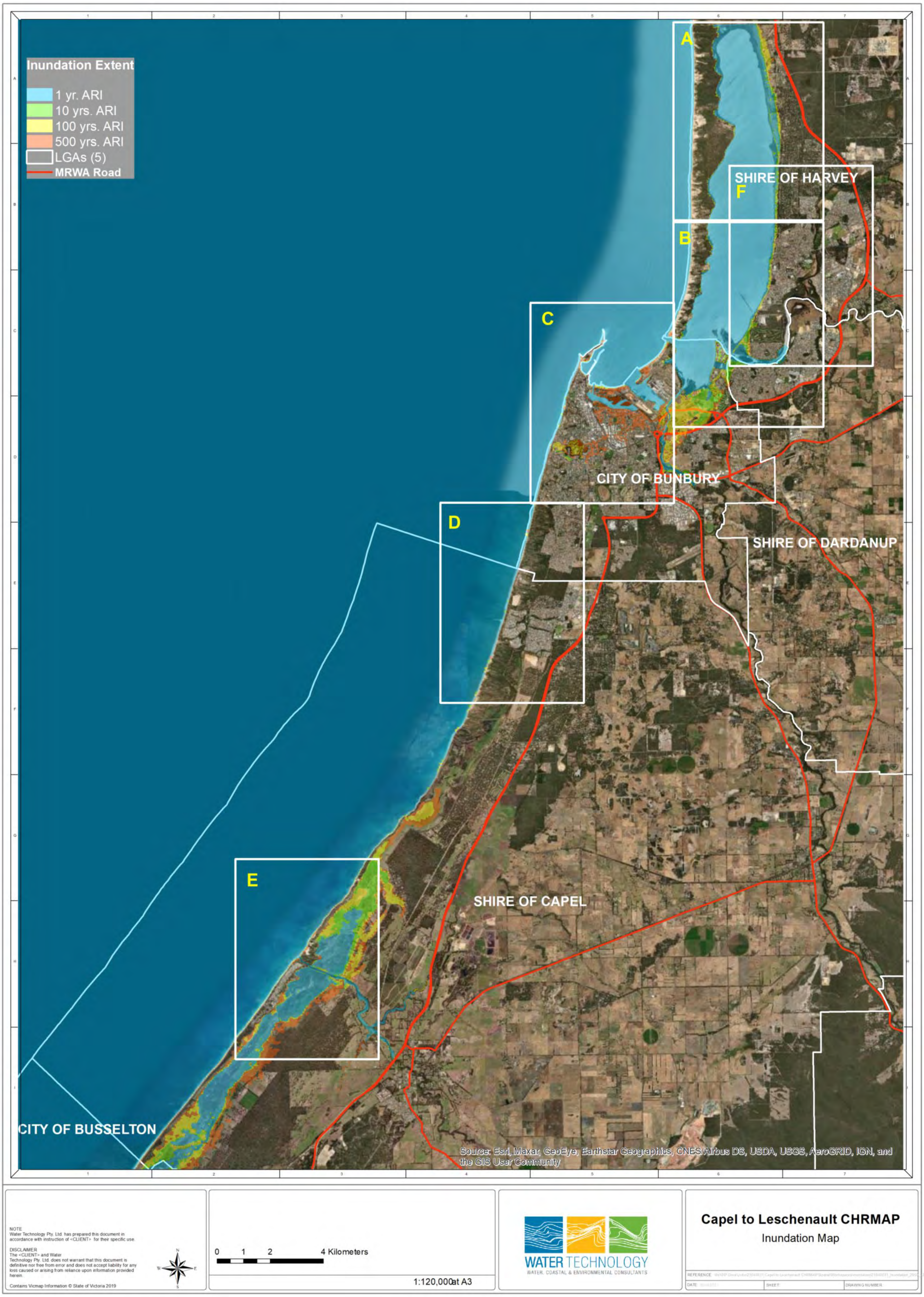


FIGURE 5-4 2050 INUNDATION EXTENT (1YR., 10 YRS., 100 YRS. AND 500 YRS. ARI PRESENTED IN BLUE, GREEN, YELLOW AND RED RESPECTIVELY)

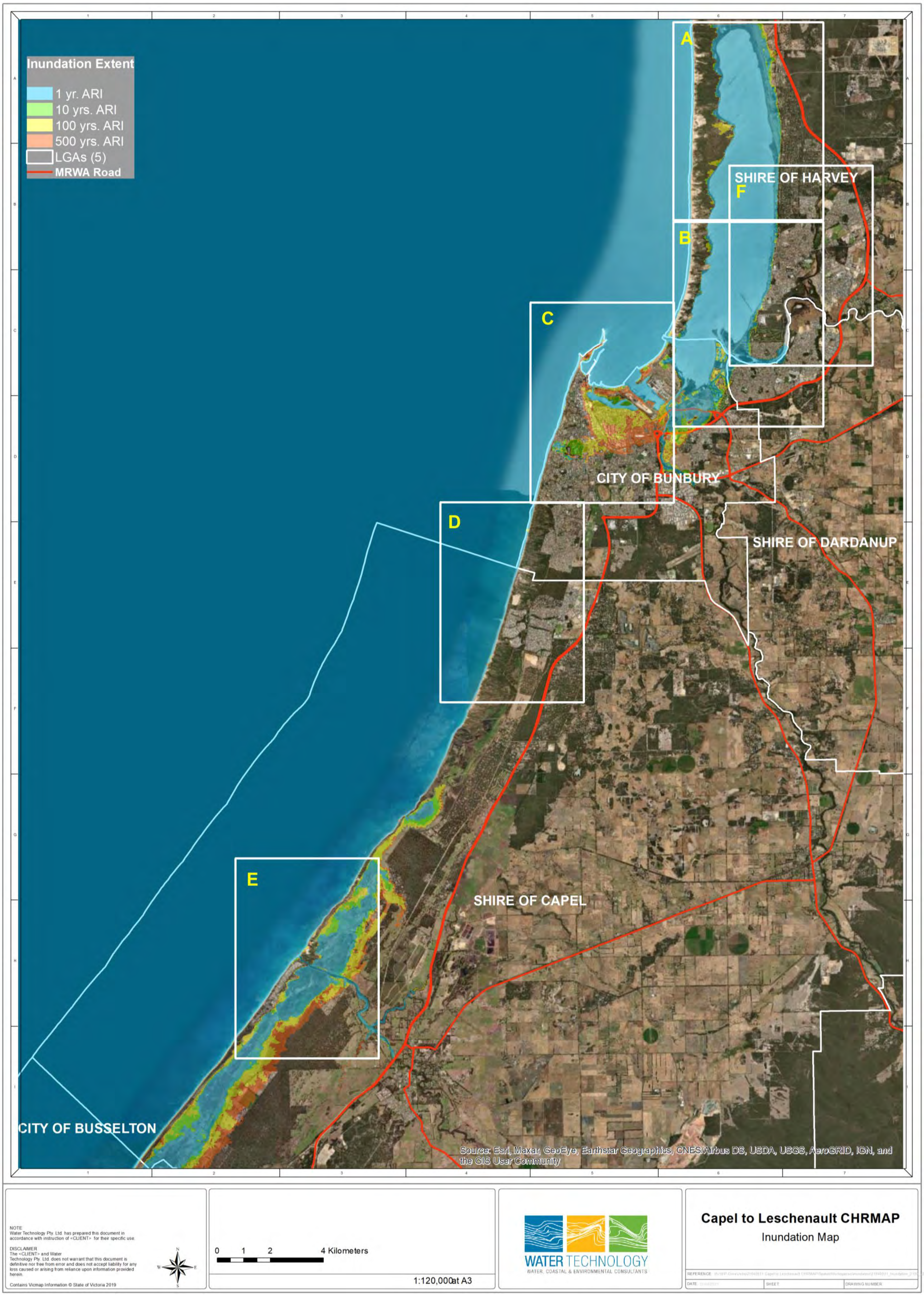


FIGURE 5-5 2120 INUNDATION EXTENT (1YR., 10 YRS., 100 YRS. AND 500 YRS. ARI PRESENTED IN BLUE, GREEN, YELLOW AND RED RESPECTIVELY)

6 SUMMARY OF HAZARD ASSESSMENT OUTCOMES

The outcomes of the coastal hazard assessment for each management unit (Figure 6-1) are summarised and discussed in Table 6-1 below.

Hazard extents can be viewed in high resolution via the link:

https://watech.maps.arcgis.com/apps/webappviewer/index.html?id=d43c39fda97d426ea6192d1a7a8543cf

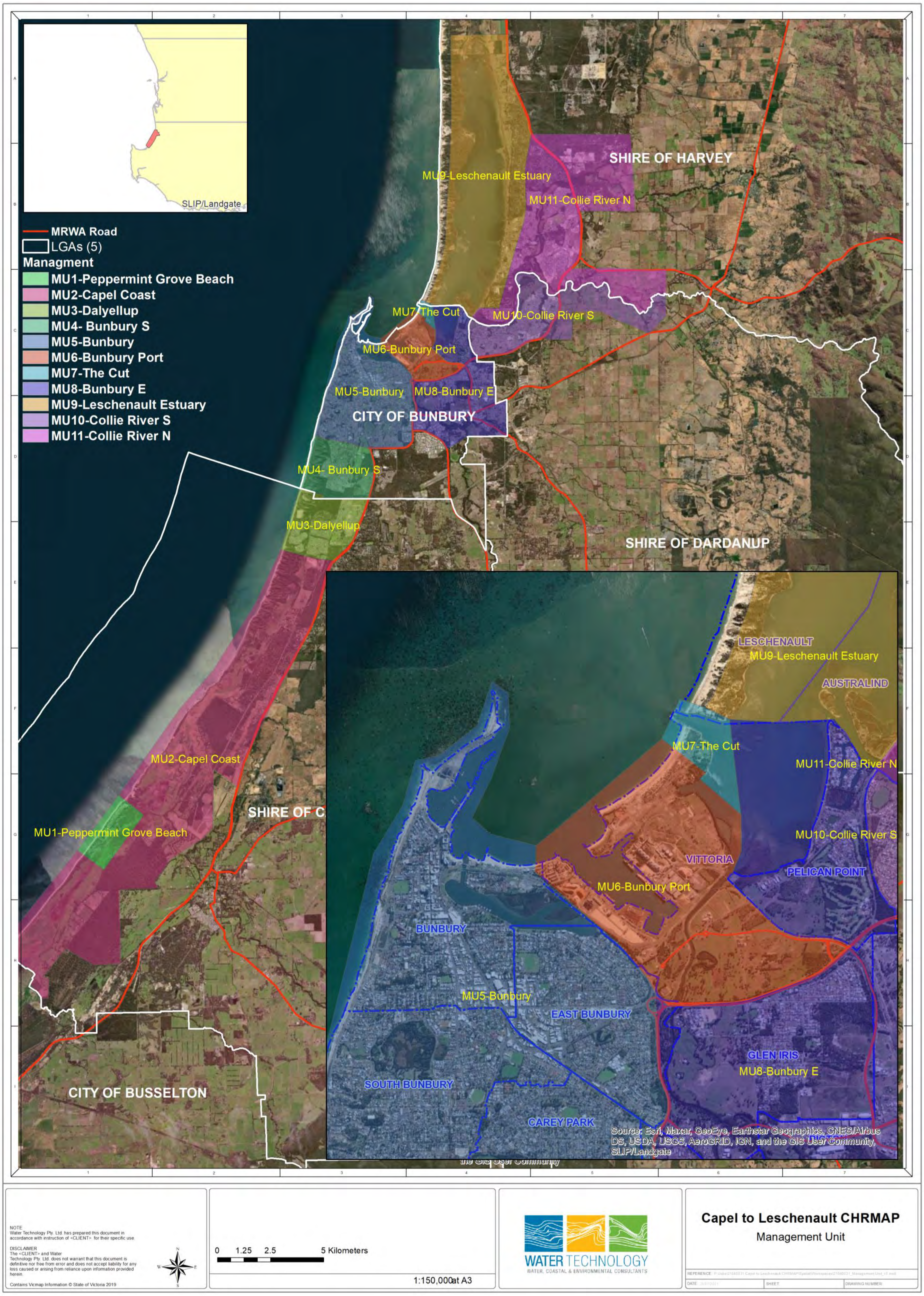
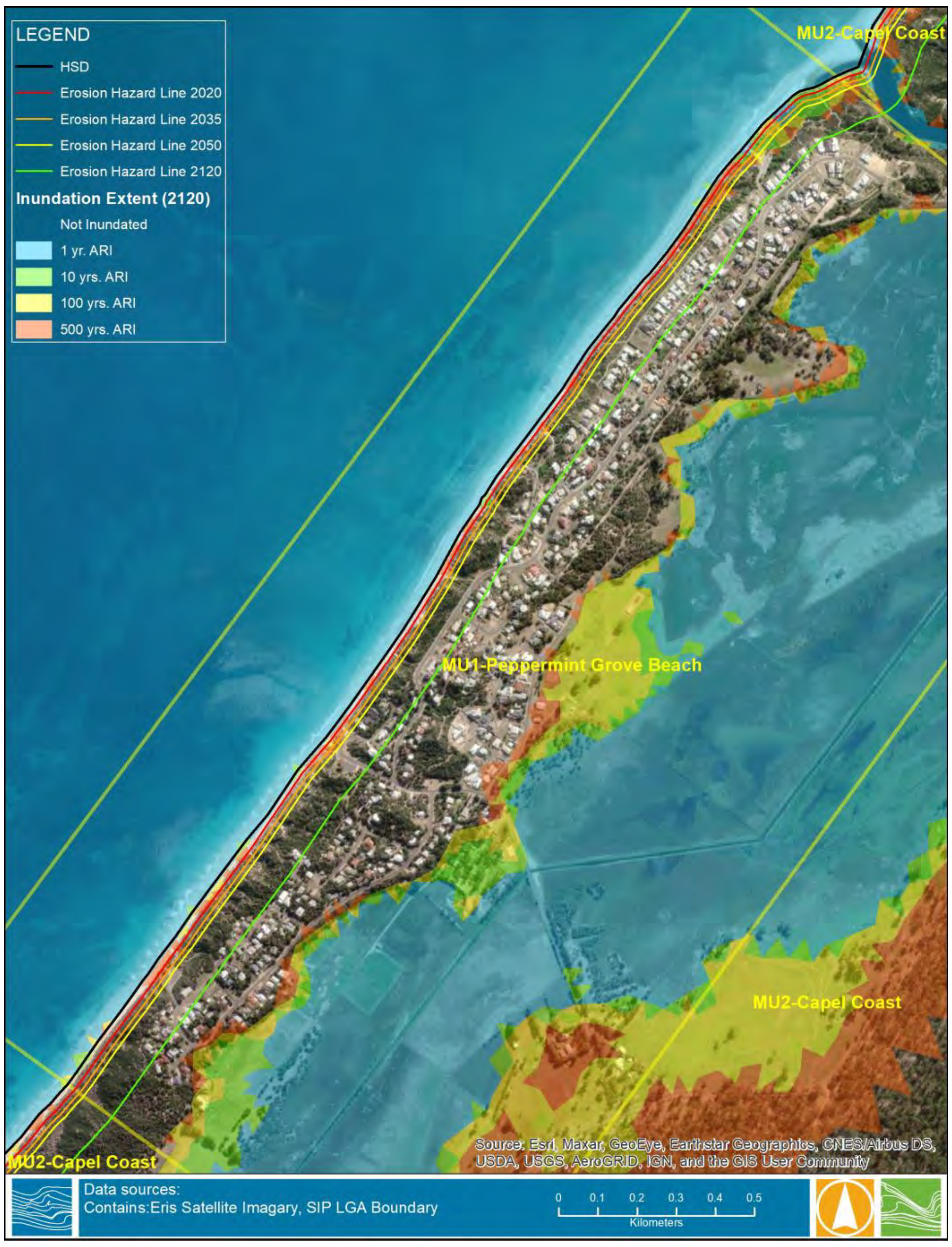
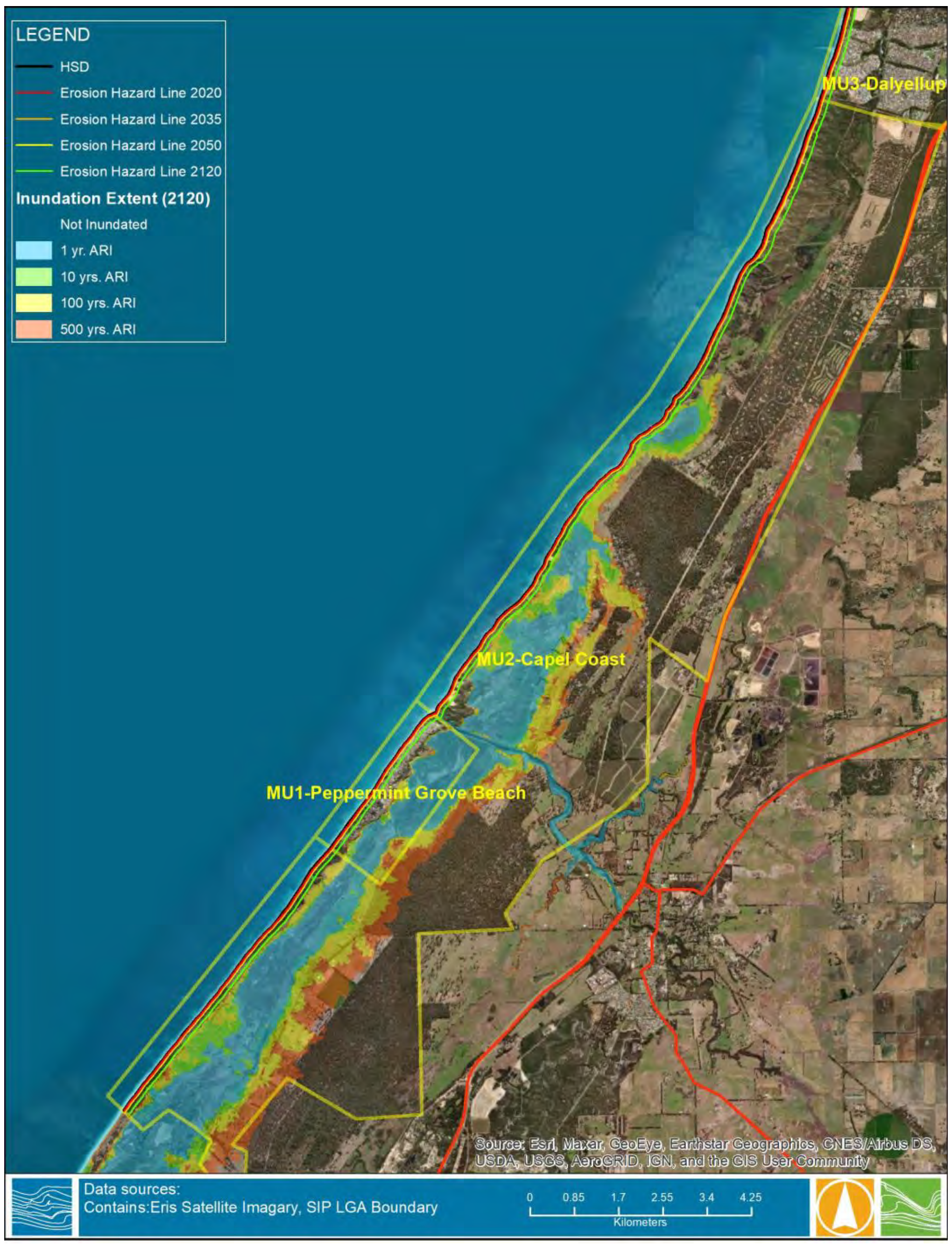


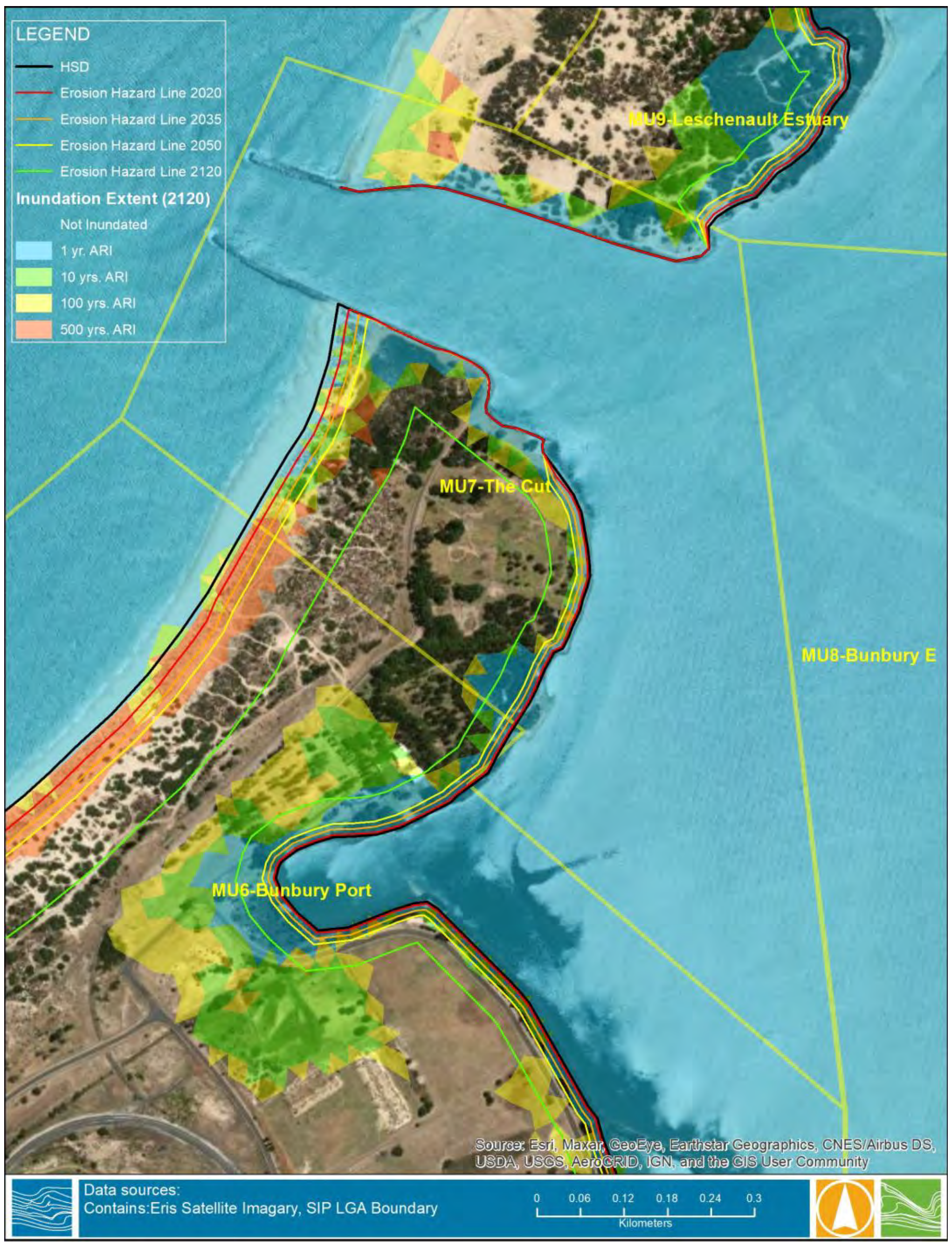
FIGURE 6-1 STUDY AREA AND MANAGEMENT UNITS

TABLE 6-1 SUMMARY OF COASTAL HAZARDS FOR EACH MANAGEMENT UNIT

Management Unit	Erosion & Inundation Hazard	Summary
MU1 – Peppermint Grove		▪ In 2120, the land depression behind the residential area will be under constant risk of inundation. Most of the residential properties are not predicted to be affected. The existing sand dune acts as a natural barrier for coastal inundation. The inundation model assumes ocean water enters the land depression through Higgins Cut, Capel River and culvert openings, and that the sand dune is not eroded. ▪ Peppermint Grove is particularly vulnerable to erosion hazard as there is only a 50-100 m wide reserved sand dune. Properties are predicted to be within the erosion hazard zone by 2120.
MU2 – Capel Coast		▪ The inundation extent extends across the land depression adjacent to Capel River. In the north of the management unit, inundation is minimal. ▪ Erosion allowances are similar along this stretch of shoreline (sandy type) ▪ Erosion risk of assets (foreshore reserves, resorts, toilets, car parks, farmlands and estates etc.) are determined by their distances from HSD.

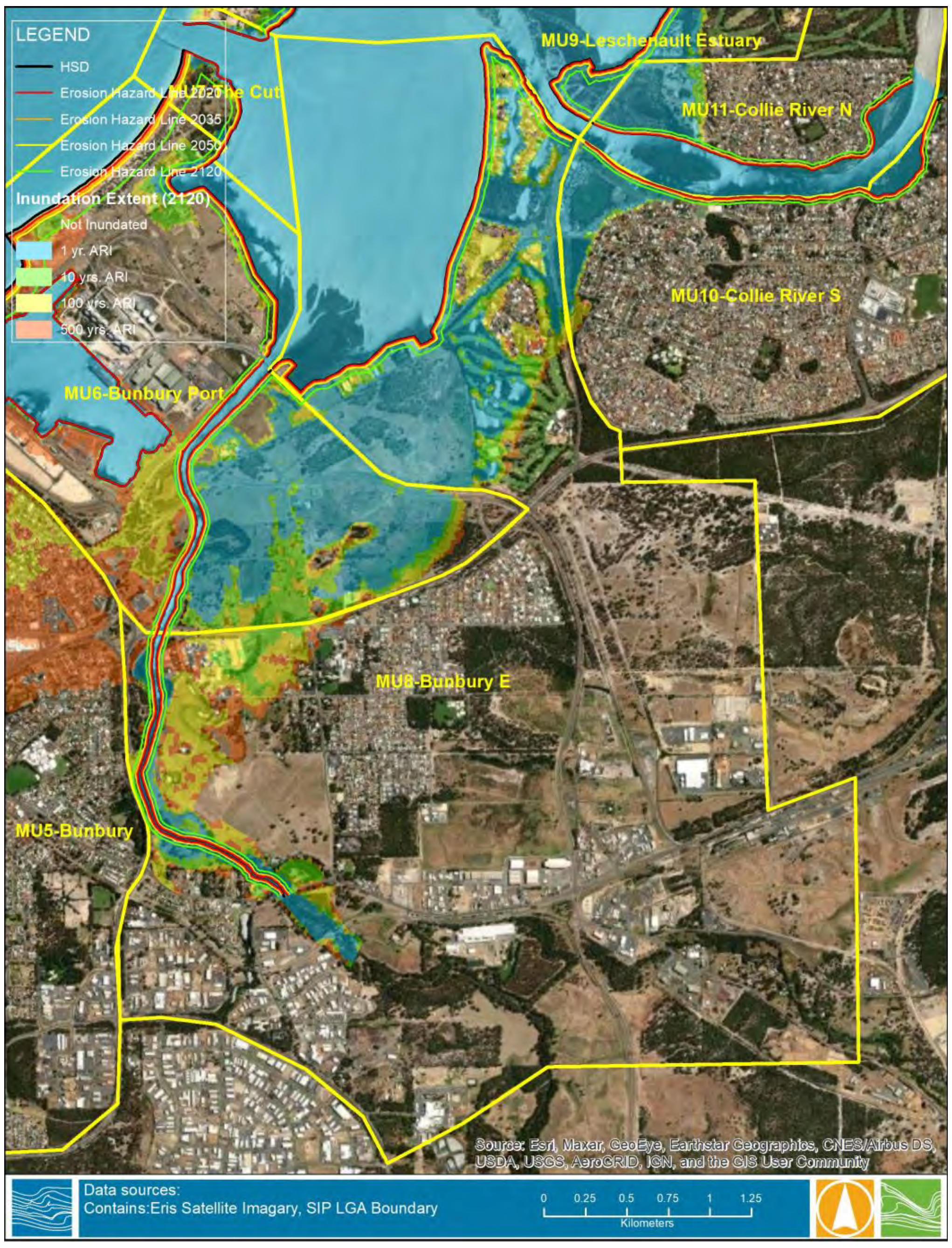
Management Unit	Erosion & Inundation Hazard	Summary
MU3 – Dalyellup		▪ Inundation is not a high risk in this management unit ▪ Residential properties in Dalyellup are predicted to be in the erosion hazard zone by 2120. ▪ The SLSC car park is predicted to be in the erosion hazard zone by 2035. ▪ The treatment ponds of the Bunbury Wastewater Treatment Plant are predicted to be in the erosion hazard zone by 2120. ▪ The Tronox landfill site is predicted to be slightly in the erosion hazard zone by 2120.
MU4 – Bunbury S		▪ Inundation is not a high risk in this management unit. ▪ Erosion is predicted to impact natural assets only within this management unit.

<table>
<tr><th>Management Unit</th><th>Erosion & Inundation Hazard</th><th>Summary</th></tr>
<tr><td>MU5 – Bunbury including open coast, Koombana Bay and Leschenault Inlet</td><td>
</td><td>Inundation is a significant risk across much of this management unit. The inundation risk is predicted to increase from present day to 2120. By 2120, the 100-year ARI is predicted to inundate a significant residential and commercial area.
The Storm barrier plays a key role in inundation control. The risk of coastal inundation would be much greater if the storm barrier was not in operation.
Much of the CBD is predicted to be under water during a 100-year and 500-year ARI storm in 2120. The crest of current storm barrier is about 2.1 m AHD, which is not predicted to be high enough to withstand these storms in 2120.
Erosion is a significant risk for buildings and natural assets along the western coast of the CoB.
Koombana Bay and Leschenault Inlet are heavily engineered. Erosion may still occur along shorelines not protected by structures.
Access to the outer harbour (Casuarina Drive) is at risk from 2035.</td></tr>
<tr><td>MU6 – Bunbury Port</td><td>
</td><td>Inundation risk at the shipping yard and other lower ground areas.
Main port facilities are not affected as they are located at higher ground and are protected by controlled shorelines.
By 2120, the land near the entrance to the inner Port will be within the erosion hazard zone. Reinforcement may be required for shoreline segments not protected.
It is noted that a high-level study using policy setbacks provides no additional value to the planning and management of lands along the Preston River (at the back end of the port).
Water Corporation levees have not been considered in the development of these lines</td></tr>
</table>

<table>
<tr><th>Management Unit</th><th>Erosion & Inundation Hazard</th><th>Summary</th></tr>
<tr><td>MU7 – the Cut</td><td>


</td><td>

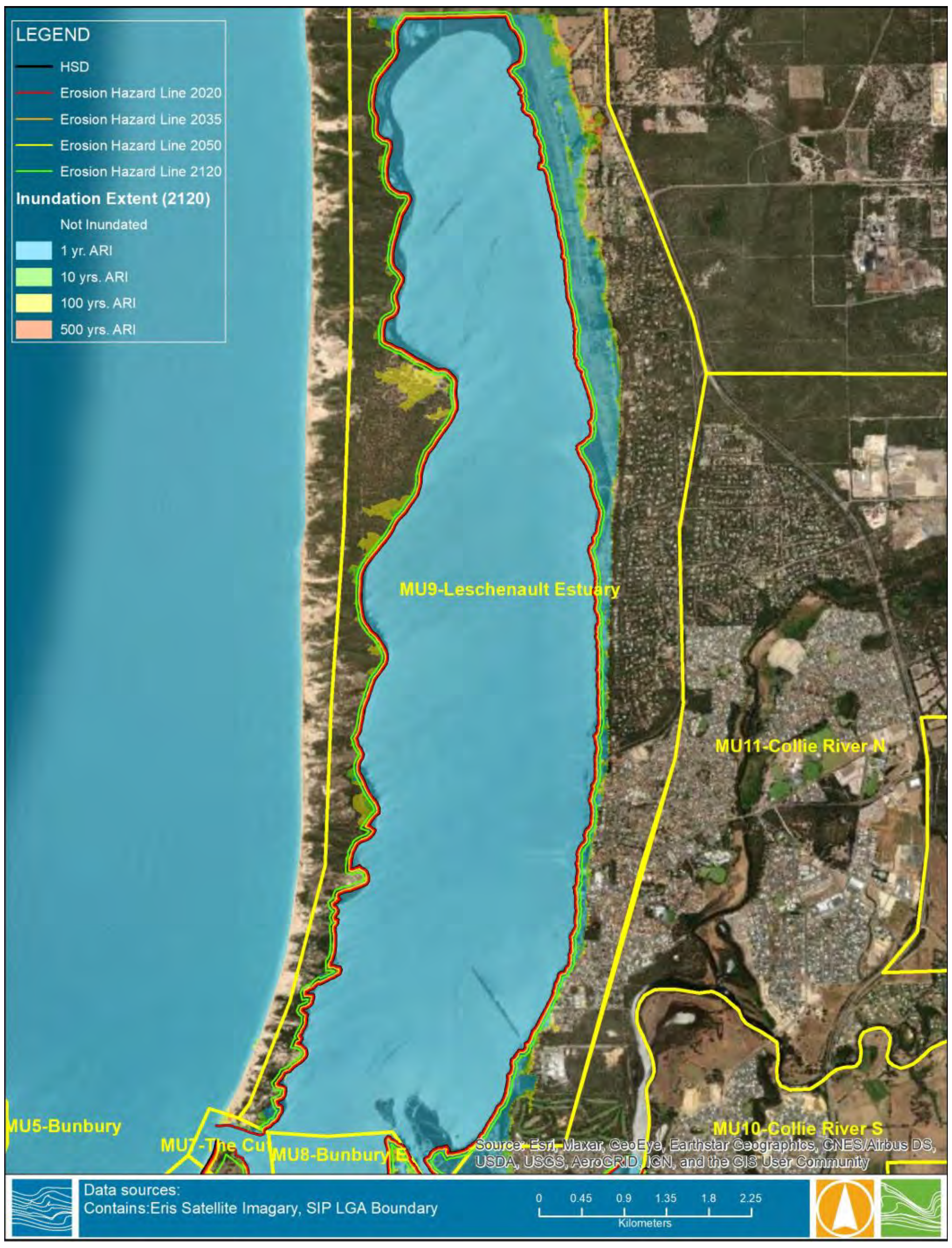
The Cut entrance is at risk of erosion by 2120. Seawater may erode the sand dune behind the seawall if it is not designed and constructed to standards. Attention must be paid to the impact of overtopping and breaching of the sand dune behind the seawall.
Inundation is not a key risk in this management unit.

</td></tr>
<tr><td>MU8 – Bunbury E including Vittoria Bay, Pelican Point and Districts along Preston River</td><td>


</td><td>

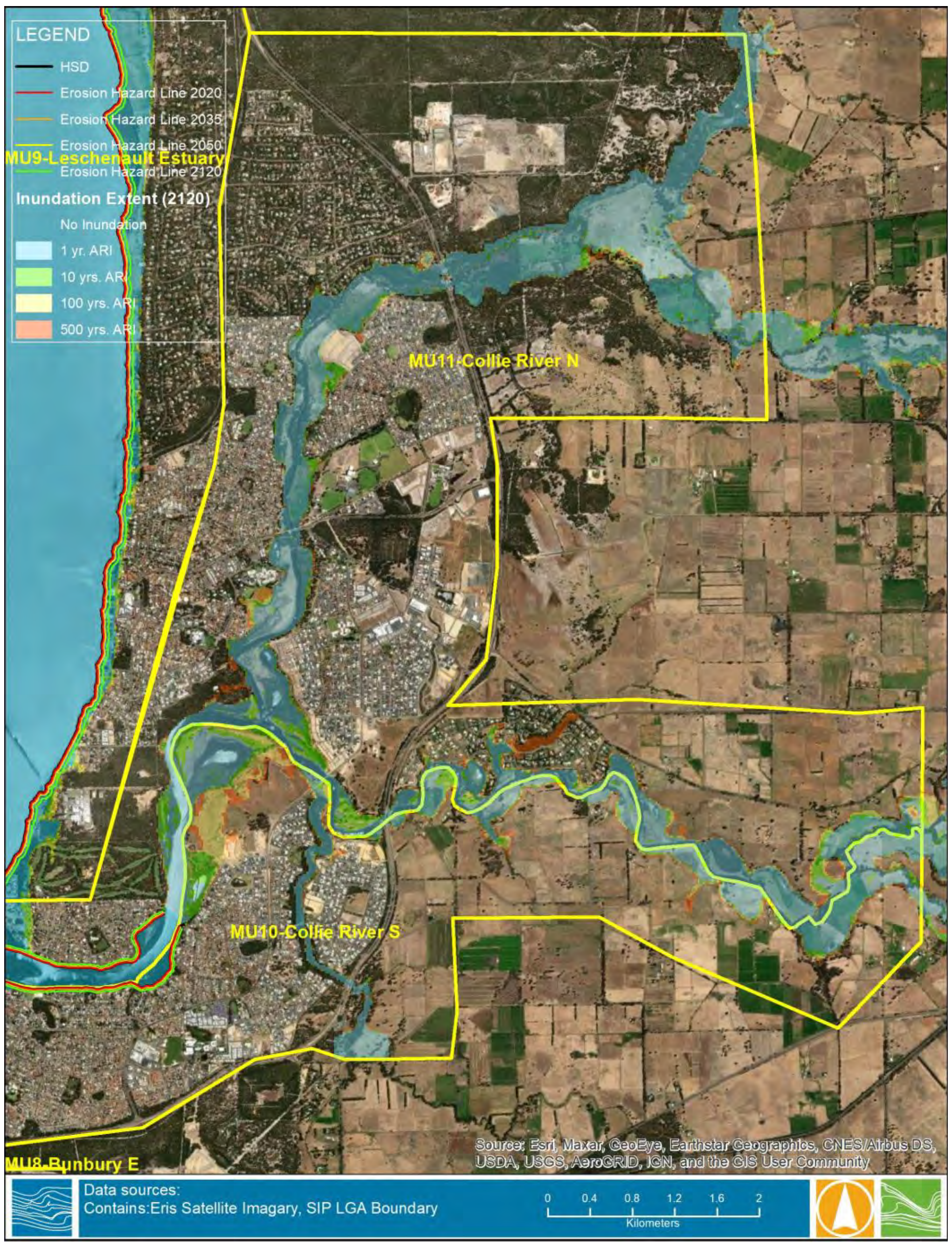
The areas surrounding Preston River and the Estuary are at risk of inundation from the present day.
Foreshore Park and the commercial properties on Estuary Drive are predicted to be in the coastal erosion hazard zone by 2120.
It is assumed the canal infrastructure will be maintained; however, the canal properties are at risk from erosion along the river and estuary fronts by 2120. This prediction however only serves the purpose of government planning and should not be used for risk assessment of individual properties.

</td></tr>
</table>

<table>
<tr><th>Management Unit</th><th>Erosion & Inundation Hazard</th><th>Summary</th></tr>
<tr><td>MU9 – Leschenault Estuary</td><td>


</td><td>

- Inundation along the eastern shoreline of the estuary is a risk from the present day. This affects foreshore reserve and residential / commercial assets.
- Significant portions of land may be affected by tidal inundation by 2120. The majority of this is foreshore reserve, with the exception of the Australind Tourist Park.
- The predicted extent of inundation is greater than the extent of erosion, especially along the eastern shoreline of the estuary.

</td></tr>
<tr><td>MU10 and MU11- Collie River Flood Plain</td><td>


</td><td>

- Inundation is predicted to be mainly within the foreshore reserve.
- Erosion lines may impact some residential properties.
  - It is noted that a high-level study using policy setbacks provides no additional value to the planning and management of lands along the Collie River. Erosion lines along the mid- and upper Collie River streams were not mapped due to the dominant impact from inland processes (erosion primarily controlled by soil composition, river floods and vegetation growth). MU10 and MU11 should be managed in accordance with DWER foreshore management policies.

</td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

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WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX A
STUDY AREA LOCALITY PLANS

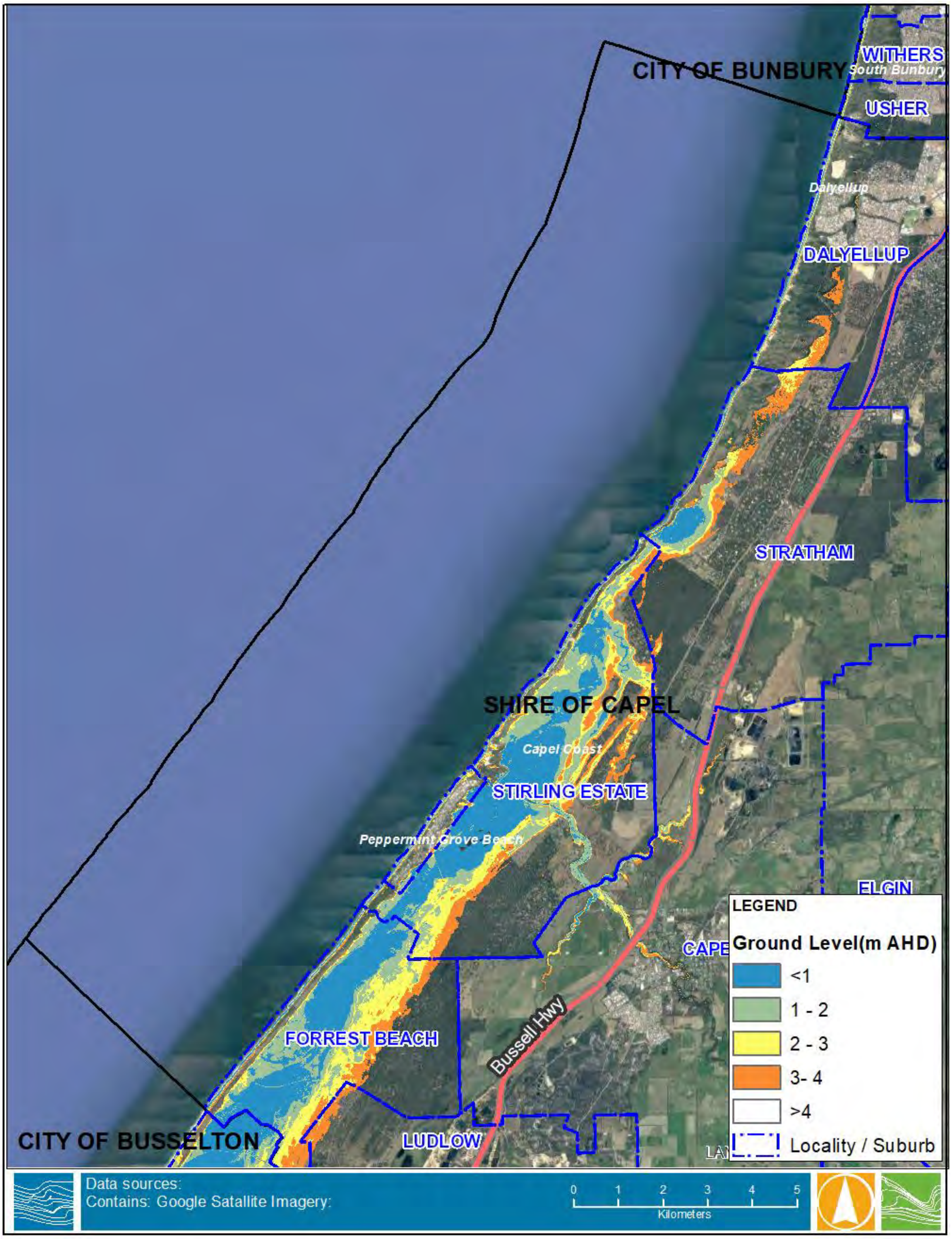


FIGURE A-1 SHIRE OF CAPEL PROJECT AREA (OVERLAYED ARE SUBURBS & ROADS AND GROUND LEVELS)

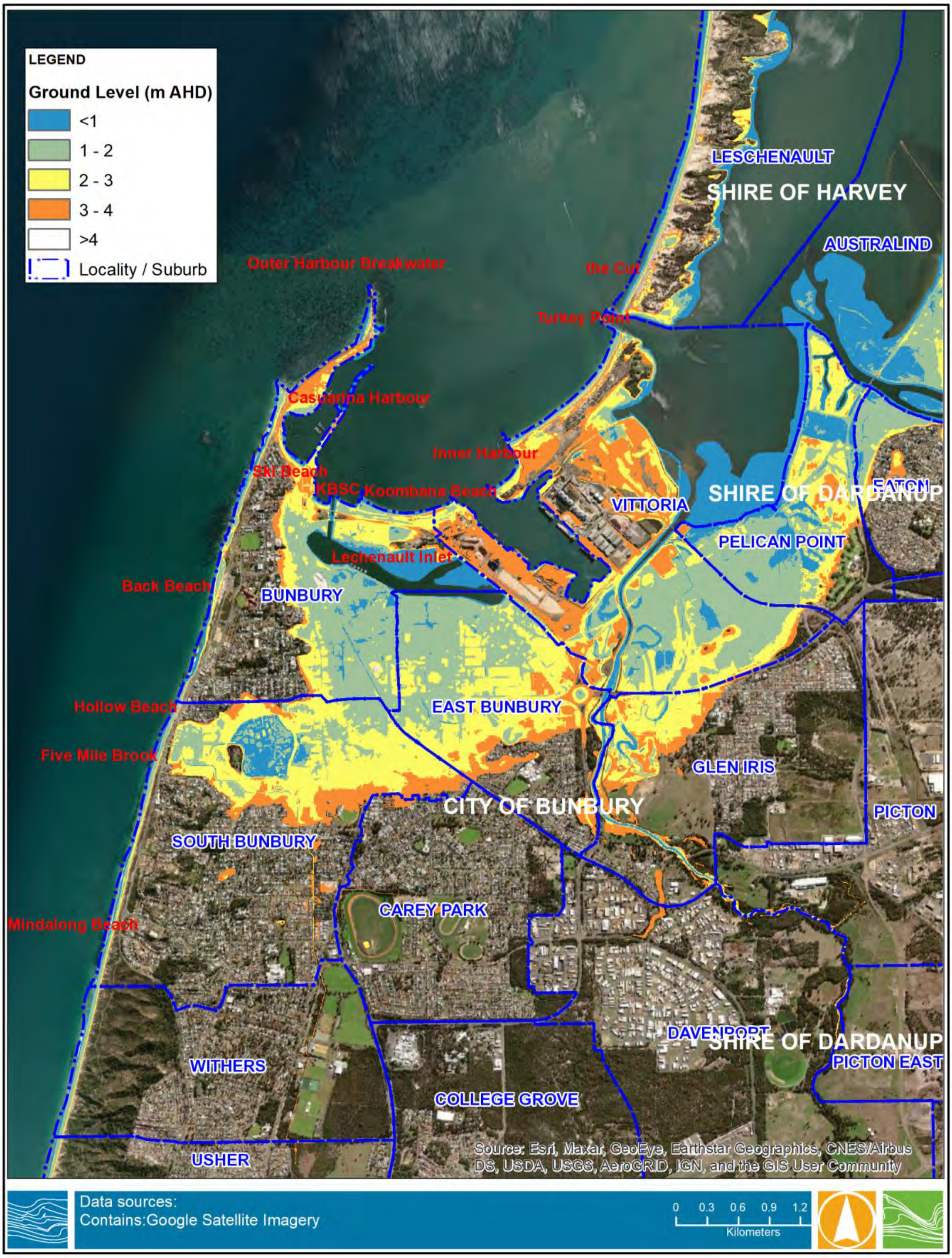


FIGURE A-2 BUNBURY PROJECT AREA (OVERLAYED ARE SUBURBS & ROADS)

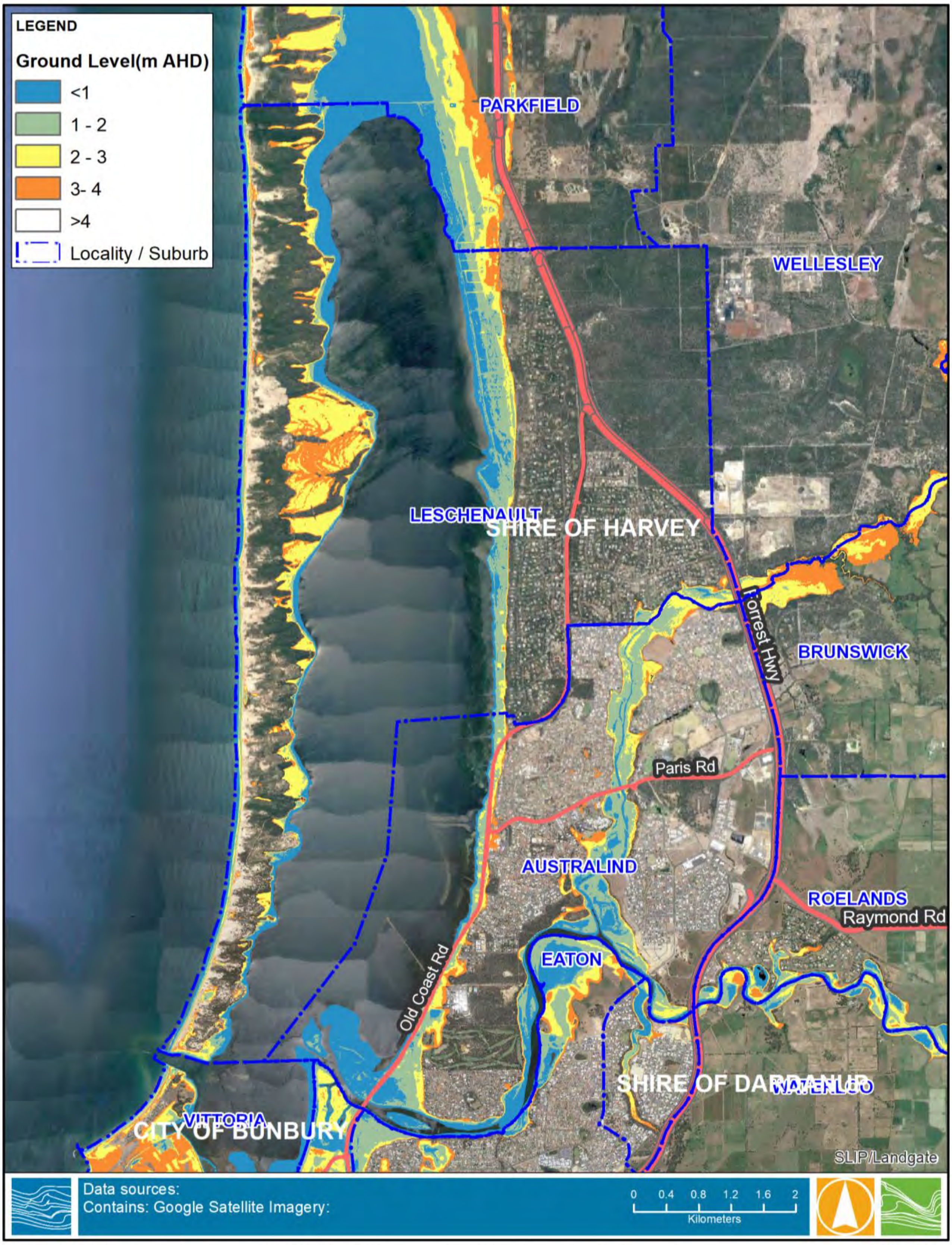


FIGURE A-3 SHIRE OF HARVEY PROJECT AREA (OVERLAYED ARE SUBURBS, ROADS AND GROUND LEVELS)

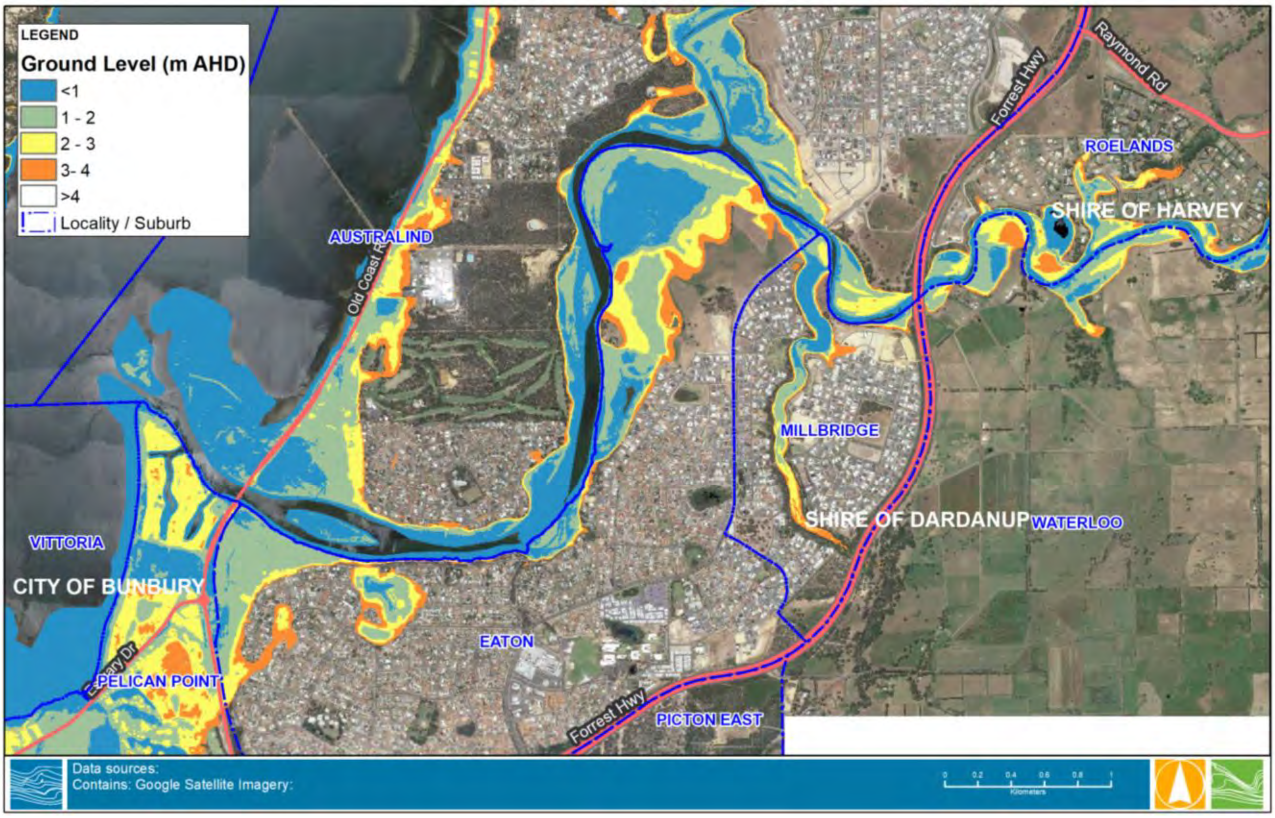
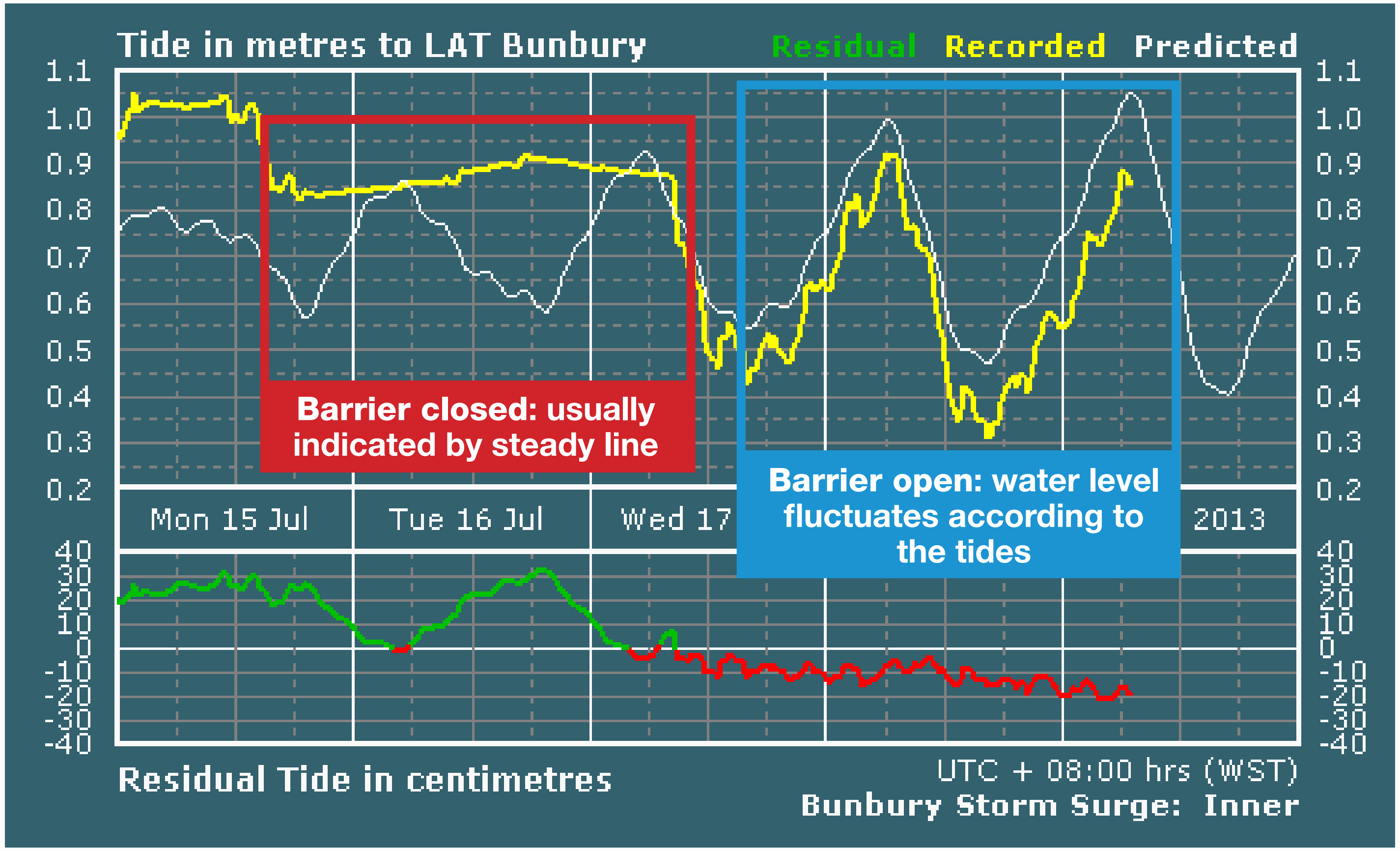


FIGURE A-4 SHIRE OF DARDANUP PROJECT SITE (OVERLAYED ARE GROUND LEVEL MAP, SUBURBS & ROADS)

APPENDIX B
STORM SURGE BARRIER DETAILS

Inner Storm Surge Barrier

Inside Leschenault Inlet



The graph is a plot of the actual water level (yellow line), predicted tide (white line) and the residual tide (green and red line: the difference between the actual water level and the predicted tide).

Before going boating on the Leschenault Inlet always plan ahead and check online at ***www.transport.wa.gov.au/imarine/ bunbury-storm-surge-barrier-tide.asp*** *if the barrier is closed or could be closed.*

Contact

Department of Transport
Coastal Management
Telephone: (08) 9435 7796
Email: bunburystormsurge@transport.wa.gov.au
Website: www.transport.wa.gov.au/imarine/
bunbury-storm-surge-barrier-tide.asp

August 2016 DoT 1484-36-01

Department of Transport

Bunbury Storm Surge Barrier

Purpose and Operation

Bunbury Storm Surge Barrier

The timely operation of Bunbury's storm surge barrier, at the western end of the Leschenault Inlet, is vital as it prevents flooding of Bunbury's low lying areas.

Location of the Bunbury Storm Surge Barrier.

Flooding of Bunbury, Cyclone Alby 1978.
Photo courtesy of The West Australian

The barrier was installed in 1980 following flooding of Bunbury townsite during cyclone Alby in 1978.

Today the barrier protects Bunbury's low lying areas from ocean flooding but careful consideration must be given to extended closure of the gates due to the threat of flooding from rainfall runoff.

Factors influencing operation

High ocean water levels are the main factor influencing the closing and opening of the barrier. High ocean water levels are caused by a combination of tide, wind and barometric pressure.

Significant high ocean water levels are most common from May to September during winter storms (low barometric pressure with strong winds) combined with high astronomical tides. However, high ocean water levels can also occur in summer associated with thunderstorms or ex-tropical cyclone events.

Based on analysis of water level information, drainage into the inlet, the duration the barrier may need to be closed, estimated rates of water level rise and damage to the City; the barrier should be closed at a maximum ocean water level of 1.2 metres above lowest astronomical tide (LAT).

Operation of the barrier

To prevent ocean and runoff flooding of Bunbury's low lying areas, the barrier may be closed before ocean water levels reach 1.2 metres LAT. When high ocean water levels are predicted, the barrier is closed to allow the CBD drainage network to fill the inlet without flooding. When high ocean water levels are predicted it is common for the barrier to be closed around 1 metre LAT.

It is rare for the barrier to be closed for extended periods; extended closure of the barrier is only likely during severe weather events.

Knowing when the barrier is closed

Two orange lights are located on the light post at the barrier and flash on and off when the barrier is closed.

The best way to find out if the barrier is closed is to check online at ***www.transport.wa.gov.au/imarine/bunbury-storm-surge-barrier-tide.asp***

Storm surge water levels can be viewed live online and can be interpreted to determine when the barrier is closed.

A	A-500	3·5·82	LUG FOR GATE RESTRAINING CHAIN ADDED	GRC	I.K.
	ZONE	DATE	REVISION	DR'N	APP'D
SURVEY BOOKS				FILE No.	
				PW 1001/75	

GENERAL NOTES

1. UNLESS OTHERWISE SHOWN ALL DIMENSIONS ARE IN MILLIMETRES
2. THIS DRAWING TO BE READ IN CONJUNCTION WITH THE SPECIFICATION
3. STEEL: A.S. 1204-'72, GR 250 OR AS SHOWN. FABRICATION: AS. 1250-'75. WELDING: A.S. 1554 PT 1 & 2-'74
4. ALL WELDS 10mm SEALED FULL CONTINUOUS FILLET UNLESS OTHERWISE SHOWN.
5. ALL CRS TO A.S. G18-'86 GRADE G18/EN 58 H, OR A.S. 1449-'79 GRADE 1449/316, AS APPLICABLE

SCALES AS SHOWN
MICROFILMED A
DATUM
ZERO ON THE TIDE GAUGE WHICH IS 0·640 m BELOW A H D

DESIGN CALC. MJT BOOK & FILE II
CHECKED SDS BOOK 3
DRAWN W.A.S. CHECKED I.K.
TRACED CHECKED

SUBMITTED DATE 4/9/79 M.J. Tarca ENGINEER
APPROVED DATE 5-9-79 for ENGINEER FOR DESIGN

PUBLIC WORKS DEPARTMENT — WESTERN AUSTRALIA
BUNBURY FORESHORE
LESCHENAULT INLET - STORM SURGE BARRIER
'U' FRAME & GATES, ARRANGEMENT & DETAILS

P.W.D.,W.A. 51788-4-1 REV'N A

PRINTS
No. OFF
ROOM No.
INITIALS
DATE

APPENDIX C
MIKE HD AND SW MODELLING

C-1 Model Tools

DHI's MIKE21 Hydrodynamics (HD) and Spectral Wave (SW) model were used to investigate the coastal erosion and inundation hazards.

- The DHI MIKE 21 Hydrodynamic model resolves the Reynolds-averaged Navier-Stokes, depth-integrated hydrostatic equations and is capable of simulating hydraulic and environmental phenomena in oceans, lakes, estuaries, bays and coastal areas.
- The DHI MIKE 21 Spectral Wave (SW) model is a fully spectral wave model that simulate the growth, propagation, refraction and diffusion of wind waves.

DHI MIKE 21 HD and SW models can be run either in coupled or decoupled modes, depending on project applications and key coastal processes to be modelled.

In this study, coastal inundation hazard is investigated through a coupled HD/SW model with inclusion of cyclonic winds and radiation stress to account for impacts from wind and wave set up, as well as river discharge inputs to account for the impact of catchment flow.

For Collie River, the existing MIKE flood model (refer Section 3.5) has been used to evaluate the river flood impact in response to a combined effect of river flood and storm surge, as well as impacts from climate change.

For erosion hazard, MIKE SW model is used to simulate the process of erosive waves for identified design storms with results extracted as inputs for beach erosion modelling.

Model Grid and Bathymetry

Two sets of model mesh are used:

- For the HD model and inundation hazard assessment, a finer mesh was used with the model domain including the river courses as well as the land depressions along the SOC (Shire of Capel) coastline. The coverage of the model mesh and bathymetry are shown in Figure C-5. The model domain extends for about 100 km along the coast and about 60km offshore. The mesh is comprised of a combination of triangular and quadrangular elements (river channel). The grid size ranges from over 5 km offshore to less than 10 m in the river channels. Typically, 20-30 m elements are used to resolve the low-lying land at Bunbury.
- For the SW model and erosion hazard assessment, a coarser mesh was used with the model domain excluding the river courses due to their minimal impacts on wind wave conditions. The coverage of the model mesh and bathymetry are shown in Figure C-6. The model domain extends for about 100 km along the coast and about 60km offshore. The computational triangular mesh of the model is sufficiently sized (~30 m near project site) to resolve the detailed wave conditions inside the Koombana Bay and the estuary.

The bathymetry was developed using the LiDAR data (up to 30 m depth and on land) and hydrographic survey data (in water) supplied by the Department of Transport (DoT), and Australia Geoscience 250 m resolution bathymetry data to fill gaps wherever DoT LiDAR /hydrographic survey data are not available.

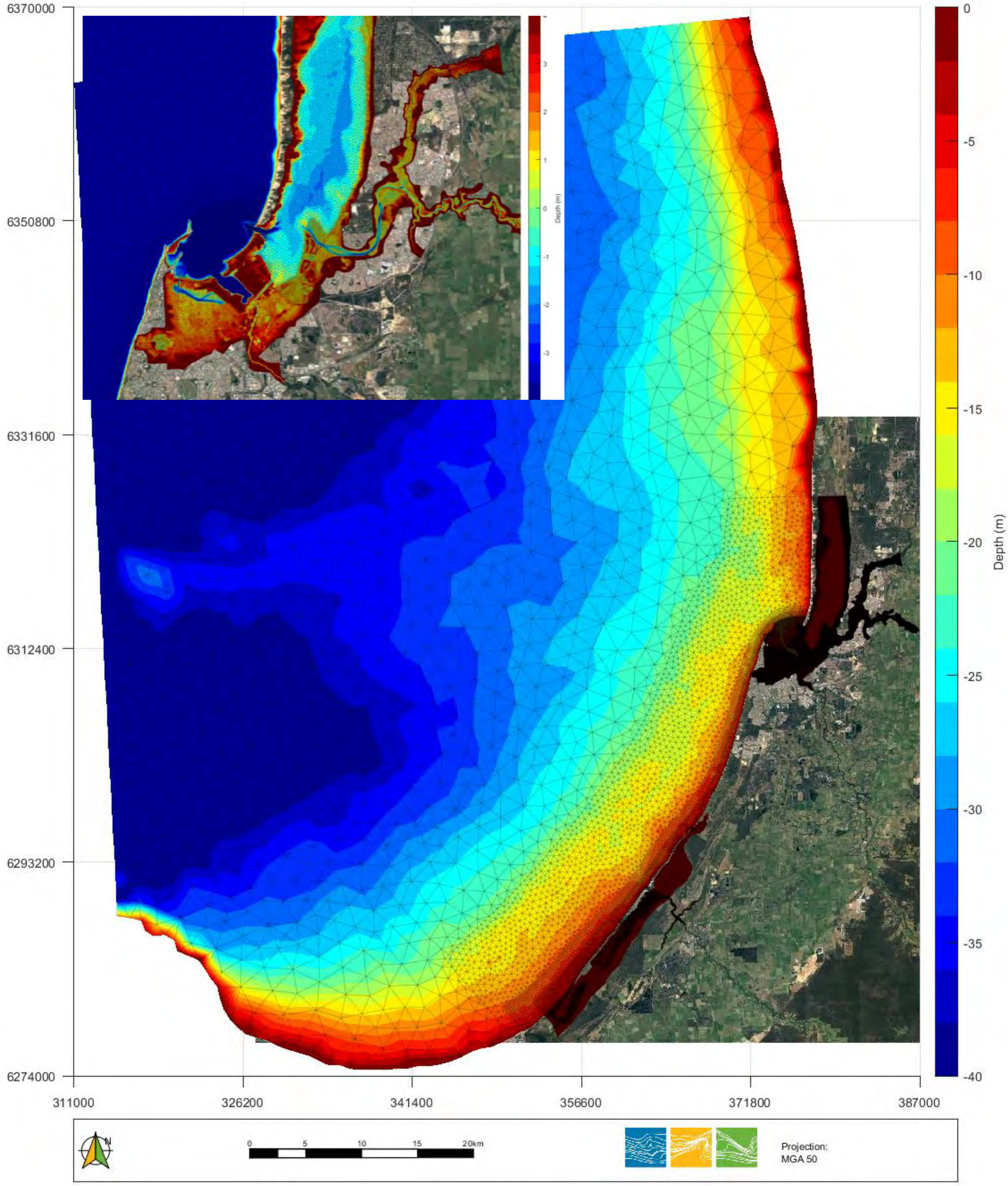


FIGURE C-5 HD/SW MODEL MESH AND BATHYMETRY FOR INUNDATION HAZARD ASSESSMENT

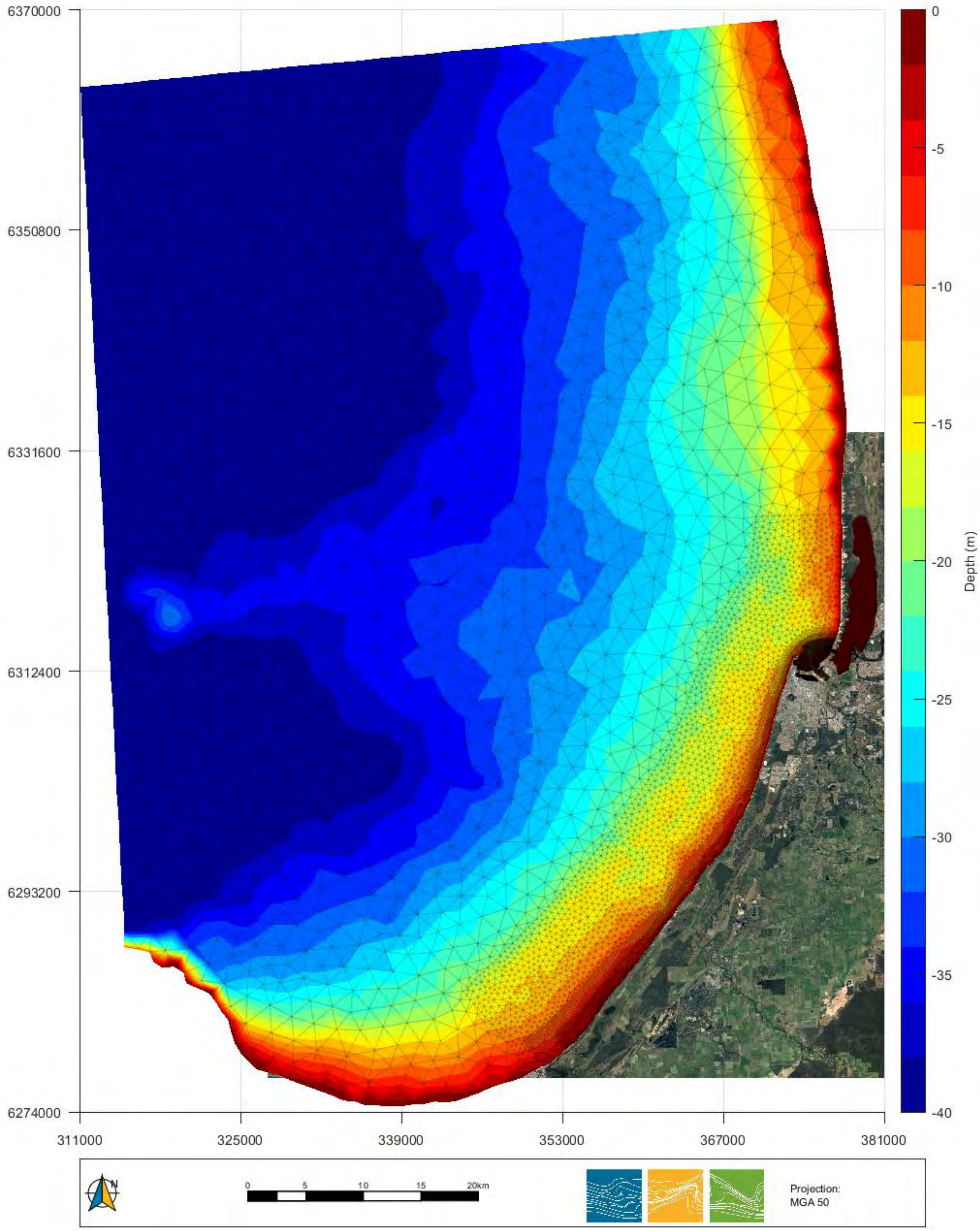


FIGURE C-6 SW MODEL MESH AND BATHYMETRY FOR EROSION HAZARD ASSESSMENT

C-2 Storm Surge Model

MIKE Storm surge model has been used to simulate the inundation extent in coastal zone from Capel to Leschenault estuary. The approach was proposed to account for the complexity of inundation process in Leschenault estuary and at land depression of Capel which cannot be accurately assessed by simple bathtub model (may overestimate the inundation risk). The model however does not attempt to replace the existing flood model along Collie River which has been carefully calibrated through inclusion of MIKE11 network, bridge network which are crucial inputs to simulate accurate river hydraulics.

Although our storm surge model includes all the river courses, model results along Collie River are trimmed to avoid confusion. River courses are included only to provide discharge input to the estuary so inundation extent within the reach of tide and SLR can be properly modelled. Inundation risk along the Collie River (for region beyond the impact of tide/SLR) is mapped directly from DWER flood model results.

Water Technology storm surge model has included structures over land to reduce the overflow of flood water across the riverbanks and roads due to limitation in 2D model resolution (~20 m). This has provided more reasonable prediction of flood over land that affected by roads and other structures, in the absence of higher resolution surface flood model.

Rainfall, infiltration, and evaporation are excluded from the model. It is not possible to simulate rainfall related urban flood without inclusion of urban drainage networks and rainfall/catchment analysis which was excluded from the scope of current CHA.

The MIKE storm tide simulates the dynamic process of coastal inundation in response to combined effects of storm winds, waves and tide. The approach is less conservative while more appropriate than the bathtub model which used a constant storm tide level everywhere to approximate the inundation risk which may overestimate the inundation risk in the estuary and at the land depression of Capel.

C-2-1 Model Inputs

Cyclone

The 500-year ARI storm is modified from the track information of TC ALBY which was suggested to have about 200-year ARI return period by Fountain, L., (2010). The track is shifted to the northeast by about 100 km, which generates a westerly cyclonic wind at Bunbury.

The modelled peak cyclone wind speed is in order of 30 m/s which is in line with the measured wind speed at Bunbury by BoM report (wind gust exceeding 36 m/s or equivalently hourly wind of 24 m/s of maximum scaled reading of the anemometer).

The maximum wind radius (MWR) of Alby near Bunbury is much larger at 50km than typical MWR in tropical region (<40km) due to extra-tropical transition and changes in Coriolis force from earth rotation. Similarly, the central pressure was higher at 930 hPa.

The modelled storm tide is about 2.8 m in Koombana Bay at peak storm which is in line with the value reported by previous studies (see section 2.2.1.3 & Table 2-2).

Overall, the approximated cyclone wind field for 500-year ARI storm is considered as appropriate for the purpose of this CHA.

Water Level

For the 500-year ARI storm, the water level boundary is taken from the tidal levels for the same period (April 1978) when TC Alby occurred.

For lower return period events, a typical tidal sequence is used with peak water level matched to the projected peak storm tide levels per Table 2-2. In this case, a storm process (four days duration) has been added over the regular tide signal. This has provided a more conservative storm tide boundary conditions for the simulation of inundation in coastal region and more importantly the attenuated impact in Leschenault estuary.

River runoff

River runoffs are sourced directly from DWER flood model inputs. The 1 yr. river runoff is scaled down from the 10 yr. river runoff sequence with factors estimated from analysis of peak river discharge projections. File Mile Brook discharge is taken from Water Technology existing model. Capel River discharge is composed from the peak river discharge projections and typical flood process of the river.

Review of historic flood events show that the peak river flood event is not correlated with severe storm tide events. Per DoW (2014), the most severe river flood event was in 1964 while the most severe coastal flood event was in 1978. TC Alby only brought a moderate and short rainfall compared to longer duration winter storms. In this study, the timing of river flood has been shifted to be in the same day as the maximum storm surge. This provides a more conservative estimate of coastal inundation where the river flood may elevate the water level in the estuary/coastal water, especially for area close to the river mouths.

Friction/ Roughness

Friction map over land and along the river courses is sourced from DWER existing model. The roughness of land/riverbed is represented by Manning's Number (m1/3/s). The land use type across the model area has been mapped and ground-truthed by the Water Science branch of the Department of Water. The land use map was simplified by combining different land use types that were expected to have a similar roughness coefficient.

Friction over the ocean basin is set as appropriate based on previous experience of the region (ranging from 30-60, depending on bottom type and depth). Model calibration has shown good results in storm surge modelling and little impact were found to be associated with configuration of bottom friction.

Structures

Main structures that may affect coastal flooding are implemented in the model including elevated roads, riverbanks, key culverts in potential coastal flooding zone. The model does not however include MIKE11 river networks, urban drainage networks, river survey profiles, culverts, bridge networks.

C-2-2 Model Calibration

Water levels were calibrated to Bunbury tidal gauge for the period during Tropical Cyclone (TC) Alby with results presented in Figure C-7. Overall, the model exhibits great performance in replicating the observed storm surge at Bunbury (black dash line). The hydrodynamic model was calibrated appropriately for primary parameters such as bottom friction and wind drag coefficient and deemed suitable for the purpose of this coastal hazard assessment.

As per conversation with DoT, the measured tidal Levels in 1978 were manually digitalised so there may be some uncertainty in the quality of data. The measured peak surge was however in line with information reported by post storm survey.

C-2-3 Model Sensitivity Test

Additional simulations are undertaken to evaluate the impact of cyclone intensity and track shifting.

Sensitivity test shows that 10% increase in cyclone intensity (centre pressure drop) only increase the storm tide level for 0.1-0.3 m, indicating a relatively moderate impact from cyclone intensity. The most significant impact is associated with track location changes which have increased the storm tide level from 1.8 m AHD to over 2.8 m AHD at Bunbury. This is because the original Alby track was about 100 km off the coast of Cape Leeuwin, for which the cyclone impact was attenuated.

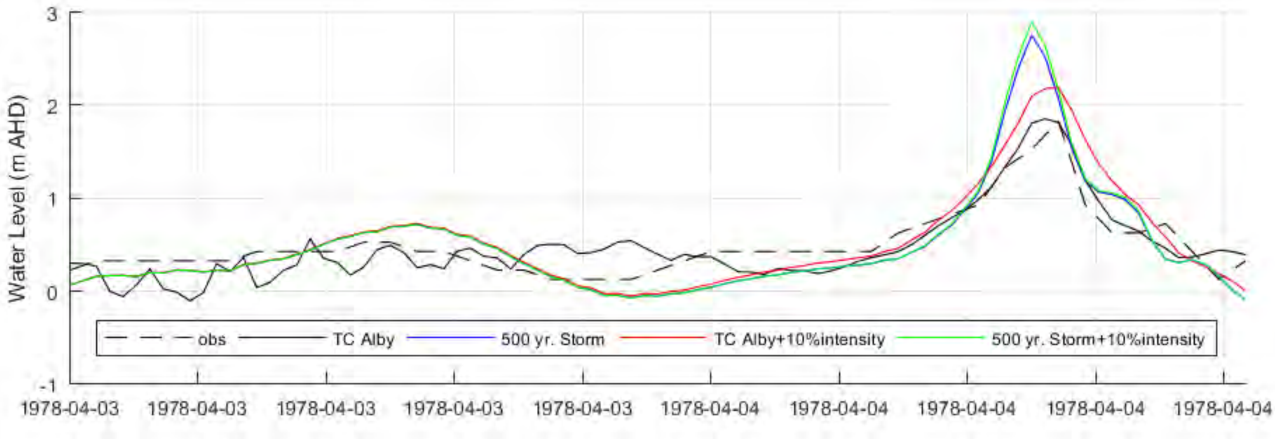


FIGURE C-7 WATER LEVEL CALIBRATION (BUNBURY TIDAL GAUGE, 1978)

C-2-4 Model Results Summary

The modelled peak steady water levels are extracted at locations shown in Figure C-8. Results extracted at are presented in Table C-1. An example of spatial distribution of modelled inundation levels (500 yrs. ARI) are shown in Figure C-9.

TABLE C-1 MODELLED PSWL (M AHD) FOR 1, 10, 100 AND 500-YEAR ARI EVENTS

Locations	Peak Steady Water Level (m AHD)															
	Present				2035				2050				2120			
	1 yr.	10 yrs.	100 yrs.	500 yrs.	1 yr.	10 yrs.	100 yrs.	500 yrs.	1 yr.	10 yrs.	100 yrs.	500 yrs.	1 yr.	10 yrs.	100 yrs.	500 yrs.
1	1.1	1.5	1.9	2.1	1.2	1.6	2.1	2.3	1.3	1.7	2.2	2.9	2.1	2.4	2.9	3.1
2	1.1	1.5	1.9	2.1	1.2	1.6	2.1	2.3	1.3	1.7	2.2	2.9	2.1	2.5	2.9	3.1
3	1.1	1.5	1.9	2.1	1.2	1.6	2.1	2.3	1.3	1.7	2.2	2.9	2.1	2.4	2.9	3.1
4	1.1	1.5	1.9	2.1	1.2	1.6	2.1	2.3	1.3	1.7	2.2	2.9	2.1	2.4	2.9	3.1
5	1.1	1.5	1.9	2.1	1.2	1.6	2.1	2.3	1.3	1.7	2.2	2.9	2.1	2.4	2.9	3.1
6	1.1	1.4	1.9	2.1	1.2	1.6	2.0	2.2	1.3	1.7	2.1	2.9	2.1	2.4	2.9	3.1
7	1.1	1.4	1.9	2.1	1.2	1.6	2.0	2.2	1.3	1.7	2.1	2.9	2.1	2.4	2.9	3.1
8	1.1	1.4	1.9	2.8	1.2	1.5	2.0	2.9	1.3	1.6	2.1	2.9	2.1	2.4	2.9	3.7
9	1.1	1.4	1.9	3.0	1.2	1.5	2.0	3.1	1.3	1.6	2.1	2.9	2.1	2.4	2.9	3.9
10	1.1	1.4	1.9	2.8	1.2	1.5	2.0	2.9	1.3	1.6	2.1	2.9	2.1	2.4	2.9	3.7
11	1.1	1.4	1.9	2.7	1.2	1.5	2.0	2.9	1.3	1.6	2.1	2.9	2.1	2.4	2.9	3.7
12	1.1	1.4	1.9	2.7	1.2	1.5	2.0	2.9	1.3	1.6	2.1	2.9	2.1	2.4	2.9	3.7
13	1.1	1.4	1.9	2.7	1.2	1.5	2.0	2.8	1.3	1.6	2.1	2.8	2.1	2.4	2.8	3.6
14	1.3	1.6	2.0	2.8	1.4	1.7	2.1	2.9	1.5	1.8	2.2	2.9	2.2	2.5	2.9	3.7
15	1.2	1.5	1.9	2.7	1.3	1.6	2.0	2.8	1.4	1.7	2.1	2.9	2.1	2.5	2.9	3.6
16	0.0	1.6	2.0	2.9	0.0	1.7	2.1	3.0	1.4	1.8	2.2	2.9	2.2	2.5	2.9	3.9
17	1.1	1.4	1.9	3.0	1.2	1.6	2.0	3.1	1.3	1.7	2.1	2.8	2.1	2.4	2.8	3.9
18	1.2	1.5	1.9	2.8	1.3	1.6	2.0	2.9	1.4	1.7	2.1	2.9	2.1	2.4	2.9	3.7
19	1.1	1.4	1.8	2.7	1.2	1.5	1.9	2.8	1.3	1.6	2.0	2.8	2.1	2.4	2.8	3.6
20*				1.2				1.3				1.9		0.6	1.9	2.6
21	0.0	0.0	1.1	1.7	0.0	0.0	1.1	1.8	0.0	0.0	1.1	2.4	0.0	1.2	2.4	2.3
22	1.2	1.6	2.4	2.7	1.2	1.7	2.4	2.8	1.2	1.7	2.4	2.8	1.5	1.9	2.8	3.2
23	1.0	1.2	1.5	2.3	1.1	1.2	1.5	2.4	1.1	1.2	1.6	2.4	1.2	1.5	2.4	3.4

* Storm surge barrier modelled as a DIKE, closed for all scenarios as storm surge is >0.7m AHD. For storm surge values <2.1 m AHD (the barrier level), water does not enter the inlet. For storm surge values >2.1 m AHD, a reduced volume flows into the inlet, due to the presence of the barrier in the model.

FIGURE C-8 DATA EXTRACTION POINTS

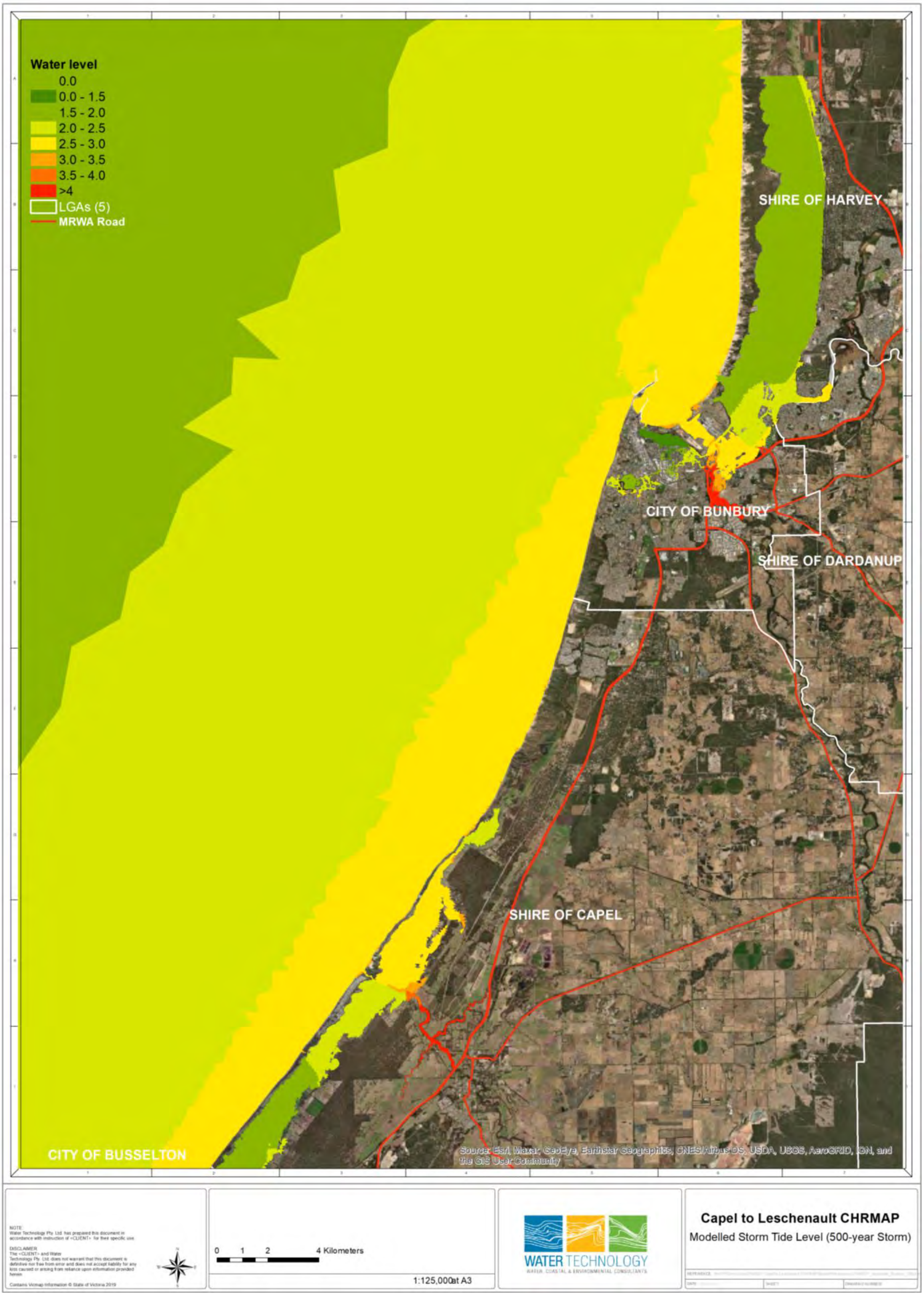


FIGURE C-9 INUNDATION EXTENT AND PSWL DURING A 500 YRS. STORM – 2120

C-3 Spectral Wave Model

C-3-1 Wave Calibration

The wave model was calibrated to measurements obtained at Bunbury Port Beacon 3 in 2015 (Figure C-10). Model results show very good agreement between modelled and observed waves. Key wave parameters e.g., Hs, Tp and Mean Wave Direction were all well simulated for both magnitude and timing of storm peaks.

The model configuration has been optimised to represent local conditions of the region. Applied wave-breaking parameters in the model are gamma = 0.8 and alpha = 1. Bottom friction is determined based on Water Technology's experience in the study area as well as friction map used by DWER Collie River flood modelling. Overall, modelling settings have been reviewed and considered suitable for the purpose of this coastal hazard assessment.

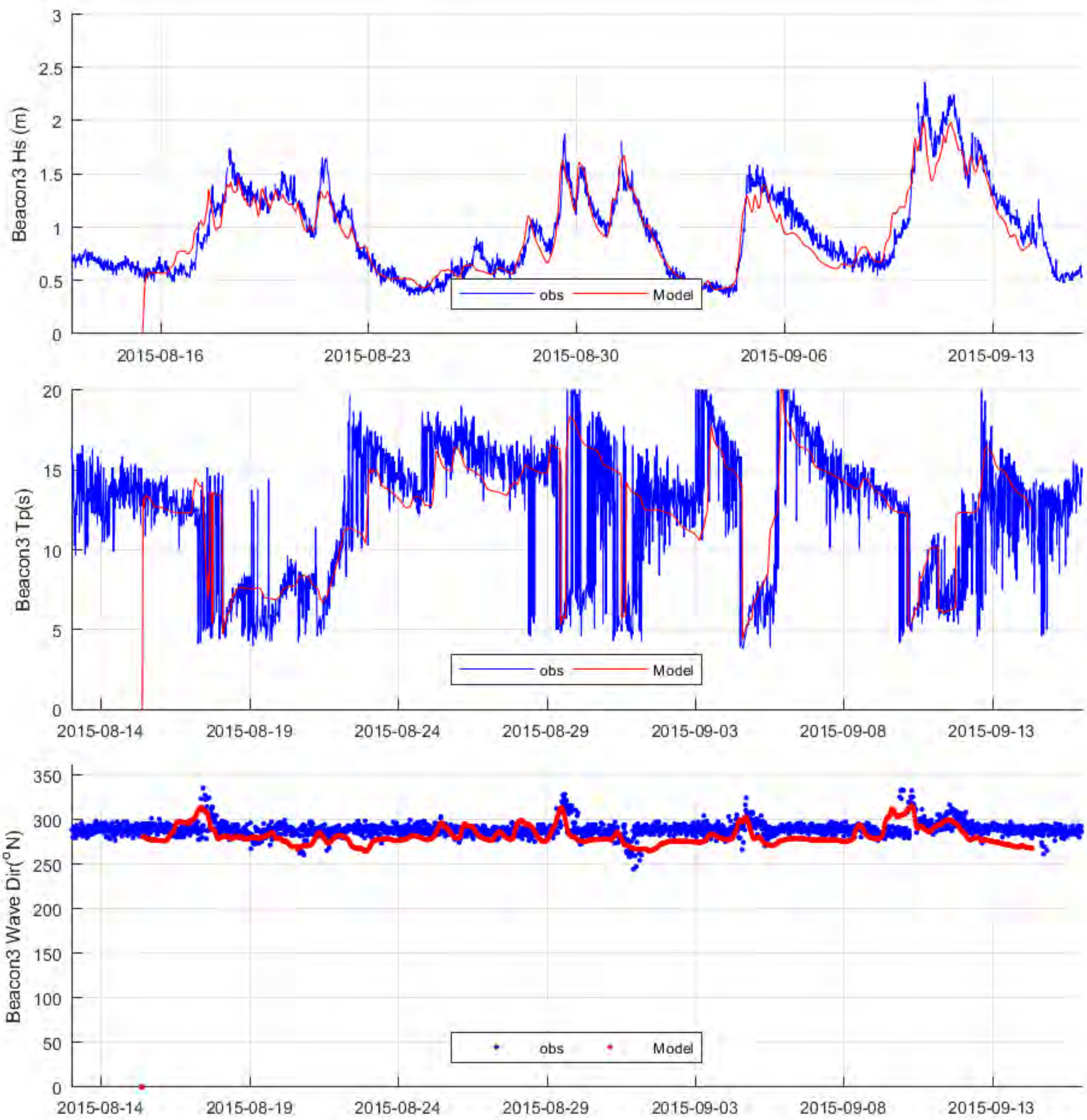


FIGURE C-10WAVE MODEL CALIBRATION (BEACON 3, 2015)

C-3-2 Model Results

Water Technology simulated the 100-year ARI event, selected based on its Total Wave Power and potential to cause coastal erosion; storm “a” was selected (MPRA 2018). The simulation was run in HD/SW coupled mode, to allow for water level feedback into the wave calculation. The model was forced with the supplied water level, wind and wave parameters at part of MPRA (2018). Figure C-11 shows the maximum of wave heights simulated during the 100-year ARI storm event. The modelled Hs ranges from over 3 metres nearshore to less than 1.5 m at Koombana Beach, less than 1 m near the entrance of Casuarina Harbour, less than 0.2 m inside the Casuarina Harbour/Leschenault Inlet and less than 0.8 m inside the Leschenault Estuary.

Model results are extracted to drive the SBEACH model for the erosion hazard assessment. Refer Appendix D below for time series plots of the key parameters from this storm.

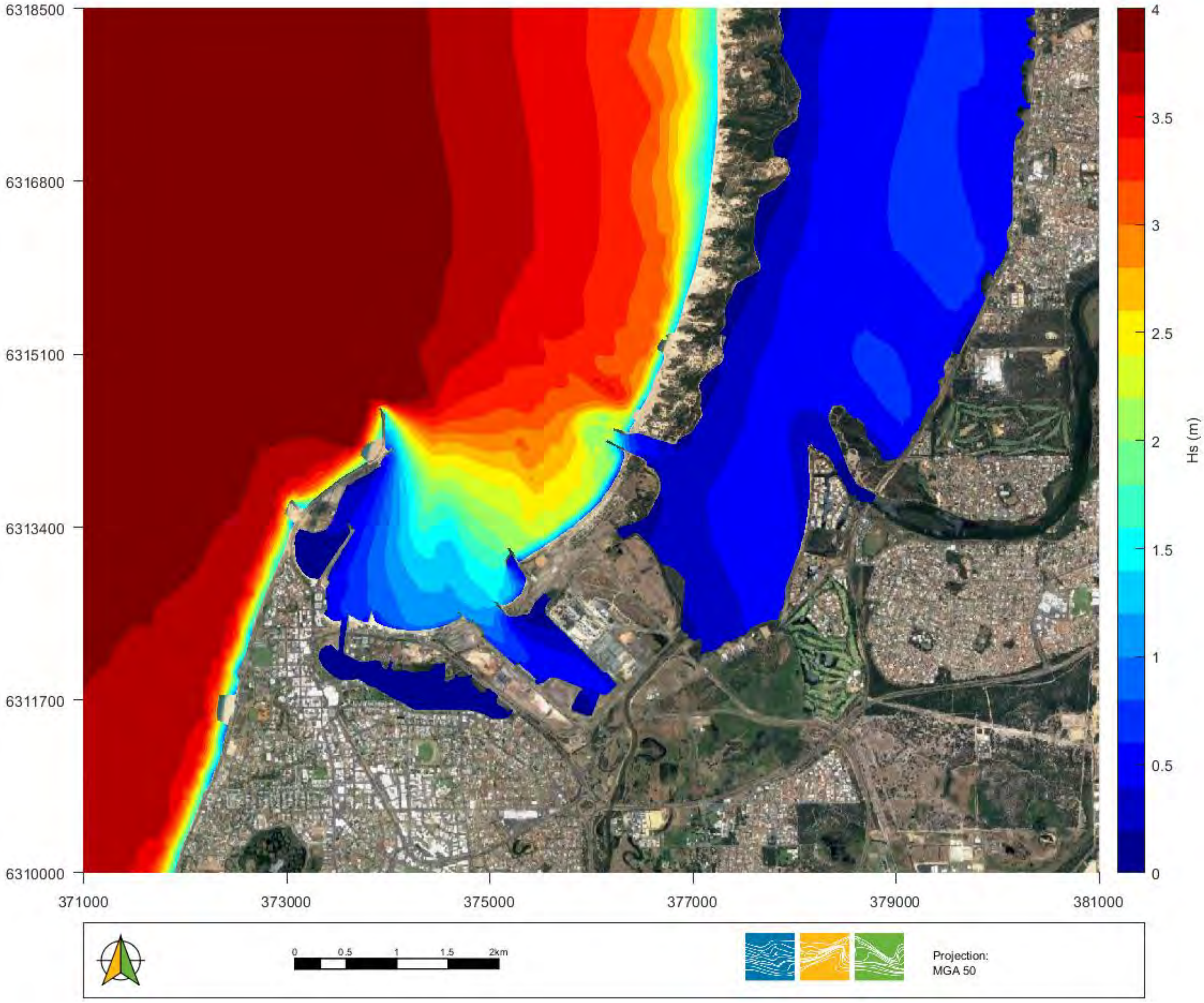


FIGURE C-11 MAXIMIUM WAVE HEIGHT DURING THE 100 YRS. ARI STORM

APPENDIX D
EROSION HAZARD MODELLING

D-1 S1 – Acute Erosion Allowance

The potential for storm-induced erosion was assessed using the SBEACH numerical model. This model was developed to calculate short term wave induced erosion and has been utilised in a range of studies including numerous shoreline erosion/stability assessments in Western Australia.

A variable grid resolution (1 to 50m grid size) was applied extending from the landside of the dune system to the depth of closure. In the active zone, a 1 m resolution grid was applied. DoT Lidar (from ~-30 m contour landwards) and survey data (where available) have been merged to generate the nearshore seabed and beach face elevation for bathymetry inputs. Sediment grain sizes (Table D-2) are obtained from review of existing studies in this region (Seashore Engineering (2013), GHD (2019) and Semeniuk (2000)) as well as established knowledge of sediment along southwest coast of WA. Other model settings e.g., temperature, transport rate coefficient, transport rate decay coefficient, avalanche slope and surf zone depth etc are configured as appropriate and in line with the model manual.

Critical model inputs utilised include:

- Digital elevation data to maximum -10 m AHD contour offshore
- Time-series of water level for each design event (tide plus surge)
  - Extracted from the 100-year ARI Storm a simulation (described above in Section C-3-2)
- Time-series of significant wave height (Hs), Peak wave period (Tp) and Wave direction (Wdir) for each design event
  - Extracted from the 100-year ARI Storm a simulation
- Sediment size as presented in Table D-2 below.

TABLE D-2 SEDIMENT SIZE INPUTS FROM LITERATURE REVIEW

Point	1-19	20	21	22	23	24-28	29	30	31	32	33-35
D_{50} (mm)	300	400	360	180	250	225	125	500	250	125	250

D-1-1 SBEACH Profiles

The 35 SBEACH profile locations are presented in Figure D-12.

D-1-2 Storm Inputs

Storms representing open coast, Koombana Bay and the Leschenault Estuary are presented in Figure D-13 to Figure D-15 respectively. The open coast and Koombana Bay storms were extracted from the HD/SW simulation; a constant storm was applied within Leschenault Estuary, representing the worst conditions observed during the simulation.

D-1-3 Model Results

Model results for each profile are presented in Figure D-16 to Figure D-20.

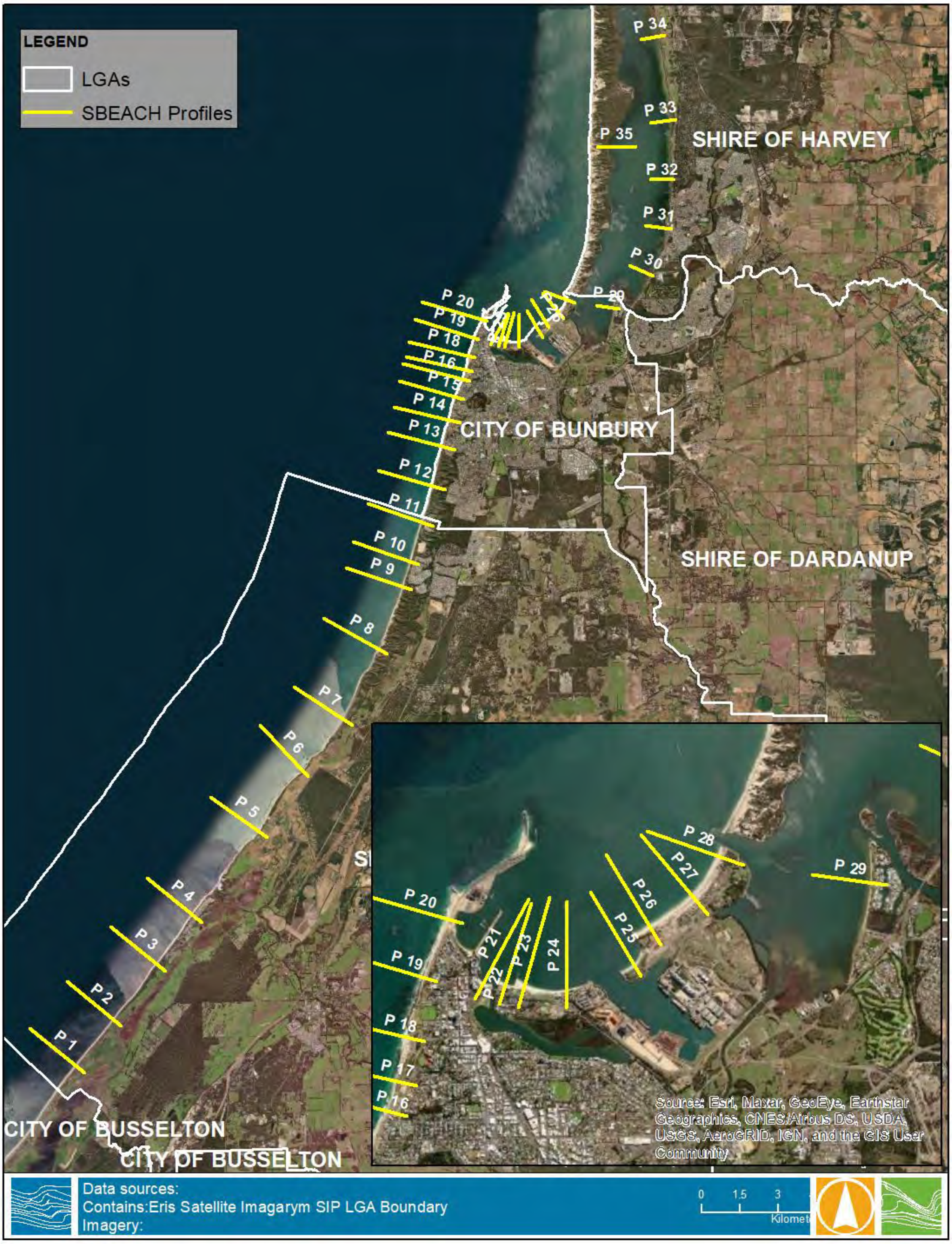


FIGURE D-12SBEACH PROFILES

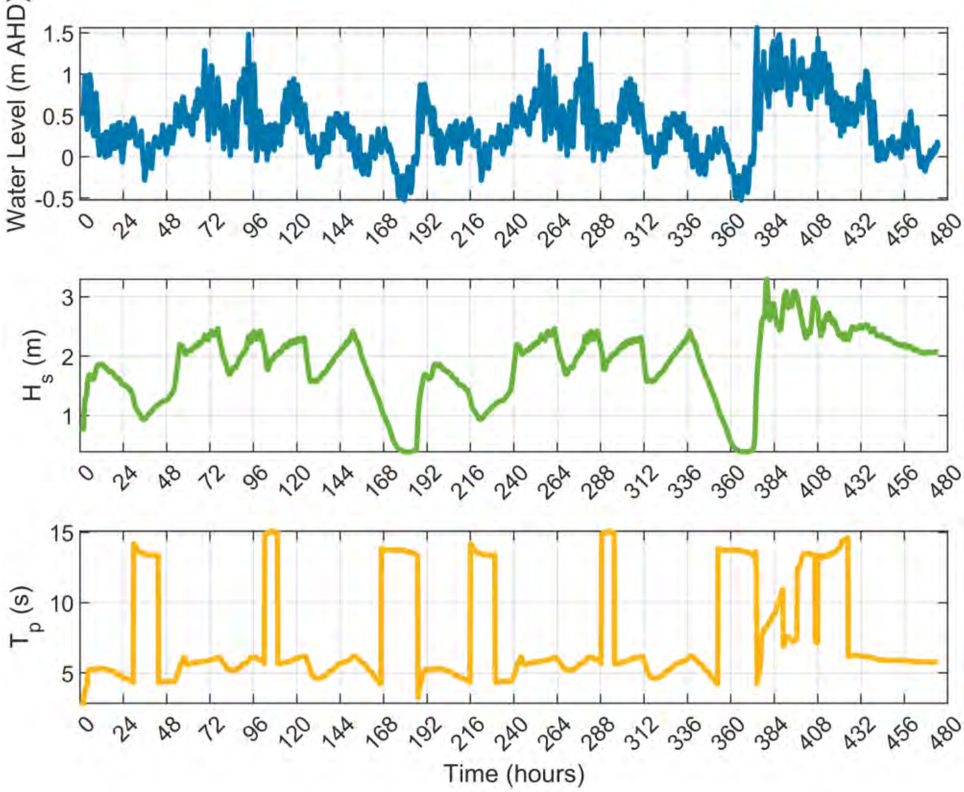


FIGURE D-13OPEN COAST SBEACH MODEL FORCING FOR 100 YRS. ARI STORM

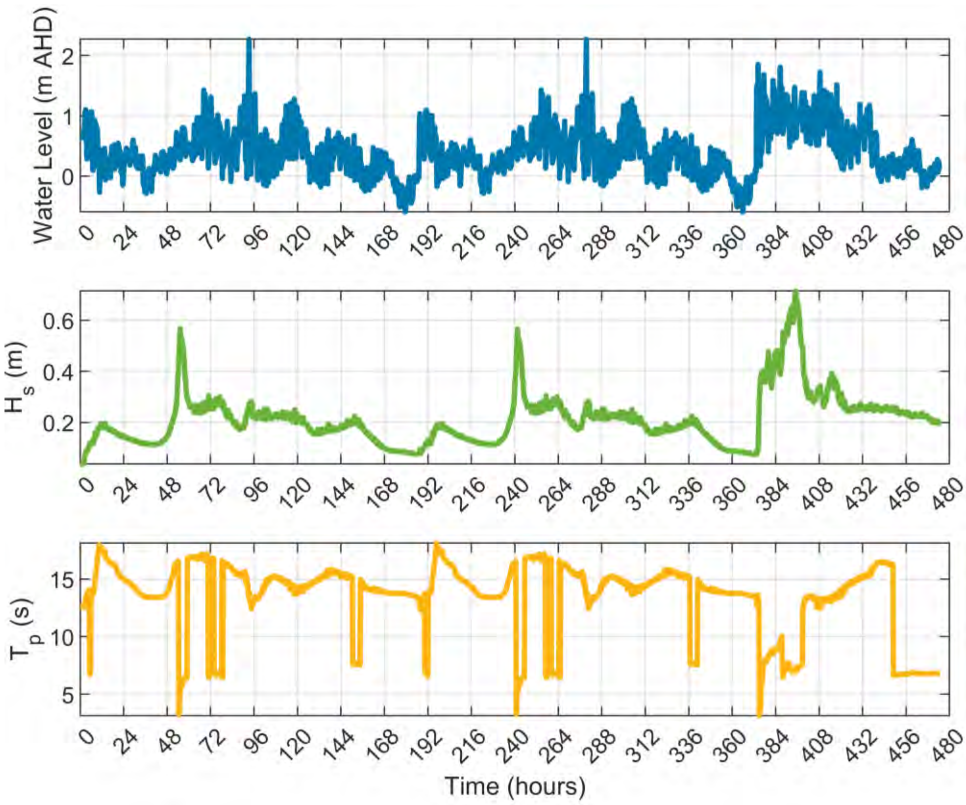


FIGURE D-14KOOMBANA BAY SBEACH MODEL FORCING FOR 100 YRS. ARI STORM

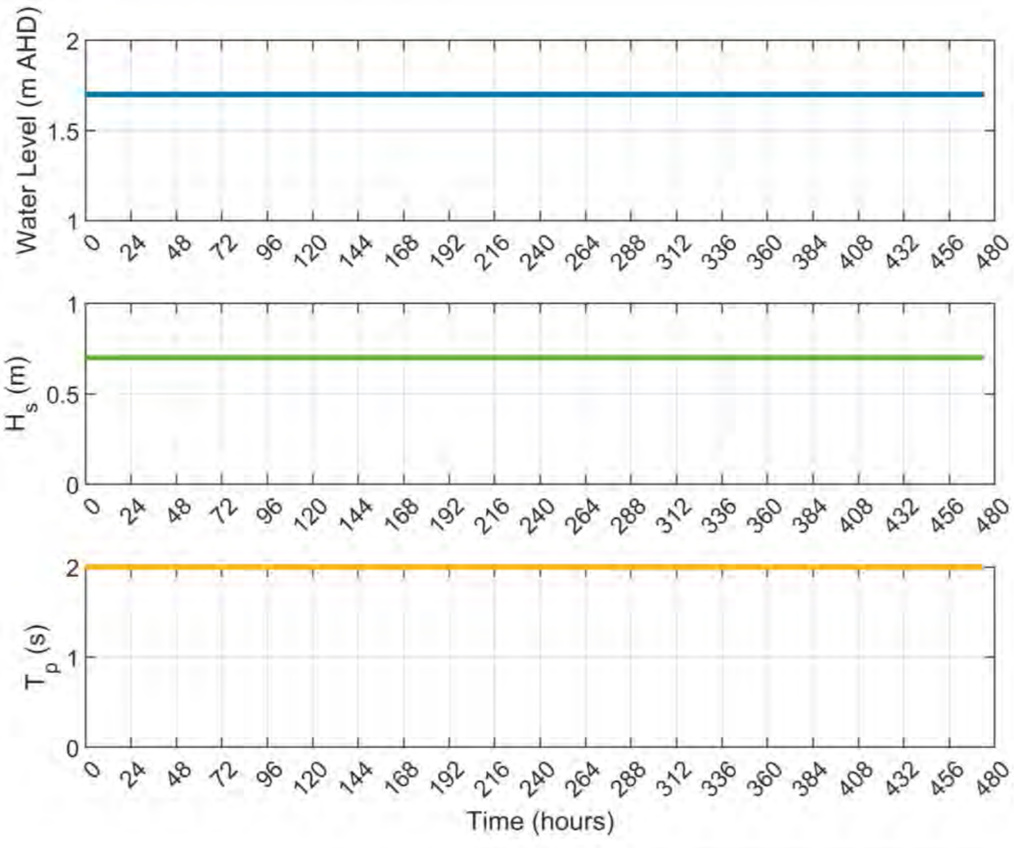


FIGURE D-15LESCHENAULT ESTUARY SBEACH MODEL FORCING FOR 100 YRS. ARI STORM

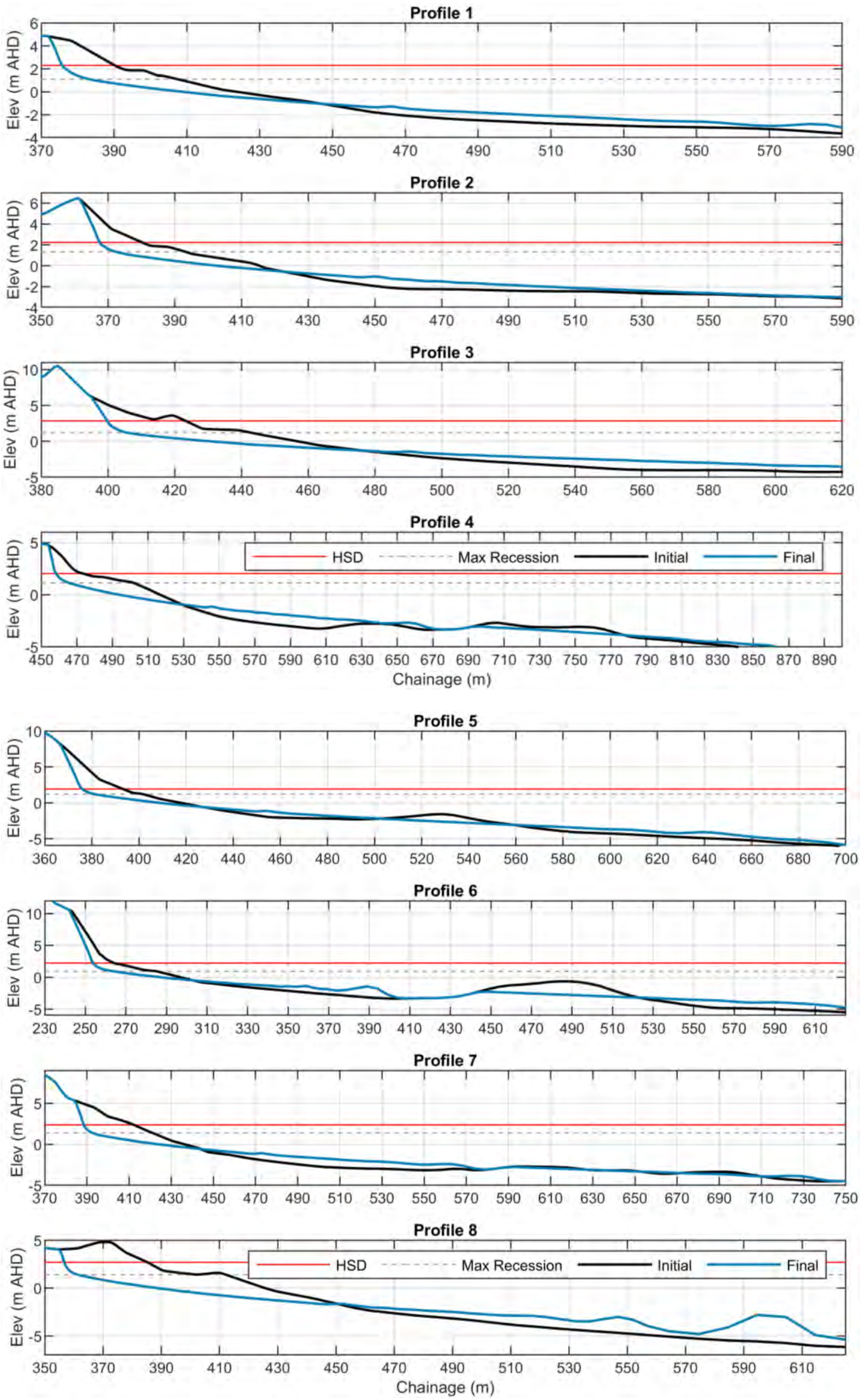


FIGURE D-16SBEACH MODEL RESULTS PROFILES 1 TO 8

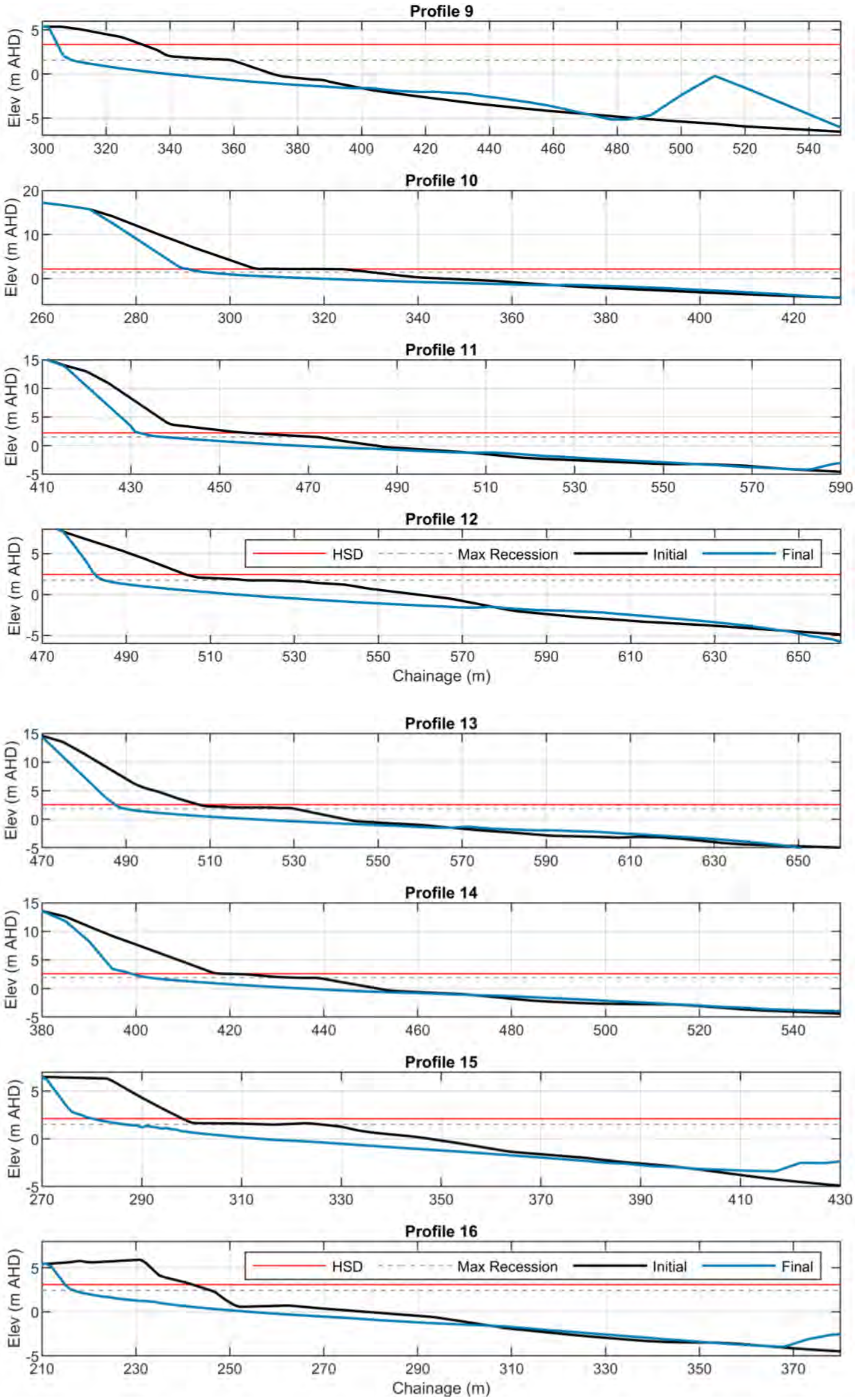


FIGURE D-17SBEACH MODEL RESULTS FOR PROFILES 9 TO 16

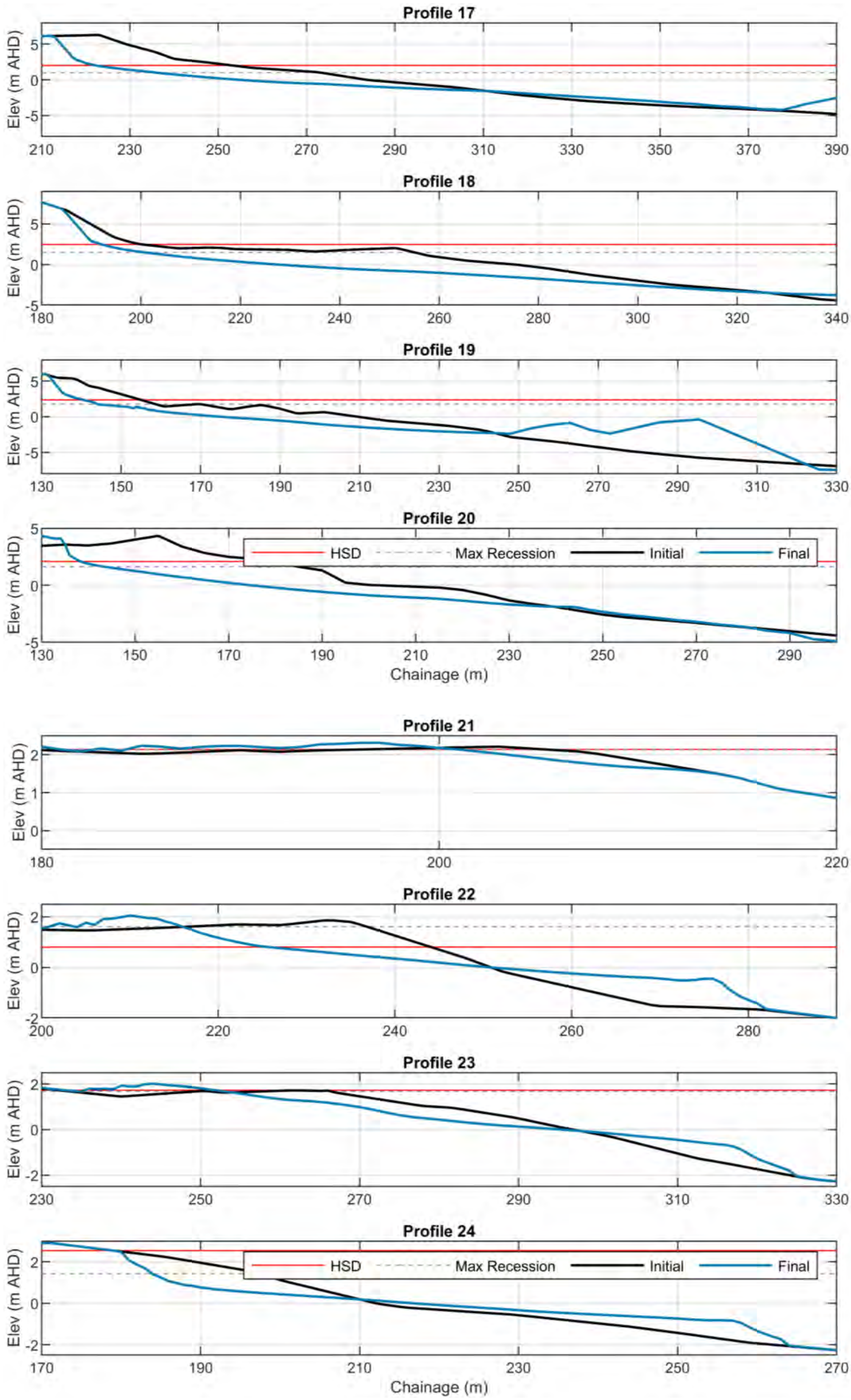


FIGURE D-18SBEACH MODEL RESULTS FOR PROFILES 17 TO 24

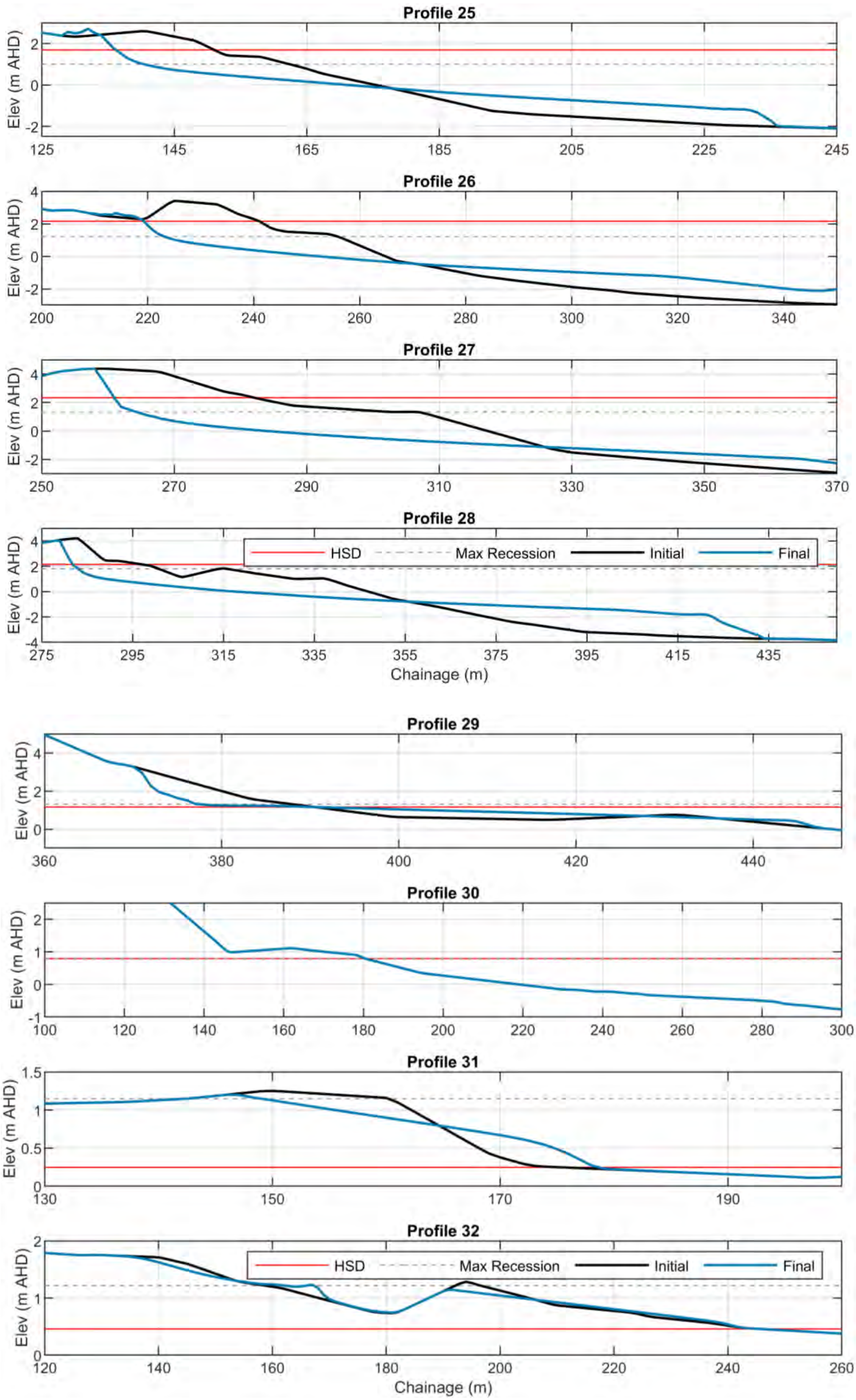


FIGURE D-19SBEACH MODEL RESULTS FOR PROFILES 25 TO 32

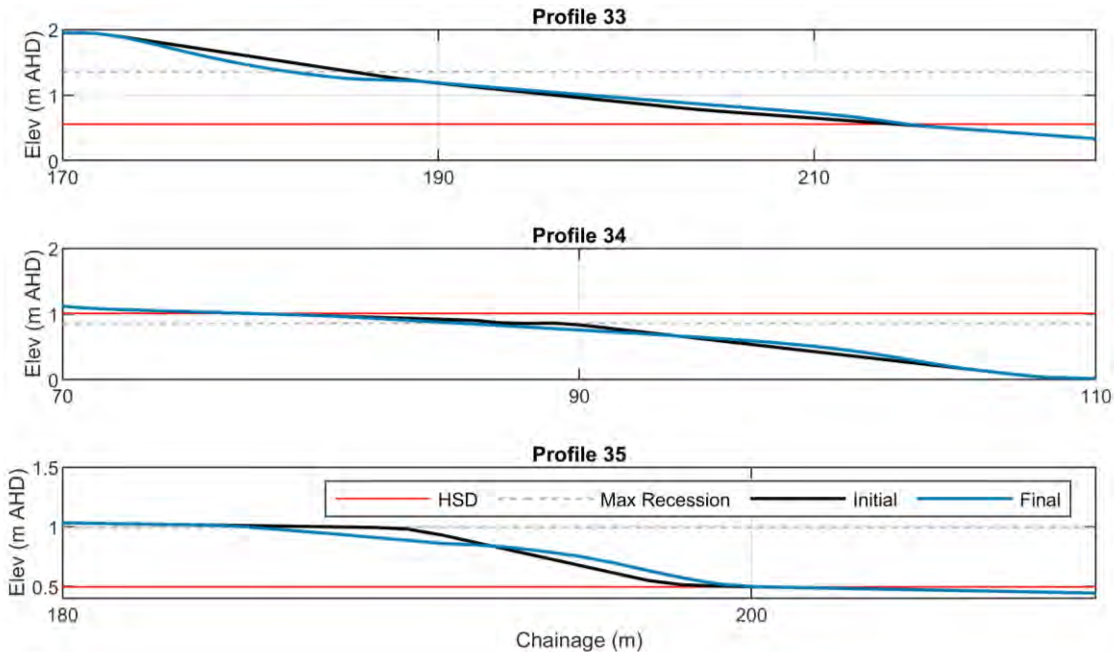


FIGURE D-20SBEACH MODEL RESULTS FOR PROFILES 33 TO 35

D-2 S2 – Chronic Historic Shoreline Movement

The historic shoreline movement trend is estimated through review of available historical shoreline changes. The approach is to analyse historical aerial imagery/vegetation lines and to use the horizontal change in the vegetation line as an indicator for historical shoreline changes. It is applicable on natural coastlines where vegetation is free to recede in response to erosion.

Analysis of historical vegetation line movements is undertaken with USGS Digital Shoreline Analysis System (DSAS 5.0) in ArcGIS. It is capable of generating beach transects and calculating shoreline movement trends based on transect crossings through historic shorelines.

Figure D-21 presents the DoT vegetation lines (from 1941 onwards) and DASA transects (250 m intervals along the Capel Coast, 100 m intervals in Koombana Bay) adopted to evaluate the shoreline movement rate along the coast of Capel to Bunbury. Historic shoreline movement within Leschenault Estuary is investigated separately, given the minimal reported movements over time and lack of vegetation lines to undertake a DSAS analysis.

Review of DoT vegetation lines shows some discontinuities where less than three shorelines are available for analysis. For these sections coast (e.g., South of Dalyellup, east of Koombana Bay), the DSAS model is unable to generate a meaningful shoreline movement rate modelling due to statistical insignificance.

FIGURE D-21S2 HISTORIC SHORELINE MOVEMENT MODELLING (DSAS MODEL PROFILES AND RESULTS)

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Appendix C

Capel to Leschenault CHRMAP

Chapter Report: Coastal Assets and Community Values

Peron Naturaliste Partnership

14 July 2022

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Version	Doc type	Reviewed by	Approved by	Date issued
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Project Name	Chapter Report: Coastal Assets and Community Values
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14 July 2022

Joanne Ludbrook
Coastal Adaptation Coordinator
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Via email: peronnaturalistepartnership@mandurah.wa.gov.au

Dear Joanne

Chapter Report: Coastal Assets and Community Values

We are pleased to present the Capel to Leschenault Coastal Hazard Risk Management and Adaptation Plan Chapter Report: Coastal Assets and Community Values. If you have any queries, please do not hesitate to contact me on (08) 6555 0105.

Yours sincerely

Joanna Garcia-Webb
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WATER TECHNOLOGY PTY LTD

EXECUTIVE SUMMARY

It is internationally recognised that the mean sea level has been rising globally since the nineteenth century and is predicted to rise at an increasing rate in the future (IPCC 2021). Rising sea levels and intensifying storm activity will increase the risk of coastal inundation (temporary coastal flooding), storm erosion and long-term shoreline recession. State governments across Australia have introduced statutory obligations that require local governments to consider and plan for these hazards. In Western Australia (WA), the governing policy is the Western Australian Planning Commission's (WAPC) State Planning Policy No. 2.6: State Coastal Planning Policy (WAPC, 2013, herein referred to as "SPP2.6"). SPP2.6 recommends management authorities develop a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for land use or development that is potentially vulnerable to coastal hazards. Specific guidelines have been developed to assist in this process (WAPC, 2019).

SPP2.6 requires adequate risk management planning is undertaken where existing or proposed development is in an area at risk of being affected by coastal hazards over the 100-year planning timeframe. SPP2.6 and the CHRMAP Guidelines provide the risk assessment framework to be applied to identify risks that are intolerable to the community, and other stakeholders such as local governments, indigenous and cultural interests, and private enterprise. Risk Management measures are then developed according to the adaptation hierarchy outlined in SPP2.6.

The Peron Naturaliste Partnership (PNP) comprises membership of nine local government authorities. The PNP's Coastal Adaptation Pathways Project identified the coastal areas of Capel, Leschenault and Greater Bunbury as being particularly exposed to coastal hazards and climate change, which triggered the need for this CHRMAP. The aim of the present study is therefore to investigate the nature and severity of coastal hazards which are likely to affect these regions from Capel to Leschenault over future planning horizons. Refer Figure 1-1 for locality and study area extent.

The objective of this CHRMAP project is to increase knowledge and understanding of coastal hazard risks, and identify risk management and adaptation measures for implementation. The outcomes will be used to inform local and state government policies, strategies and plans, including (but not limited to); planning strategies, community strategic plans, drainage strategies, asset management plans, emergency management plans, and foreshore management plans. The project will adhere to the WAPC (2019) guidelines with scope and deliverables to be consistent with the objectives identified by these guidelines and SPP2.6. The project will identify the strategic direction for coastal adaptation scenarios from the present-day to 2120 (100 yrs. management time frame), and identify an implementation plan to achieve this direction. Overall, this CHRMAP will develop a flexible adaptation pathway for the region and serve as a key reference for management, planning and policy making for the short-term (0-15 years), medium-term (15-30 years), and long-term (100 years).

This report presents the Coastal Values and Community Assets Chapter Report, which identifies the assets and community values within the coastal hazard zone. The flow chart displayed in Figure 1-2 indicates where this component sits with reference to the greater study; the 'Coastal Values and Community Assets' phase corresponds to the bottom half of the bubble shaded in red.

All the assets in the coastal hazard zone were identified and classified into 9 categories as listed below. Risks to these assets will be considered by applying the success criteria in the Vulnerability, Risk Analysis and Evaluation phase of the project (refer Figure 1-2 for project phases).

- Roads
- Residential land
- Commercial land and assets
- Public and community assets not located in the foreshore reserve e.g., car parks, recreational facilities

- Developed foreshore reserve, including coastal, estuary and river foreshore areas
- Undeveloped foreshore reserve, including coastal, estuary and river foreshore areas
- Environmental
- Agricultural / rural lands
- Aboriginal heritage

The link below presents the hazard and asset information together overlain on an aerial photograph for ease of viewing. All information layers can be turned on and off, and it is possible to zoom in on sites within the study area. Clicking on an asset displays its category, planning horizon in which it is predicted to become affected, and the Management Unit. It is recommended that each Steering Group member view the link to gain further understanding of assets at risk within their jurisdictions.

https://watech.maps.arcgis.com/apps/webappviewer/index.html?id=d43c39fda97d426ea6192d1a7a8543cf

Tables containing a breakdown of assets by Management Unit, category and planning horizon are presented in Appendix A and Appendix B for erosion and inundation respectively. **A summary and brief discussion of these assets is presented in Table 3-1**.

Community and stakeholder involvement is a critical component of the CHRMAP process, as it defines what and how much value is placed on assets within the study area. This will inform the adaptation planning process and ensure all needs are considered. As such, the project contains a high level of community and stakeholder engagement. This provides ownership of the CHRMAP with those that it affects, and acceptance of its outcomes. The engagement is discussed further in Section 4 and Appendix C.

The values collated from the engagement to date have been used to generate the success criteria for the vulnerability and risk assessment component of the CHRMAP. These will be key to the whole CHRMAP as it is these that will ultimately drive the selection of adaptation options. It is important that a comprehensive approach be applied at this stage of the project, in order to provide a CHRMAP applicable to all stakeholders.

The success criteria are defined below. These criteria will be revised during the course of the CHRMAP to ensure the final document reflects all stakeholder views.

- Conserve, enhance and maintain the natural environment and character of the study area
- Facilitate and promote public usage and enjoyment of the natural environment, coast, estuaries and rivers
- Protection of the cultural values of the coastline
- Manage impacts to the existing residential areas from erosion and inundation
- Maintain critical infrastructure supporting the community (roads, utilities).
- Manage and maintain coastal infrastructure that provides access to the water and supports the lifestyle enjoyed by people in the region
- Retain the widest possible range of risk management options for future users of the coast

WATER TECHNOLOGY
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1 INTRODUCTION

It is internationally recognised that the mean sea level has been rising globally since the nineteenth century and is predicted to rise at an increasing rate in the future (IPCC 2014). Rising sea levels and intensifying storm activity will increase the risk of coastal inundation (temporary coastal flooding), storm erosion and long-term shoreline recession. State governments across Australia have introduced obligations that require local governments to consider and plan for these hazards. In Western Australia (WA), the governing policy is the Western Australian Planning Commission's State Planning Policy No. 2.6: State Coastal Planning Policy (WAPC, 2013, herein referred to as "SPP2.6"). SPP2.6 recommends management authorities develop a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for land use or development that is vulnerable to coastal hazards. Specific guidelines have been developed to assist in this process (WAPC, 2019).

One of the key objectives of SPP2.6 is to establish coastal foreshore reserves which include allowances for the protection, conservation and enhancement of coastal values across the state. Risk assessment processes are then utilised to identify risks that are intolerable to the community, and other stakeholders such as local governments, indigenous and cultural interests, and private enterprise. Adaptation measures are then developed according to the preferential adaptation hierarchy outlined in SPP2.6.

The Peron Naturaliste Partnership (PNP) comprises membership of nine local government authorities. The PNP's Coastal Adaptation Pathways Project identified the coastal areas of Capel, Leschenault and Greater Bunbury as being particularly exposed to coastal hazards and climate change, which triggered the need for this CHRMAP. The aim of the present study is therefore to investigate and plan for coastal hazards which are likely to affect these regions from Capel to Leschenault – refer Figure 1-1 for locality and study area extent.

This CHRMAP project is expected to increase knowledge and understanding of coastal hazard risks and identify risk management and adaptation measures for implementation. The outcomes will be used to inform local government policies, strategies and plans, including (but not limited to); planning strategies, community strategic plans, drainage strategies, asset management plans, emergency management plans, and foreshore management plans. The project will adhere to the WAPC (2019) guidelines with scope and deliverables to be consistent with the objectives identified by these guidelines and SPP2.6. The project will identify the strategic direction for coastal adaptation scenarios from the present to 2120 (100-year management time frame), and identify an implementation plan to achieve this direction. Overall, this CHRMAP will develop a flexible adaptation pathway for the region and serve as a key reference for management, planning and policy making for the short-term (0-15 years), medium-term (15-30 years), and long-term (100 years).

This report presents the Coastal Values and Community Assets Chapter Report, which identifies the assets and community values within the coastal hazard zone. The flow chart displayed in Figure 1-2 indicates where this component sits with reference to the greater study; the 'Coastal Values and Community Assets' phase corresponds to the bottom half of the bubble shaded in red.

Delivery of this project will occur over 9 stages (as summarised in Figure 1-2), each of which represents a key hold point. The staged approached is developed according to the PNP's scope and is in line with the CHRMAP Guidelines (WAPC, 2019).

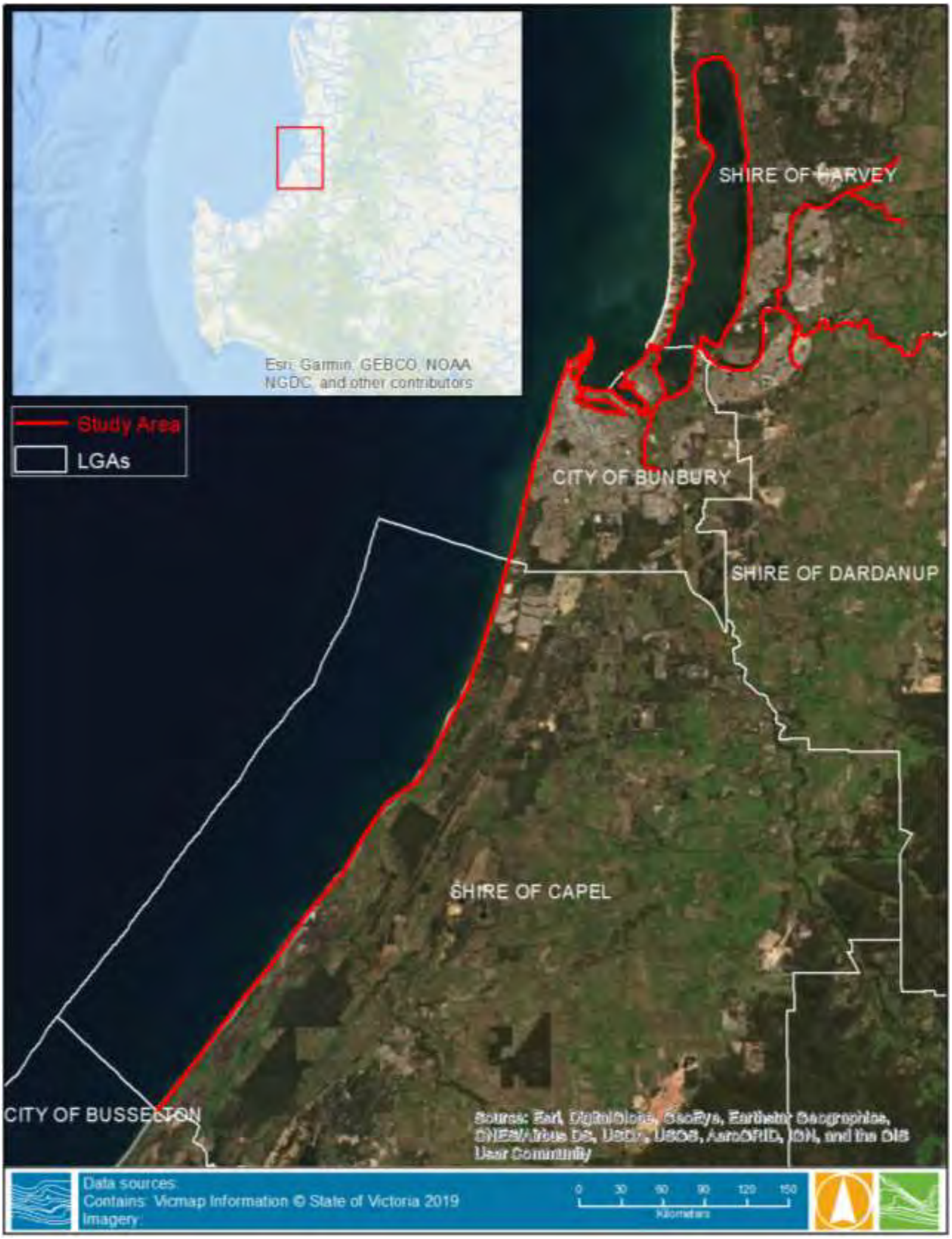

Figure 1-1 Project Area

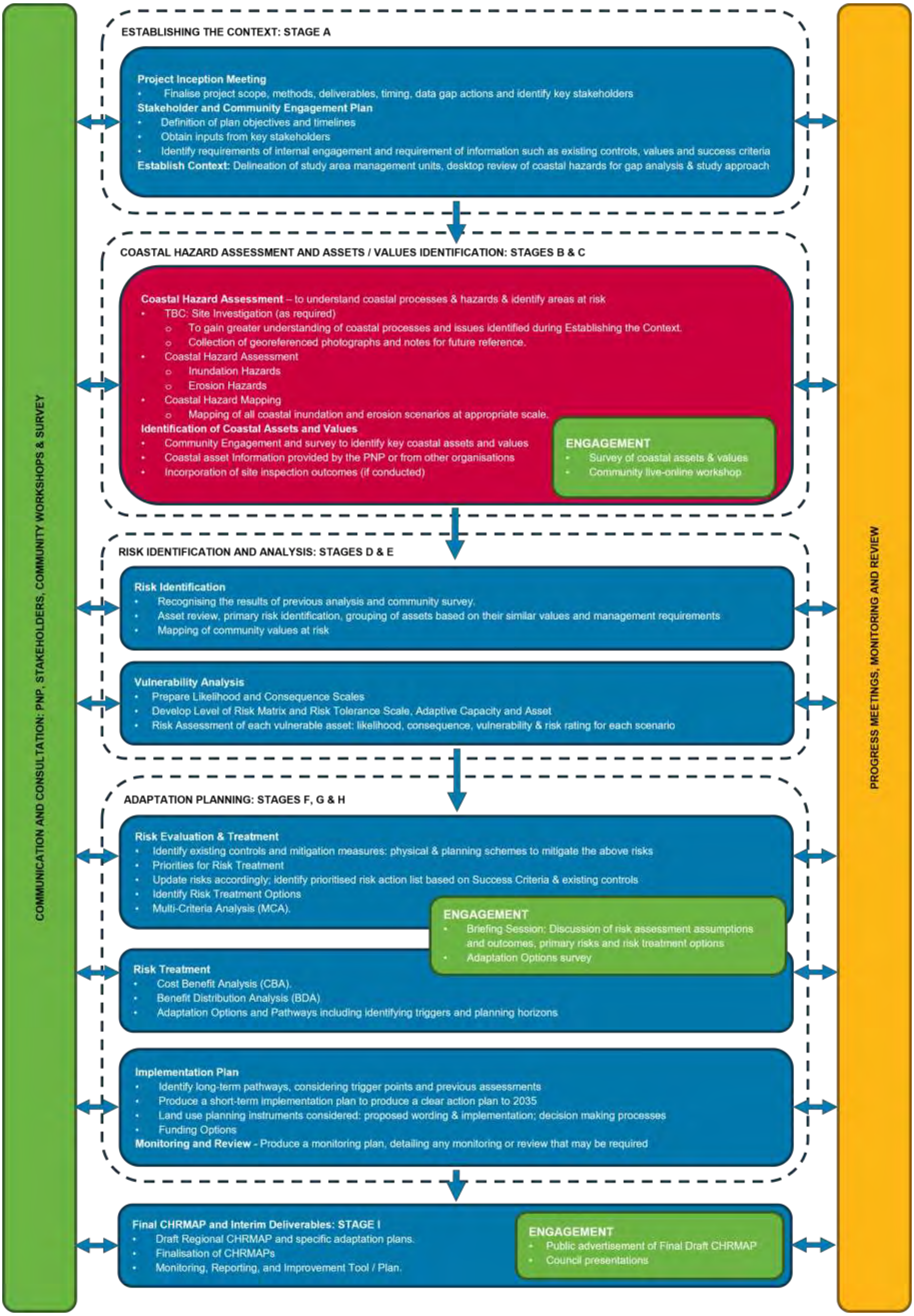

Figure 1-2 CHRMAP Methodology Flow Chart (adapted from WAPC, 2019)

2 MANAGEMENT UNITS

A project Steering Group has been established to oversee preparation and completion of the CHRMAP, including review of project deliverables. The Steering Group plays an advisory role in the project and consists of various representatives. The members of project steering group and key stakeholders are summarised in Table 2-1.

Table 2-1 Steering Group members

Organisation	Role of organisation in study area
PNP	Regional facilitator and client project manager.
Shire of Capel	Local coastal land and riverine shoreline manager.
City of Bunbury	Local coastal, riverine shoreline, and estuarine/inlet land manager.
Shire of Harvey	Local coastal, riverine shoreline, and estuarine land manager.
Shire of Dardanup	Local riverine shoreline land manager.
Department of Biodiversity, Conservation & Attractions (DBCA)	Local coastal, riverine shoreline, and estuarine land manager. Data custodian.
Southern Ports, Bunbury	Local coastal land manager; data custodians.
Department of Planning, Lands & Heritage (DPLH)	Technical scoping, advice and review; data custodians, presence required by funding agreement for project
Department of Transport (DoT)	Local coastal land manager; and technical scoping, advice and review; data custodians.
Department of Water & Environmental Regulation (DWER)	Technical scoping, advice and review; data custodians.

To facilitate the coastal hazard assessment and development of adaptation options, the study area is delineated into several management units which are determined according to a set of factors:

- Jurisdiction boundaries
- Presence of coastal assets and relevant stakeholders
- Coastal processes and potential hazard types.

For Shire of Capel, the shoreline can be divided into three primary management units:

- MU1 - Peppermint Grove Beach
- MU2 - Capel Coast (coastal reserve and farmland)
- MU3 - Dalyellup Beach

For City of Bunbury, the shoreline can be divided into five primary management units:

- MU4 - Bunbury S
- MU5 - Bunbury (including Five Mile Brook district, Koombana Bay, Leschenault Inlet)
- MU6 - Bunbury Port
- MU7 - The Cut

- MU81 – Bunbury E

Shire of Dardanup does not have an open coast. Primary hazards are potential riverbank erosion and inundation of lowlands along the Collie River. The area is defined as an individual management unit:

- MU10 - Collie River S.

For Shire of Harvey, the shoreline can be subdivided into two primary management units:

- MU9 - Leschenault Estuary
- MU11 - Collie River N, consisting of lands on the northern side of Collie River and along the Wellesley River and Brunswick River

Open ocean coast within Shire of Harvey is excluded from the scope of this CHRMAP.

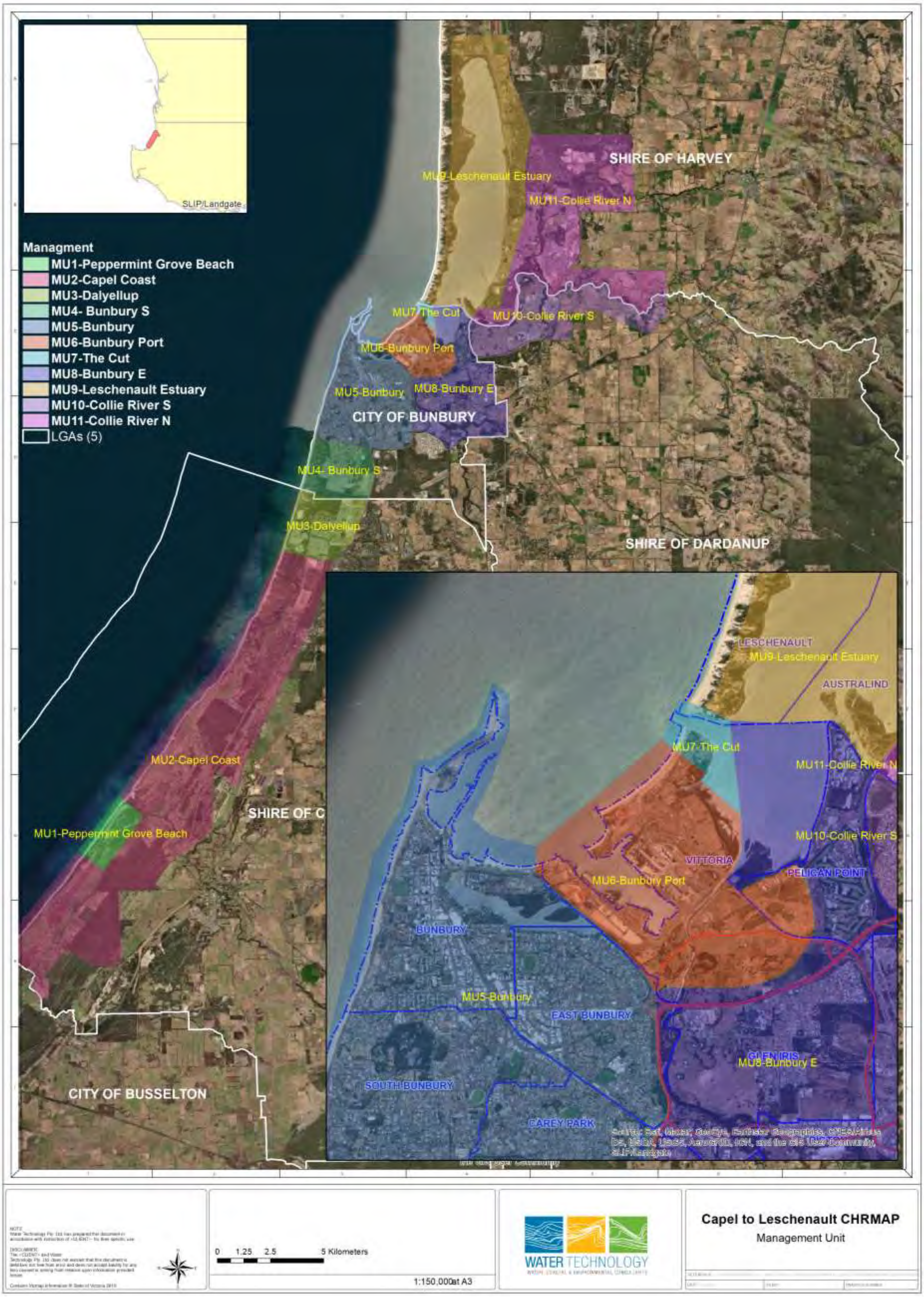

Figure 2-1 Study Area and Management Units

3 IDENTIFICATION OF COASTAL ASSETS

3.1 Collection Methodology

Coastal assets were identified in the following ways:

- Asset information was provided in excel and spatial file formats for use in this study by Steering Group members. These were imported into the GIS database developed for the project, and used as the basis for the coastal asset identification.
- Landgate assets database, for example for roads.
- The coastal values survey(s) and other engagement activities to identify additional assets of importance and value to the community.
- Site visit to investigate locations where information was not clear from the desktop assessment.
- Manual identification of further assets from aerial photography (e.g., developed areas of foreshore reserve)

3.2 Asset Classifications

At the time of identification, each asset was categorised into a classification. This aims to simplify the adaptation planning process in subsequent phases of the project. The study team grouped assets as follows:

- Roads
- Residential land including both occupied and vacant land
- Commercial land and assets e.g., Bars, shops, markets etc.
- Public and community assets not located in the foreshore reserve e.g., car parks, recreational facilities
- Developed foreshore reserve, including coastal, estuary and river foreshore areas
  - Reserve containing public assets, e.g., car parks, public ablutions, playgrounds, walkway, access structures
- Undeveloped foreshore reserve, including coastal, estuary and river foreshore areas
- Environmental
  - Contaminated sites
  - DBCA data. This includes habitat areas potentially suitable for Matters of National Environmental Significance (such as Carnaby's Cockatoo's and Western Ringtail Possums), Threatened and Priority Ecological Communities, and known locations of threatened flora.
- Agricultural / rural lands
- Aboriginal heritage

One of the main challenges of this CHRMAP is the numerous assets and management zones. This asset classification was developed to address the main coastal adaptation issues and key locations, and enable a simple yet effective method for adaptation planning.

3.3 Asset Data

The link below presents the hazard and asset information together overlain on an aerial photograph for ease of viewing. All information layers can be turned on and off, and it is possible to zoom in on sites within the study area. Clicking on an asset displays its category, planning horizon in which it is predicted to become affected and the Management Unit. It is recommended that each Steering Group member view the link to gain further understanding of assets at risk within their jurisdictions.

https://watech.maps.arcgis.com/apps/webappviewer/index.html?id=d43c39fda97d426ea6192d1a7a8543cf

Tables containing a breakdown of assets by Management Unit, category and planning horizon are presented in Appendix A and Appendix B for erosion and inundation respectively. **A summary of the totals for a selection of key asset types and a brief discussion is presented in Table 3-1**.

This asset data will be assessed in the vulnerability assessment, and subsequent stages of the CHRMAP.

Table 3-1 Summary of hazards to assets (refer Appendix A and Appendix B for full list of predicted asset numbers at risk by category. If categories not mentioned within table, they are not identified as at risk in the corresponding MU)

Management Unit	Summary	Snapshot of Assets at Risk
MU1 – Peppermint Grove	▪ Peppermint Grove is particularly vulnerable to erosion hazard as there is only a 50-100 m wide reserved sand dune. Residential properties are predicted to be within the erosion hazard zone by 2120. ▪ In 2120, the land depression behind the residential area will be under constant risk of inundation. The majority of the residential properties are not predicted to be affected by inundation. The existing sand dune acts as a natural barrier for coastal inundation. The inundation model assumes ocean water enters the land depression through Capel River and culvert openings, rather than by breaching of the dunes along the open coast.	▪ Peppermint Grove Road at risk of inundation ▪ By 2120, 39 environmental assets at risk from erosion; 54 by inundation ▪ 154 residential properties predicted to be impacted by erosion by 2120 ▪ 30 residential properties predicted to be impacted by inundation by 2120 ▪ 19 agricultural / rural lots predicted to be impacted by inundation by 2120 ▪ Undeveloped foreshore, public and community assets are at risk from both inundation and erosion from the present day
MU2 – Capel Coast	▪ Most of the assets at risk of erosion are environmental and undeveloped foreshore ▪ Agricultural / rural lots are predicted to be impacted by both erosion and inundation. ▪ The inundation extent extends across the land depression adjacent to Capel River. In the north of the management unit, inundation is minimal. ▪ The dominant land use of rural / agricultural and regional open space is reflected in the assets-at-risk totals	▪ Approximately 30 roads at risk of inundation by 2120 ▪ By 2120, 116 environmental assets at risk from erosion; 200 by inundation ▪ 136 agricultural / rural lots predicted to be impacted by inundation by 2120; 55 by erosion ▪ 6 Aboriginal Heritage assets in the erosion hazard zone from the present day ▪ Undeveloped foreshore, public and community assets are at risk from both inundation and erosion from the present day
MU3 – Dalyellup	▪ Erosion is the main risk for this MU, with residential and environmental categories the most affected. ▪ Inundation is not a high risk in this management unit	▪ By 2120, 42 environmental assets at risk from erosion; 4 by inundation ▪ 64 residential properties predicted to be impacted by erosion by 2120 ▪ The SLSC car park is predicted to be in the erosion hazard zone by 2035. ▪ The treatment ponds of the Bunbury Wastewater Treatment Plant are predicted to be in the erosion hazard zone by 2120. ▪ Developed foreshore, public and community assets are at risk from erosion from 2035; undeveloped foreshore by the present day
MU4 – Bunbury S	▪ Erosion is predicted to impact natural assets within this management unit. ▪ Inundation is not a high risk in this management unit.	▪ By 2120, 12 environmental assets at risk from erosion; 7 by inundation ▪ Developed and undeveloped foreshore is at risk from erosion from the present day; public and community assets are by 2120
MU5 – Bunbury including open coast, Koombana Bay and Leschenault Inlet	▪ Erosion is a significant risk from the present day to both built and natural assets along the western coast of the City of Bunbury. ▪ Inundation is a significant risk across much of this management unit. The inundation risk is predicted to increase from present day to 2120. By 2120, the 1-year ARI is predicted to inundate a significant residential and commercial area. ▪ Environmental, public and community assets are also predicted to be significantly impacted by inundation	▪ Approximately 340 roads at risk of inundation by 2120; 57 by erosion ▪ By 2120, 141 environmental assets at risk from erosion; 277 by inundation ▪ 267 residential properties predicted to be impacted by erosion by 2120 ▪ 2106 residential properties predicted to be impacted by inundation by 2120 ▪ By 2120, 8 commercial assets at risk of erosion, 500 from inundation ▪ 4 Aboriginal Heritage assets in both hazard zones from the present day ▪ Developed and undeveloped foreshore, public and community assets are at risk from erosion and inundation from the present day
MU6 – Bunbury Port	▪ By 2120, the land at the entrance to the inner Port is completely within the erosion hazard zone ▪ Inundation is the main risk in this management unit. ▪ It is noted that a high-level study using policy setbacks provides no additional value to the planning and management of lands along the Preston River.	▪ Approximately 8 roads at risk of inundation by 2120; 3 by erosion ▪ By 2120, 90 environmental assets at risk from erosion; 78 by inundation ▪ 2 agricultural / rural lots predicted to be impacted by erosion by 2120, 4 by inundation ▪ By 2120, 13 commercial assets at risk of erosion, 7 from inundation ▪ Developed and undeveloped foreshore, public and community assets are at risk from erosion from the present day ▪ Public and community, undeveloped foreshore at risk of inundation from the present day

Management Unit	Summary	Snapshot of Assets at Risk
MU7 – the Cut	▪ The Cut entrance is at risk of erosion and inundation by 2120 (assuming seawalls are not maintained). ▪ Natural assets are at risk in this management unit	▪ By 2120, 129 environmental assets at risk from erosion; 91 by inundation ▪ The undeveloped foreshore reserve is at risk of erosion and inundation from the present day
MU8 – Bunbury E including Vittoria Bay, Pelican Point and Districts along Preston River	▪ Inundation is the biggest risk for this management unit ▪ The areas surrounding Preston River and the Estuary are at risk of inundation from the present day. ▪ It is assumed the canal infrastructure will be maintained; however, the canal properties are at risk from erosion along the river and estuary fronts by 2120. ▪ Foreshore Park and the commercial properties on Estuary Drive are predicted to be in the coastal erosion hazard zone by 2120.	▪ Approximately 19 roads at risk of erosion by 2120; 79 by inundation ▪ By 2120, 104 environmental assets at risk from erosion; 145 by inundation ▪ 92 residential properties predicted to be impacted by erosion by 2120 ▪ 409 residential properties predicted to be impacted by inundation by 2120 ▪ By 2120, 2 commercial assets at risk of erosion, 8 from inundation ▪ By 2120, 4 Aboriginal Heritage assets at risk of erosion, 7 by inundation ▪ Public and community, developed and undeveloped foreshore at risk of erosion and inundation from the present day
MU9 – Leschenault Estuary	▪ Inundation along the eastern shoreline of the estuary is a risk from the present day. This affects foreshore reserve and residential / commercial assets. ▪ Significant portions of land may be permanently inundated by 2120. The majority of this is foreshore reserve, with the exception of the Australind Tourist Park.	▪ Approximately 37 roads at risk of erosion by 2120; 25 by inundation ▪ By 2120, 359 environmental assets at risk from erosion; 314 by inundation ▪ 86 residential properties predicted to be impacted by erosion / permanent inundation by 2120 ▪ 170 residential properties predicted to be impacted by inundation by 2120 ▪ 43 agricultural / rural lots predicted to be impacted by inundation by 2120, 33 by erosion ▪ 2 Aboriginal Heritage assets at risk from both erosion and inundation from the present day ▪ Undeveloped foreshore at risk of erosion from the present day ▪ Public and community assets at risk of inundation from the present day; from erosion by 2050
MU10 Collie River S	▪ Inundation is mainly within the foreshore reserve (within CHRMAP study area bounds). ▪ Erosion lines may impact some residential properties; however, these properties are at the limit of these areas so highly sensitive to the somewhat subjective definition of the HSD. – It is noted that a high-level study using policy setbacks provides no additional value to the planning and management of lands along the Collie River.	▪ Approximately 7 roads at risk of erosion by 2120; 5 by inundation ▪ By 2120, 57 environmental assets at risk from erosion; 54 by inundation ▪ 14 residential properties predicted to be impacted by erosion by 2120 ▪ 36 residential properties predicted to be impacted by inundation by 2120 ▪ 3 commercial properties at risk of inundation from the present day ▪ 2 Aboriginal Heritage assets at risk from inundation from the present day ▪ Public and community assets at risk of erosion and inundation from the present day
MU11-Collie River N	▪ Inundation is mainly within the foreshore reserve (within CHRMAP study area bounds). ▪ Erosion lines may impact some residential properties; however, these properties are at the limit of these areas so highly sensitive to the somewhat subjective definition of the HSD. – It is noted that a high-level study using policy setbacks provides no additional value to the planning and management of lands along the Collie River.	▪ Approximately 13 roads at risk of erosion by 2120; 7 by inundation ▪ By 2120, 57 environmental assets at risk from erosion; 58 by inundation ▪ 49 residential properties predicted to be impacted by erosion by 2120 ▪ 35 residential properties predicted to be impacted by inundation by 2120 ▪ Undeveloped foreshore, public and community assets at risk of erosion and inundation from the present day

4 COMMUNITY VALUES ASSESSMENT

The full engagement outcomes summary report can be viewed in Appendix C. A summary is provided below.

4.1 Engagement Process

The engagement activities for this stage of the project included:

- Use of an interactive project tool (Social Pinpoint) to answer CHRMAP value survey questions and pin values and comments spatially on a project map;
- Hard copy surveys mirroring the online component;
- Community workshop held on 2nd September 2021 in a location in each of the four LGAs and linked online to discuss coastal processes, map community values and understand issues and concerns of the community for the study area;
- Direct engagement with Traditional Owners and Indigenous representatives.
-
- Stakeholder meetings

In the preliminary stage of engagement, stakeholders could visit an online project page with a mapping tool and survey to drop pins and comment on activities they value and their locational preferences for these activities on the map. Participants could also respond to a survey and provide any other feedback on how they use the different areas of the coastline. The survey was available online and in hard copy at the LGA administration centres.

The survey and mapping tool was open from 26th July 2021 to 10th September 2021. In addition, people could provide survey responses in hard copy.

The project team received 84 CHRMAP values survey responses online, 97 hard copy survey responses (a total of 181 survey responses) and 56 'pins' were placed on the map. Whilst 'place of residence' was not included in the survey, more than 50% of respondents visited locations in the Shire of Capel most often, and approximately 30% of respondents visited beaches in the City of Bunbury most often.

Stakeholders were further engaged through the following:

- Social media posts
- Key briefings with the Project Steering Group (PSG) including administrative and elected members from PNP, the four LGAs, the Department of Planning, Lands and Heritage and the Department of Transport
- Briefings to key staff members and Executive Management at the LGAs.

28 people attended the workshop.

In total more than 150 participants contributed to this stage of engagement, with an approximate reach of more than 445 local community members and organisations.

4.2 Community Values Survey Summary

The community told the project team that the coastal zone is important to them for many recreation, social and cultural reasons. A total of 181 survey responses were received.

Survey responses indicate coastal and estuarine and riverine areas are valued for activities like walking, swimming, snorkelling, diving, boating, exploring with the family, and coastal vegetation and landforms. Protecting the environment was also highly valued.

Another strong theme was around coastal erosion and climate changes being observed by respondents.

4.3 Community Values Workshop Summary

Key coastal, estuarine and riverine values identified by workshop participants are as follows:

- Beaches and estuarine areas for activities like walking, swimming, snorkelling, exercise, views, fishing, surfing, 4WDing
- Wetlands and environmental areas for their flora and fauna diversity which participants could view.
- Coastal views, walks and scenery.
- Coastal vegetation and the natural environment generally.
- Opportunities for observing wildlife at various locations and protecting habitat for these communities and species.

Key issues and concerns / risks to the coastal values:

- Beach erosion and its environmental, social and financial impacts
- Vegetation retention, revegetation and the need to do more to protect coastal areas from erosion came up multiple times in the different LGAs.
- Environmental protection was generally very highly valued.
- Sea level rise and climate change was also a key discussion point at the workshop, with participants wanting to see decision makers actively addressing climate change impacts.
- Contamination and pollution impacts on fauna and flora and the health of waterways from industrial activities along the coastline and river environment, including the port at Bunbury.
- Protection of coastal wetlands that mitigate against impacts of extreme events and that are home to birds and wildlife
- Biodiversity and habitat loss
- Human impact on the coastal and estuarine natural assets and values to the community

5 SUCCESS CRITERIA

The values collated from the engagement to date have been used to generate the success criteria for the vulnerability and risk assessment component of the CHRMAP. These will be key to the whole CHRMAP as it is these that will ultimately drive the selection of adaptation options. It is important that a comprehensive approach be applied at this stage of the project, in order to provide a CHRMAP applicable to all stakeholders.

The success criteria are defined in Table 5-1. These criteria will be revised during the course of the CHRMAP to ensure the final document reflects all stakeholder views.

Table 5-1 Success criteria

- Conserve, enhance and maintain the natural environment and character of the study area
- Facilitate and promote public usage and enjoyment of the natural environment, coast, estuaries and rivers
- Protection of the cultural values of the coastline
- Manage impacts to the existing residential areas from erosion and inundation
- Maintain critical infrastructure supporting the community (roads, utilities).
- Manage and maintain coastal infrastructure that provides access to the water and supports the lifestyle enjoyed by people in the region
- Retain the widest possible range of risk management options for future users of the coast

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APPENDIX A
ASSETS IN EROSION HAZARD ZONE

Table A-2 Predicted assets in the erosion hazard zone, grouped by management unit & planning horizon

Management Unit	2020	2035	2050	2120
MU1-Peppermint Grove Beach	**40**	**52**	**54**	**231**
Roads		3	3	21
Residential	2	3	3	154
Commercial				
Public and Community		1	1	2
Foreshore - Developed				
Foreshore - Undeveloped	10	15	15	15
Environmental	28	30	32	39
Agricultural / Rural				
Aboriginal Heritage				
MU2-Capel Coast	**104**	**114**	**121**	**197**
Roads				6
Public and Community		1	3	4
Foreshore - Undeveloped	7	7	9	10
Environmental	71	79	82	116
Agricultural / Rural	20	21	21	55
Aboriginal Heritage	6	6	6	6
MU3-Dalyellup	**18**	**30**	**31**	**112**
Residential		4	4	64
Commercial		1	1	1
Public and Community		3	3	3
Foreshore - Developed		1	1	1
Foreshore - Undeveloped	1	1	1	1
Environmental	17	20	21	42
MU4- Bunbury S	**10**	**11**	**11**	**16**
Public and Community				2
Foreshore - Developed	1	1	1	1
Foreshore - Undeveloped	1	1	1	1
Environmental	8	9	9	12
MU5-Bunbury	**110**	**130**	**183**	**564**
Roads	10	16	21	57
Residential		4	33	267
Commercial	3	3	4	8

Management Unit	2020	2035	2050	2120
Public and Community	5	5	14	50
Foreshore - Developed	14	15	18	20
Foreshore - Undeveloped	14	15	15	16
Environmental	60	68	74	141
Aboriginal Heritage	4	4	4	4
PORT				1
MU6-Bunbury Port	**85**	**99**	**99**	**136**
Roads	3	3	3	3
Commercial	9	13	13	13
Public and Community	2	2	2	2
Foreshore - Undeveloped	6	6	6	6
Environmental	49	56	56	90
Agricultural / Rural				2
PORT	16	19	19	20
MU7-The Cut	**29**	**119**	**119**	**130**
Foreshore - Undeveloped	1	1	1	1
Environmental	28	118	118	129
MU8-Bunbury E	**119**	**127**	**141**	**256**
Roads	9	10	13	19
Residential	3	3	11	92
Commercial		2	2	2
Public and Community	16	17	17	22
Foreshore - Developed	4	4	4	5
Foreshore - Undeveloped	8	8	8	8
Environmental	76	80	82	104
Aboriginal Heritage	3	3	4	4
MU9-Leschenault Estuary	**317**	**342**	**384**	**591**
Roads	7	9	16	37
Residential		1	15	86
Commercial				5
Public and Community			6	27
Foreshore - Undeveloped	41	41	41	42
Environmental	266	285	296	359
Agricultural / Rural	1	4	8	33
Aboriginal Heritage	2	2	2	2

Management Unit	2020	2035	2050	2120
MU10-Collie River S	**65**	**77**	**86**	**104**
Roads	2	4	4	7
Residential			6	14
Public and Community	6	7	7	8
Environmental	57	66	69	75
MU11-Collie River N	**60**	**61**	**79**	**128**
Roads	4	4	6	13
Residential	1	1	17	49
Public and Community	3	3	3	6
Foreshore - Undeveloped	3	3	3	3
Environmental	49	50	50	57
TOTAL	957	1162	1308	2465

APPENDIX B
ASSETS IN INUNDATION HAZARD EXTENT

Table B-3 Predicted assets in the present-day inundation hazard zone, grouped by asset type & management unit

Management Unit	1-year ARI	10-year ARI	100-year ARI	500-year ARI
MU1-Peppermint Grove Beach	**83**	**5**	**13**	**29**
Roads	2			
Residential	2		1	3
Commercial	1			
Public and Community			1	2
Foreshore - Developed				
Foreshore - Undeveloped	1	1		4
Environmental	54	4	11	18
Agricultural / Rural	23			2
Aboriginal Heritage				
MU2-Capel Coast	**404**	**87**	**157**	**116**
Roads	30	9	18	5
Commercial			1	
Public and Community	1			4
Foreshore - Undeveloped	5			
Environmental	227	48	97	78
Agricultural / Rural	135	30	41	28
Aboriginal Heritage	6			1
MU3-Dalyellup	**4**	**1**	**0**	**0**
Environmental	4	1		
MU4- Bunbury S	**9**			
Foreshore - Developed	1			
Foreshore - Undeveloped	1			
Environmental	7			
MU5-Bunbury	**195**	**45**	**275**	**1494**
Roads	22	2	14	173
Residential	20	36	95	1023
Commercial	8		1	112
Public and Community	42	2	41	78
Foreshore - Developed	18	1	6	10
Foreshore - Undeveloped	16		1	
Environmental	65	4	117	97

Management Unit	1-year ARI	10-year ARI	100-year ARI	500-year ARI
Aboriginal Heritage	4			1
MU6-Bunbury Port	**89**	**6**	**106**	**19**
Roads	3		5	3
Commercial	8	5	3	
Public and Community			6	
Foreshore - Undeveloped	6			
Environmental	57	1	50	10
Agricultural / Rural	1		4	
PORT	14		38	6
MU7-The Cut	**30**	**3**	**89**	**2**
Foreshore - Undeveloped	1			
Environmental	29	3	89	2
MU8-Bunbury E	**221**	**68**	**342**	**155**
Roads	17	8	49	20
Residential	10	38	218	106
Commercial	9		3	4
Public and Community	27	1	23	13
Foreshore - Developed	5		1	
Foreshore - Undeveloped	8			
Environmental	139	18	34	11
Agricultural / Rural			11	1
Aboriginal Heritage	6	3	3	
MU9-Leschenault Estuary	**398**	**136**	**173**	
Roads	18	12	15	
Residential	5	32	92	
Commercial			4	
Public and Community	6	10	9	
Foreshore - Undeveloped	41			
Environmental	291	68	43	
Agricultural / Rural	35	14	10	
Aboriginal Heritage	2			
MU10-Collie River S	**58**	**27**	**32**	**31**
Roads	1	4		
Residential		7	25	19
Commercial		2		

Management Unit	1-year ARI	10-year ARI	100-year ARI	500-year ARI
Public and Community	6	5	1	1
Environmental	51	9	6	11
MU11-Collie River N	**71**	**3**	**23**	**31**
Roads	3	1	4	2
Residential	3		9	26
Public and Community	4	1	2	1
Foreshore - Undeveloped	3			
Environmental	58	1	8	2
TOTAL	1562	381	1210	1877

Table B-4 Predicted assets in the 2035 inundation hazard zone, grouped by asset type & management unit

Management Unit	1-year ARI	10-year ARI	100-year ARI	500-year ARI
MU1-Peppermint Grove Beach	**84**	**5**	**13**	**34**
Roads	2			1
Residential	2		1	3
Commercial	1			
Public and Community			1	2
Foreshore - Undeveloped	2	1		5
Environmental	54	4	11	21
Agricultural / Rural	23			2
MU2-Capel Coast	**405**	**92**	**157**	**121**
Roads	30	11	18	6
Commercial			1	
Public and Community	1			4
Foreshore - Undeveloped	5			
Environmental	227	48	97	80
Agricultural / Rural	136	33	41	30
Aboriginal Heritage	6			1
MU3-Dalyellup	**4**	**1**	**0**	**0**
Environmental	4	1		
MU4- Bunbury S	**9**			
Foreshore - Developed	1			
Foreshore - Undeveloped	1			

Management Unit	1-year ARI	10-year ARI	100-year ARI	500-year ARI
Environmental	7			
MU5-Bunbury	**195**	**47**	**276**	**1675**
Roads	22	2	14	183
Residential	20	37	96	1166
Commercial	8		1	115
Public and Community	42	2	41	81
Foreshore - Developed	18	2	6	14
Foreshore - Undeveloped	16		1	
Environmental	65	4	117	115
Aboriginal Heritage	4			1
MU6-Bunbury Port	**91**	**13**	**106**	**19**
Roads	3	2	5	3
Commercial	9	6	3	
Public and Community			6	
Foreshore - Undeveloped	6			
Environmental	58	3	50	10
Agricultural / Rural	1	2	4	
PORT	14		38	6
MU7-The Cut	**30**	**6**	**89**	**2**
Foreshore - Undeveloped	1			
Environmental	29	6	89	2
MU8-Bunbury E	**242**	**154**	**342**	**161**
Roads	18	11	49	20
Residential	23	99	218	112
Commercial	9		3	4
Public and Community	27	3	23	13
Foreshore - Developed	5		1	
Foreshore - Undeveloped	8			
Environmental	145	36	34	11
Agricultural / Rural		1	11	1
Aboriginal Heritage	7	4	3	
MU9-Leschenault Estuary	**447**	**182**	**199**	**5**
Roads	20	15	18	
Residential	18	45	102	2
Commercial		1	4	

Management Unit	1-year ARI	10-year ARI	100-year ARI	500-year ARI
Public and Community	9	12	12	1
Foreshore - Undeveloped	41			
Environmental	314	88	53	2
Agricultural / Rural	43	21	10	
Aboriginal Heritage	2			
MU10-Collie River S	**64**	**52**	**32**	**31**
Roads	2	5		
Residential	1	9	25	19
Commercial	1	3		
Public and Community	6	11	1	1
Environmental	54	22	6	11
Aboriginal Heritage		2		
MU11-Collie River N	**72**	**7**	**23**	**31**
Roads	4	2	4	2
Residential	3		9	26
Public and Community	4	1	2	1
Foreshore - Undeveloped	3			
Environmental	58	4	8	2
TOTAL	1643	559	1237	2079

Table B-5 Predicted assets in the 2050 inundation hazard zone, grouped by asset type & management unit

Management Unit	1-year ARI	10-year ARI	100-year ARI	500-year ARI
MU1-Peppermint Grove Beach	**84**	**5**	**15**	**38**
Roads	2			2
Residential	2		1	3
Commercial	1			
Public and Community			1	3
Foreshore - Undeveloped	2	1	1	6
Environmental	54	4	12	22
Agricultural / Rural	23			2
MU2-Capel Coast	**405**	**92**	**162**	**138**
Roads	30	11	18	8
Commercial			1	

Management Unit	1-year ARI	10-year ARI	100-year ARI	500-year ARI
Public and Community	1			4
Foreshore - Undeveloped	5			
Environmental	227	48	100	93
Agricultural / Rural	136	33	43	32
Aboriginal Heritage	6			1
MU3-Dalyellup	**4**	**1**	**0**	**0**
Environmental	4	1		
MU4- Bunbury S	**9**			
Foreshore - Developed	1			
Foreshore - Undeveloped	1			
Environmental	7			
MU5-Bunbury	**195**	**47**	**308**	**2052**
Roads	22	2	16	218
Residential	20	37	115	1466
Commercial	8		2	134
Public and Community	42	2	45	102
Foreshore - Developed	18	2	6	14
Foreshore - Undeveloped	16		1	
Environmental	65	4	123	117
Aboriginal Heritage	4			1
MU6-Bunbury Port	**91**	**13**	**108**	**19**
Roads	3	2	5	3
Commercial	9	6	3	
Public and Community			6	
Foreshore - Undeveloped	6			
Environmental	58	3	50	10
Agricultural / Rural	1	2	4	
PORT	14		40	6
MU7-The Cut	**30**	**6**	**89**	**2**
Foreshore - Undeveloped	1			
Environmental	29	6	89	2
MU8-Bunbury E	**242**	**154**	**385**	**165**
Roads	18	11	57	20
Residential	23	99	244	116
Commercial	9		6	4

Management Unit	1-year ARI	10-year ARI	100-year ARI	500-year ARI
Public and Community	27	3	28	13
Foreshore - Developed	5		1	
Foreshore - Undeveloped	8			
Environmental	145	36	34	11
Agricultural / Rural		1	12	1
Aboriginal Heritage	7	4	3	
MU9-Leschenault Estuary	**447**	**182**	**229**	**7**
Roads	20	15	21	
Residential	18	45	124	2
Commercial		1	4	
Public and Community	9	12	13	1
Foreshore - Undeveloped	41			
Environmental	314	88	57	4
Agricultural / Rural	43	21	10	
Aboriginal Heritage	2			
MU10-Collie River S	**64**	**52**	**41**	**31**
Roads	2	5		
Residential	1	9	30	19
Commercial	1	3		
Public and Community	6	11	1	1
Environmental	54	22	10	11
Aboriginal Heritage		2		
MU11-Collie River N	**72**	**7**	**37**	**31**
Roads	4	2	5	2
Residential	3		22	26
Public and Community	4	1	2	1
Foreshore - Undeveloped	3			
Environmental	58	4	8	2
TOTAL	1643	559	1374	2483

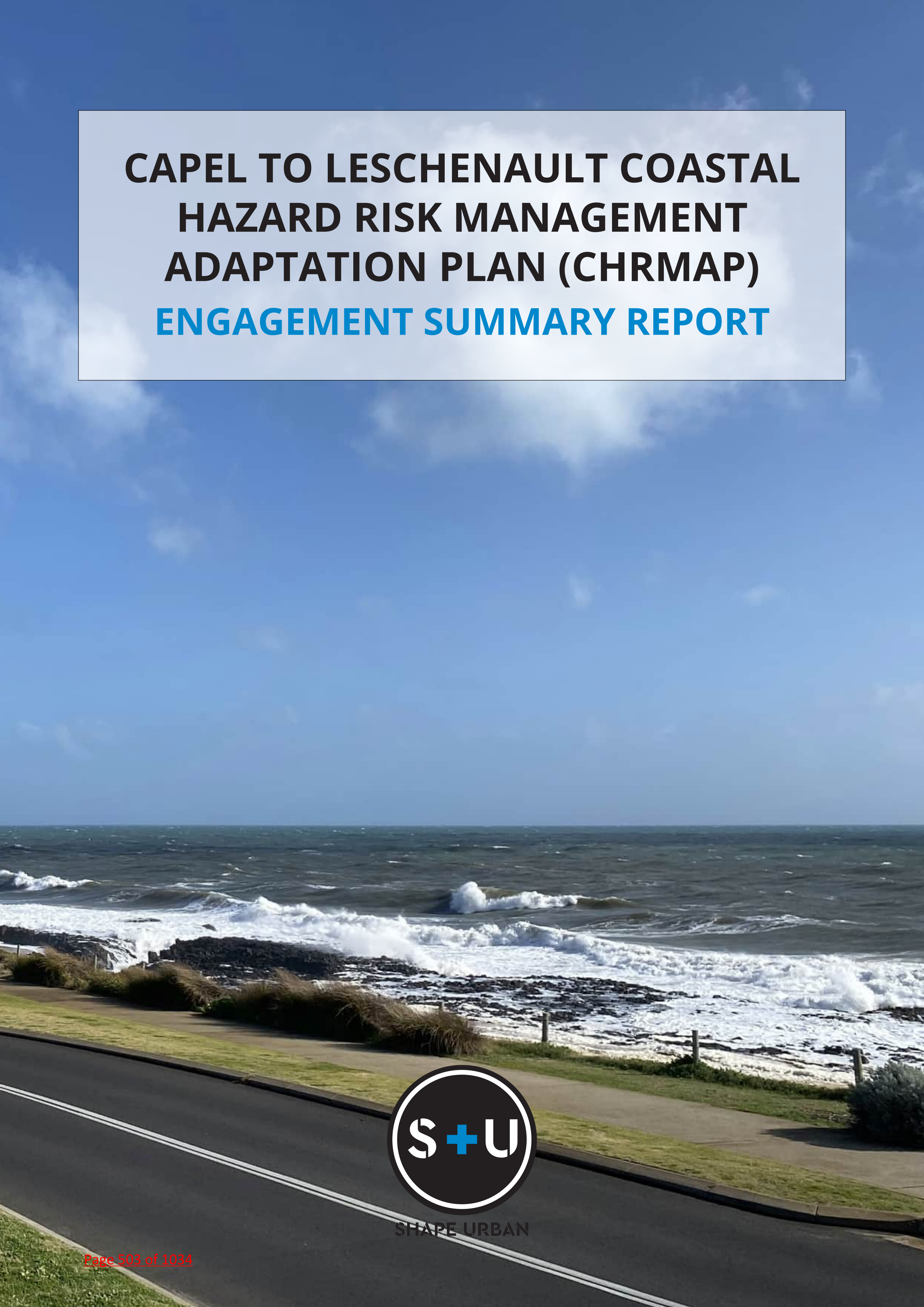
Table B-6 Predicted assets in the 2120 inundation hazard zone, grouped by asset type & management unit

Management Unit	1-year ARI	10-year ARI	100-year ARI	500-year ARI
MU1-Peppermint Grove Beach	**84**	**5**	**43**	**88**
Roads	2		1	10
Residential	2		4	30
Commercial	1			
Public and Community			4	4
Foreshore - Undeveloped	2	1	2	12
Environmental	54	4	30	30
Agricultural / Rural	23		2	2
MU2-Capel Coast	**405**	**92**	**294**	**209**
Roads	30	11	27	20
Commercial			1	
Public and Community	1		4	7
Foreshore - Undeveloped	5		1	1
Environmental	227	48	190	140
Agricultural / Rural	136	33	70	40
Aboriginal Heritage	6		1	1
MU3-Dalyellup	**4**	**1**	**0**	**0**
Environmental	4	1		
MU4- Bunbury S	**9**			
Foreshore - Developed	1			
Foreshore - Undeveloped	1			
Environmental	7			
MU5-Bunbury	**195**	**47**	**2822**	**3232**
Roads	22	2	311	340
Residential	20	37	1558	2106
Commercial	8		509	491
Public and Community	42	2	150	126
Foreshore - Developed	18	2	15	15
Foreshore - Undeveloped	16		1	
Environmental	65	4	277	153
Aboriginal Heritage	4		1	1
MU6-Bunbury Port	**91**	**13**	**143**	**27**
Roads	3	2	8	5
Commercial	9	6	3	

Management Unit	1-year ARI	10-year ARI	100-year ARI	500-year ARI
Public and Community			6	
Foreshore - Undeveloped	6			
Environmental	58	3	78	16
Agricultural / Rural	1	2	4	
PORT	14		44	6
MU7-The Cut	**30**	**6**	**91**	**2**
Foreshore - Undeveloped	1			
Environmental	29	6	91	2
MU8-Bunbury E	**242**	**154**	**590**	**184**
Roads	18	11	79	21
Residential	23	99	409	126
Commercial	9		8	8
Public and Community	27	3	35	15
Foreshore - Developed	5		1	
Foreshore - Undeveloped	8			
Environmental	145	36	42	13
Agricultural / Rural		1	12	1
Aboriginal Heritage	7	4	4	
MU9-Leschenault Estuary	**447**	**182**	**316**	**15**
Roads	20	15	25	1
Residential	18	45	170	2
Commercial		1	4	
Public and Community	9	12	17	1
Foreshore - Undeveloped	41			
Environmental	314	88	87	10
Agricultural / Rural	43	21	13	1
Aboriginal Heritage	2			
MU10-Collie River S	**64**	**52**	**51**	**34**
Roads	2	5		
Residential	1	9	36	19
Commercial	1	3		
Public and Community	6	11	3	2
Environmental	54	22	12	13
Aboriginal Heritage		2		
MU11-Collie River N	**72**	**7**	**54**	**33**

Management Unit	1-year ARI	10-year ARI	100-year ARI	500-year ARI
Roads	4	2	7	2
Residential	3		35	28
Public and Community	4	1	2	1
Foreshore - Undeveloped	3			
Environmental	58	4	10	2
TOTAL	1643	559	4404	3824

APPENDIX C
ENGAGEMENT OUTCOMES REPORT



CAPEL TO LESCHENAULT COASTAL HAZARD RISK MANAGEMENT ADAPTATION PLAN (CHRMAP)

ENGAGEMENT SUMMARY REPORT

SHAPE URBAN

EXECUTIVE SUMMARY

The Capel to Leschenault coastline is highly valued by the people who call it home, however the coastal areas are subject to erosion and inundation risks, which will have a significant impact on its communities over time.

The Peron Naturaliste Partnership (PNP), the City of Bunbury and the Shires of Capel, Dardanup and Harvey have partnered with the Department of Biodiversity, Conservation and Attractions, Department of Water and Environmental Regulation and Southern Ports Authority to develop a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) to understand how these changes can be best managed into the future.

In 2019 a CHRMAP was prepared for the Koombana Bay area that examined erosion risks and adaptation options, but this is the only location. The Koombana Bay CHRMAP will be considered in the context of the broader CHRMAP area in this study.

A critical part of this project is the engagement with the local community and relevant stakeholders. Given the coastline's susceptibility to coastal erosion, extreme weather events and climate change risks, the stakeholder engagement for the project has been shaped to facilitate an understanding of coastal challenges, hazards and risks, understand how the community values assets along the coastline and the value they place on protection for those assets.

These values will help inform the management actions and adaptation strategies for use and protection of the management units that make up the project area's coastal zone. The coastal zone for this project includes the coastline and low-lying areas around the Leschenault Inlet and Estuary and associated rivers including the Preston/ Collie River.

This engagement summary report presents outcomes of the engagement undertaken to collect community coastal values for the coastal townsites in the City of Bunbury, Shire of Capel, Shire of Dardanup and Shire of Harvey.

A workshop was undertaken in a nominated location in each of the local government areas and linked online on 2 September 2021.

Key values from online and in-person engagement are the use of coastal and estuarine areas for activities like walking, swimming, boating, family time; wanting to see/ the need for retention of coastal vegetation and landforms; protection of the environment; observation of coastal erosion occurring and a desire to see this be addressed.

This report will be updated as engagement for the project progresses and the community values are translated into coastal assessments, trade-offs, risks and adaptation approaches.

We thank all those who were involved in generating these values via the online engagement platform (Social Pinpoint), social media or email, and through the workshopping processes.

CONTENTS

1.0 INTRODUCTION

1.1 BACKGROUND

The Capel to Leschenault coastline is highly valued by the people who call it home, however the coastal areas are subject to erosion and inundation risks, which will result in coastline changes over different time periods and have a significant impact on its communities over time. There will also be further changes as a result of climate change, such as sea level rise and more severe storm events.

Balancing the community's desire to live near the coast and managing the impacts of coastal processes is therefore becoming more important.

The Peron Naturaliste Partnership (PNP), the City of Bunbury and the Shires of Capel, Dardanup and Harvey have partnered with the Department of Biodiversity, Conservation and Attractions (DBCA), Department of Water and Environmental Regulation (DWER) and Southern Ports Authority (SPA) to develop a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for the area to understand how these changes can be best managed into the future.

The study area sits across four local government areas (LGAs), namely the Shire of Harvey, City of Bunbury, Shire of Dardanup, and Shire of Capel (Figure 1 refers). The study areas consists of sand and mixed coasts, estuaries and inlets (e.g. Leschenault Inlet), rivers (Collie River and Preston River), and numerous areas of important coastal infrastructure under the management of different government organisations (including Port of Bunbury, Koombana Bay Sailing Club, Casuarina Harbour, jetties, groynes, seawalls, bridges).

The region has been identified in Western Australia as an erosion hotspot and is considered a priority for coastal hazard assessment and management planning.

A critical part of this project is the engagement with the local community and relevant stakeholders. Preliminary stakeholder engagement aims to raise awareness of the project, gather knowledge of how the community values assets along the coastline and ensure that concerns and aspirations are properly understood.

These values and concerns will help inform the selection of appropriate adaptation strategies to respond to the coastal risks in later stages of the project.

This report details the engagement and workshops undertaken in the preliminary engagement stage.

This report will continue to be updated as more engagement work is undertaken.

1.2 ENGAGEMENT ACTIVITIES

The engagement activities for this stage of the project included:

- use of an interactive project tool (Social Pinpoint) to answer CHRMAP value survey questions and pin values and comments spatially on a project map;
- hard copy surveys mirroring the online component;
- a community workshop held in a location in each of the four LGAs and linked online to discuss coastal processes, map community values and understand issues and concerns of the community for the study area; and
- stakeholder meetings.

Figure 1 - Capel to Leschenault CHRMAP Study Area

1.3 PURPOSE OF THE REPORT

The purpose of this report is to summarise the stakeholder engagement process undertaken through the preliminary engagement phase. It includes activities undertaken, the information presented and modes of engagement.

The report details feedback received. Responses from the engagement and the community workshop are detailed through the report. All individual comments from online and hard copy surveys and the workshop can be found unedited in the Appendices section of this report.

1.4 ENGAGEMENT SUMMARY

In the preliminary stage of engagement stakeholders could visit an online project page with a mapping tool and survey to drop pins and comment on activities they value and their locational preferences for these activities on the map.

Participants could also respond to a survey and provide any other feedback on how they use the different areas of the coastline. The survey was available online and in hard copy at the LGA administration centres.

The survey and mapping tool was open from 26 July 2021 to 10 September 2021. In addition, people could provide survey responses in hard copy.

The project team received 84 CHRMAP values survey responses online, 97 hard copy survey responses (a total of 181 survey responses) and 56 'pins' were placed on the map.

Stakeholders were further engaged through the following:

- Social media posts
- Key briefings with the Project Steering Group (PSG) including administrative and elected members from PNP, the four LGAs, the Department of Planning, Lands and Heritage and the Department of Transport
- Briefings to key staff members and Executive Management at the LGAs.

28 people attended the workshop.

In total more than 150 participants contributed to this stage of engagement, with an approximate reach of more than 445 local community members and organisations.

The community's values and other stakeholder feedback received will be used to inform the development of adaptation options for the study area.

The project team will also be looking to schedule targeted meetings with identified key stakeholders as part of the next engagement stage.

This report will be updated with these outcomes and the outcomes of additional engagement as the project progresses.

2.0 PRELIMINARY FEEDBACK

2.1 ONLINE ENGAGEMENT

The PNP's website was used to provide a summary of the project and direct the community to a dedicated project page (https://getinvolved.mysocialpinpoint.com.au/capel-to-leschenault-chrmap).

The community could view project information, frequently asked questions, access the survey, register for project updates, register for the workshop or do a combination of these things.

Online engagement is measured by splitting the level of interaction into three groups; aware, informed and engaged.

Aware

The total number of participants aware of the project through the online engagement tools can be measured by the number of people that viewed at least one page of the website relating to the project. 1,443 participants visited at least one page of the project online.

Informed

Of those who were aware, a smaller group were informed further about the project. This can be measured by the number of interactions with the pages. These people numbered 445.

Engaged

The total who contributed or engaged by using one of the tools was 114. From these, 114 engaged contributors submitted a total of 84 survey responses and 56 pins were placed.

Other

The LGAs also offered the community the opportunity to fill in the CHRMAP Values survey that was on the Social Pinpoint project page in hard copy. 97 hard copy surveys were received, resulting in a total of 181 surveys being completed.

2.2 SOCIAL MEDIA

The four LGAs used social media, specifically Facebook, to promote the project and any engagement activities. The following statitstics show the amount of engagement generated by social media activity:

- Shire of Capel - 6 August 2021 - post received 3 likes
- City of Bunbury - 11 August 2021 - post received 227 reactions, 47 comments and 43 shares. Reactions to the City of Bunbury post were 201 likes, 21 love, 3 laugh, 1 surprised and 1 care
- Shire of Harvey - 23 August 2021 - post received 7 likes, 1 comment and 2 shares
- Shire of Capel - 27 August 2021 - post received 4 likes and 2 shares
- Shire of Dardanup - 30 August 2021- no feedback (noting the workshop was hosted on 2 September 2021).

Comments on City of Bunbury post related to erosion and the loss of beaches and views to date, a desire to declare a climate emergency, how vegetation contributed to values (both the coastal processes benefit and impacting viewsd), and observations of other LGAs that had used physical controls like groynes and sand fill, and the negative impacts of these measures.

One respondent wanted to see a carpark that is easily accessible to be able to view the ocean.

2.3 CHRMAP SURVEY

The community told the project team that the coastal zone is important to them for many recreation, social and cultural reasons.

The coastal zone for this project includes the coastline and low-lying areas around the Leschenault Inlet and Estuary and associated rivers including the Preston/Collie River.

A survey was set up to understand the importance of the study area to the community for a range of activities, and the importance to the community of being able to undertake these activities.

The CHRMAP survey asked the community 15 individual questions about how they use and value the coastal areas, how they value different adaptation responses, and their relationship to the coastal townsites.

Two additional questions asked respondents about their age and gender.

A total of 181 survey responses were received. The following section summarises the responses to the survey questions.

Q1 - Within the project area which area do you visit the most?

Peppermint Grove Beach was the most popular response to this question (76 mentions). The next most popular location was Dalyellup Beach (58 mentions), followed by Koombana Bay (15 mentions).

Leschenault Inlet, Lighthouse Beach and Forrest Beach all received (10 mentions) .

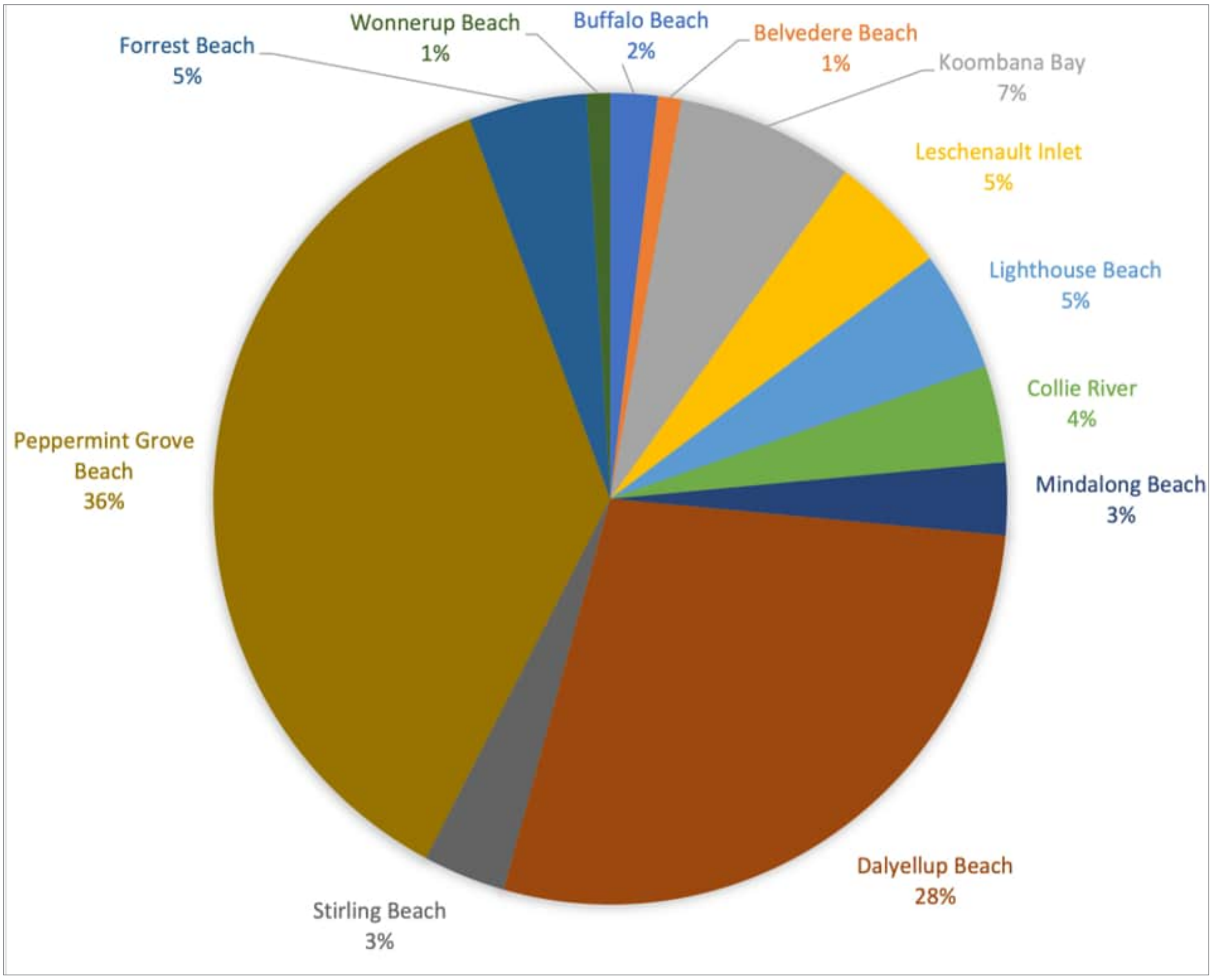


Figure 2 - Question 1

Q2 - How often do you visit the beach, foreshore area and/or Leschenault Inlet and Estuary?

The frequency of visitation to areas varied. 68 respondents visited weekly (37%), 61 respondents visited daily (33%), 29 visited monthly (16%) and 23 visited occasionally (12%).

Three respondents visited these areas rarely (2%).

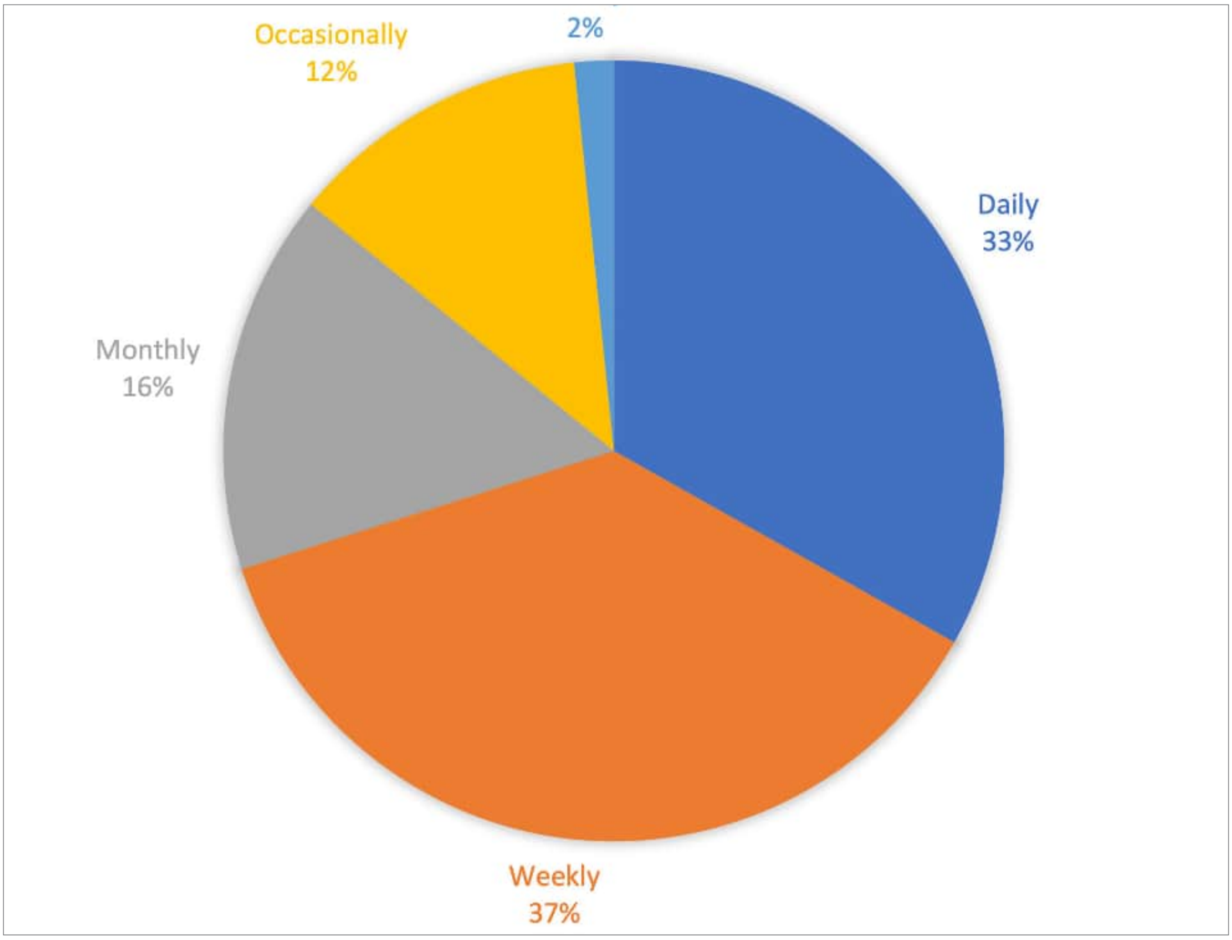


Figure 3 - Question 2

Q3 - What do you use the beach, foreshore area and/or Leschenault Inlet and Estuary for?

People were able to select multiple options regarding what they use the beach or foreshore areas for.

Beach based activities was the most popular use with 136 mentions, followed closely by water based activities (128 mentions). Foreshore based and nature based activities were also well represented, with 111 and 100 mentions respectively.

The beach, water, foreshore and nature based activities comprise a variety of reasons, as depicted in Figure 4 below.

9 respondents selected the 'Other' option and provided responses about what they used these areas for. Responses included being a landowner adjacent to the coast, for exercise (noting this was a beach based activity option), dog walking, photography, for views, rowing and to use the sailing club.

Two respondents did not want to see any more development on the coast and suggested no four-wheel driving be permitted.

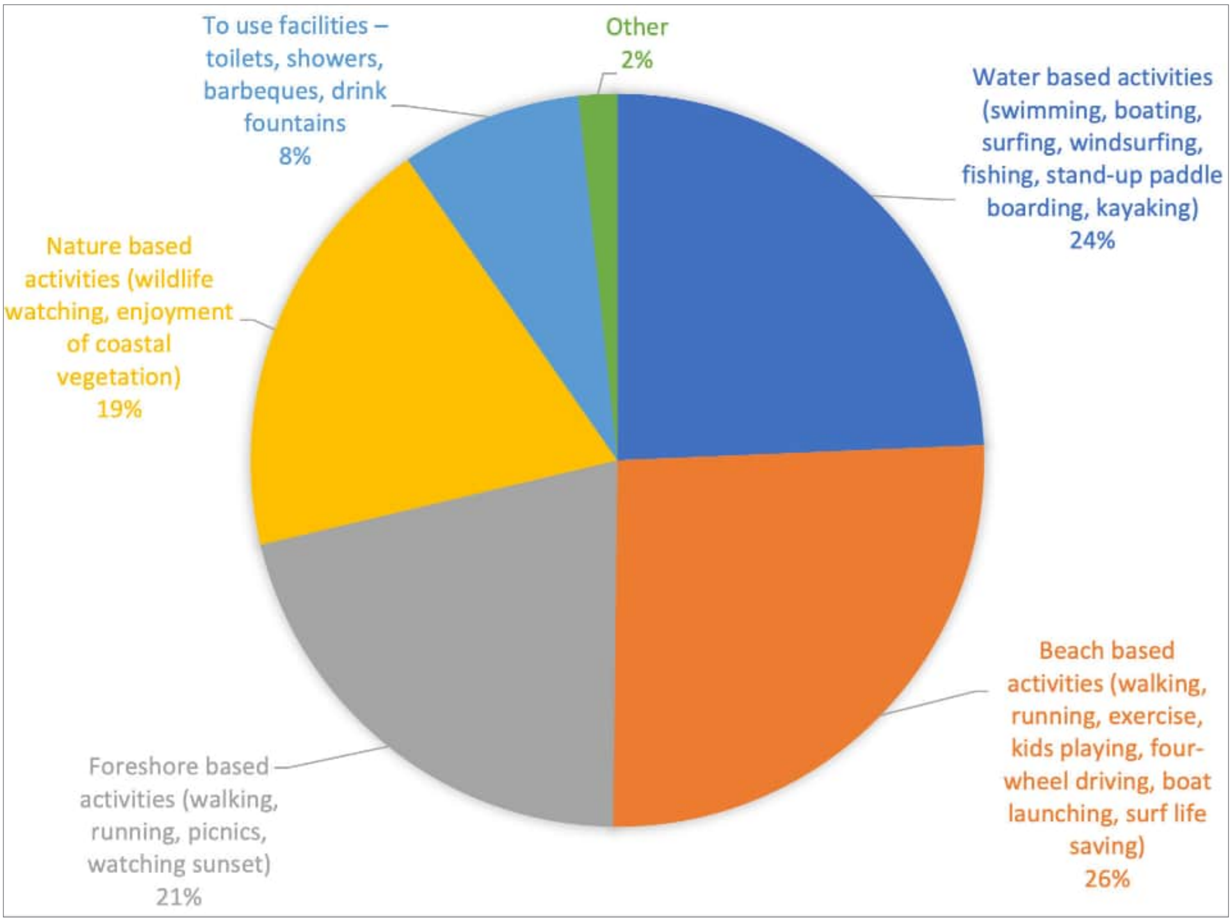


Figure 4 - Question 3

Q4 - How would you describe your understanding of coastal erosion and coastal flooding?

85 respondents (46%) had a general awareness of coastal erosion and flooding, 62 (34%) had a good understanding, and 26 (14%) had a very good understanding.

Nine respondents (5%) were uncertain about coastal erosion and flooding and one (1%) was not at alll aware.

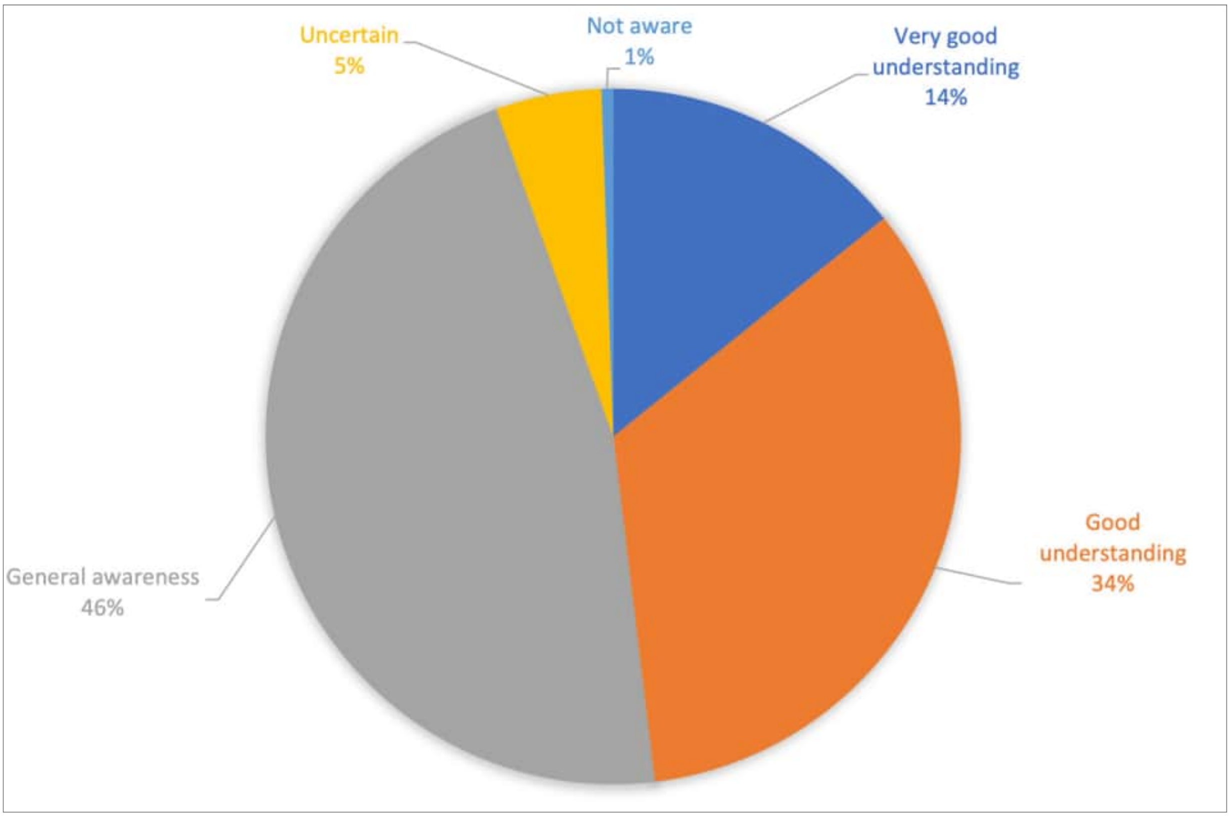


Figure 5 - Question 4

Q5 - What do you consider to be the most important values of the Capel to Leschenault project area?

Respondents were asked to rank a selection of 10 values in order of importance to them from one (1) to 10.

When averaged across all responses, the most important values to respondents were:

1. Preserving the natural environment and ecological ecosystems ;
2. Retention of natural landscapes not interrupted by human-made structures; and
3. Opportunities to use beaches for passive recreation activities (e.g. swimming and walking).

The ranking for all ten options are shown at Figure 6.

1. Preserving the natural environment and ecological systems
2. Retention of natural landscapes, not interrupted by human-made structures
3. Opportunities to use beaches for passive recreation activities (e.g. swimming and walking)
4. Ongoing provision of beaches and foreshore reserves for current and future generations
5. Ensuring that all residents and visitors are able to access the beach and foreshore
6. Conservation of heritage sites
7. Opportunities to enjoy the coastal landscape (e.g. viewing platforms and interpretive signage)
8. Opportunities to use public foreshore facilities (e.g. toilets, showers, picnic and BBQ facilities)
9. Opportunities to use facilities that support active recreation (e.g. boat ramps and jetties)
10. Opportunities to use for commercial operations that support the local economy (e.g cafes, jetties and tourism activities)

Figure 6 - Question 5

Q6 - On a scale of 1 to 5 (where 1 is strongly disagree and 5 is strongly agree), how do you feel about the following options for coastal management?

Respondents were asked to rate nine coastal management approaches from 1 (strongly disagree) to 5 (strongly agree).

These responses follow.

Preserve dunes, revegetate foreshore reserves and do not remove beach wrack (seaweed) to lower the risk of coastal erosion

A majority of respondents (100 strongly agree votes and 50 agree votes) were in favour of preserving dunes, revegetating foreshore reserves and not removing beach wrack.

Six respondents strongly disagreed and two disagreed with this management approach.

Three respondents didn't have a positive or negative view on this management approach.

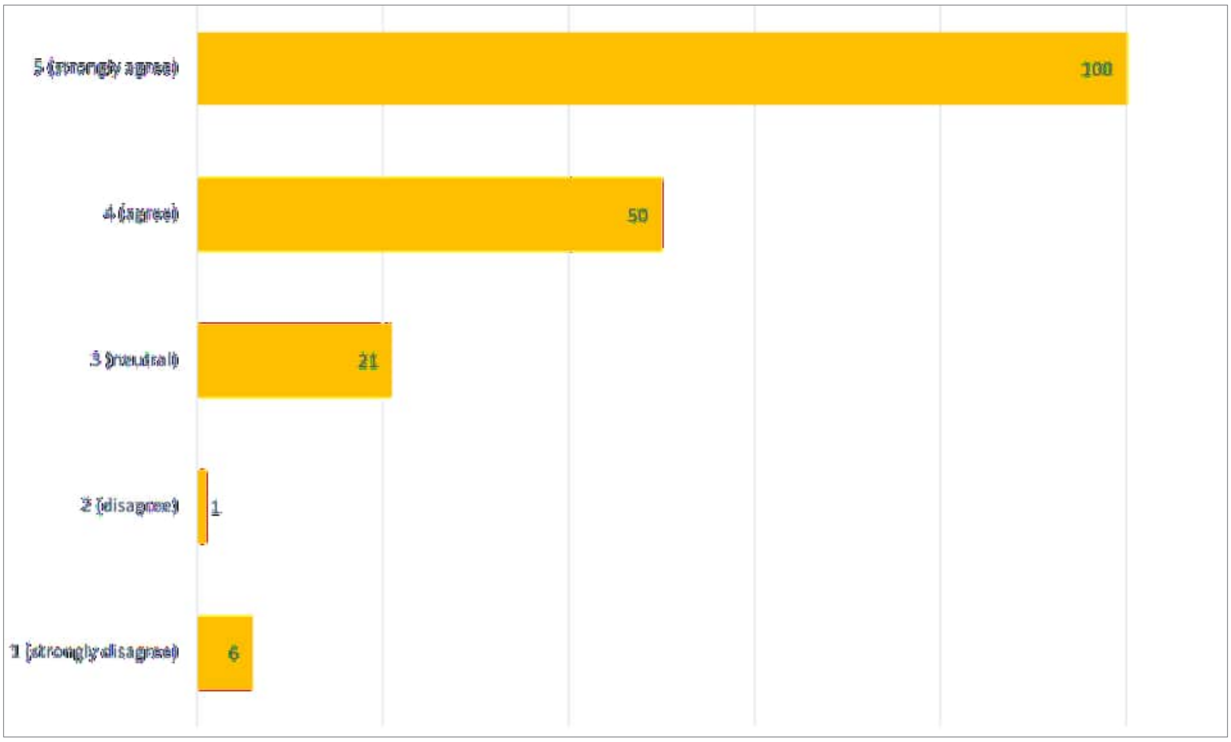


Figure 7 - Preservation to lower risk of coastal erosion

Landowners should be allowed to protect their property where they have demonstrated there will be no impact on the adjoining coast

76 respondents agreed that landowners should be allowed to protect their property where they have demonstrated there will be no impact on the adjoining coast.

This was the most favoured response, followed by 55 respondents who strongly agreed with this management approach.

Two respondents disagreed with this management approach, one strongly disagreed and three respondents were neutral about this management approach.

Figure 8 refers.

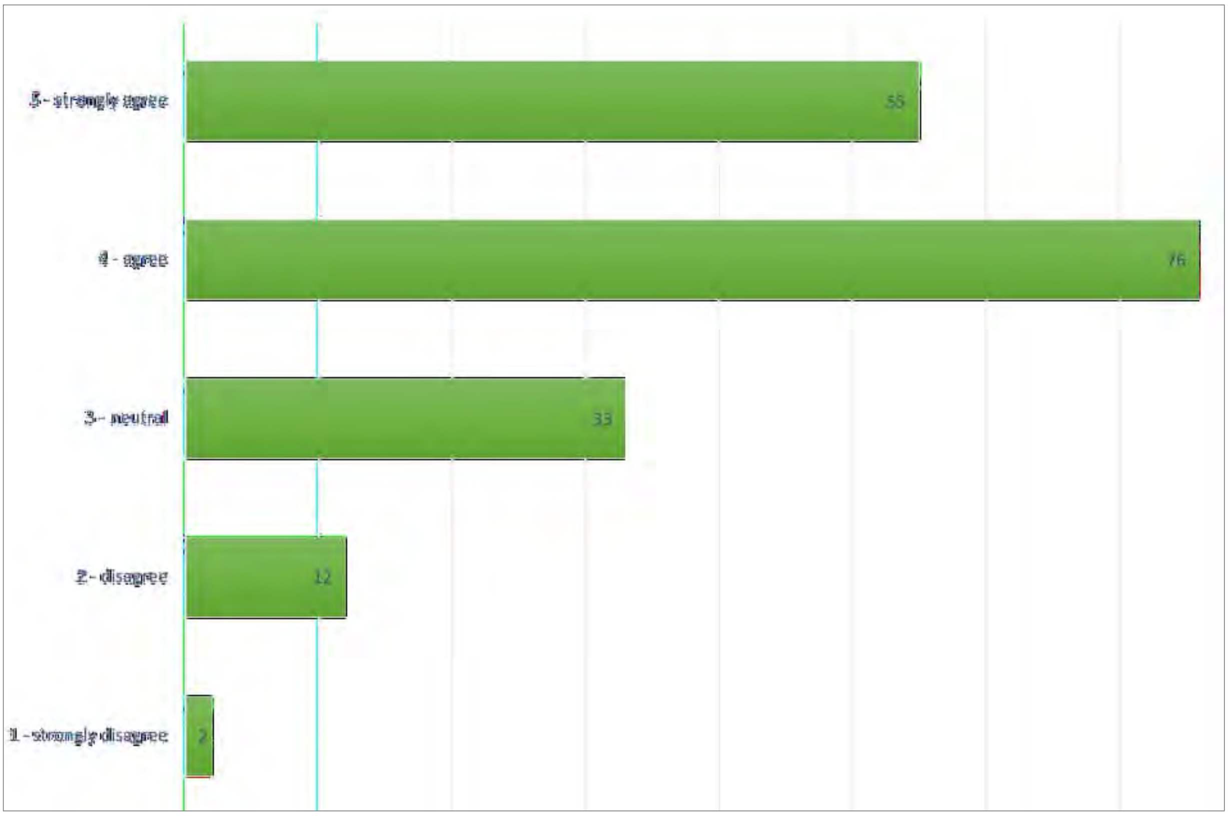


Figure 8 - Protect private property with demonstration of no coastal impact

Beneficiaries of protection works should bear the capital and maintenance costs of those works

Responses to this question were distributed broadly from strongly disagree to strongly agree. Percentages have thus been used to differentiate how respondents felt about this management approach.

33% of respondents were neutral about beneficiaries of protection works bearing the costs of these works. 28% of respondents agreed with the management approach and 15.8% strongly agreed.

9.7% of respondents strongly disagreed and 15.8% strongly agreed with the premise of this management approach.

The distribution of these responses suggest that this may require further discussion during the next engagement stage.

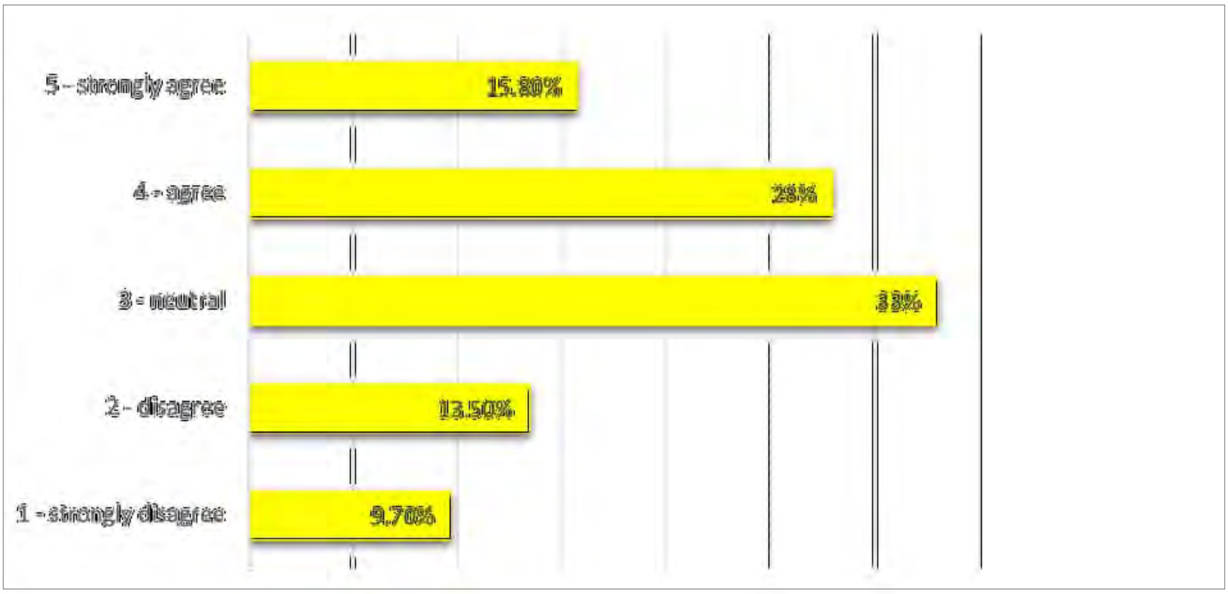


Figure 9 - Beneficiaries of protection works should bear cost

Protect private property from erosion, even if this results in the loss of public foreshore reserve and beach access

Responses to this question were also distributed broadly. Percentages have thus been used to differentiate how respondents felt about this management approach.

28.7% of respondents disagreed that private property should be protected from erosion even if it results in the loss of public foreshore reserve and beach access. 18.6% strongly disagreed with this management approach.

14.9% agreed and 12.8% strongly agreed with this management approach.

5% were neutral.

This response suggests that this approach should also be discussed further during the next engagement stage.

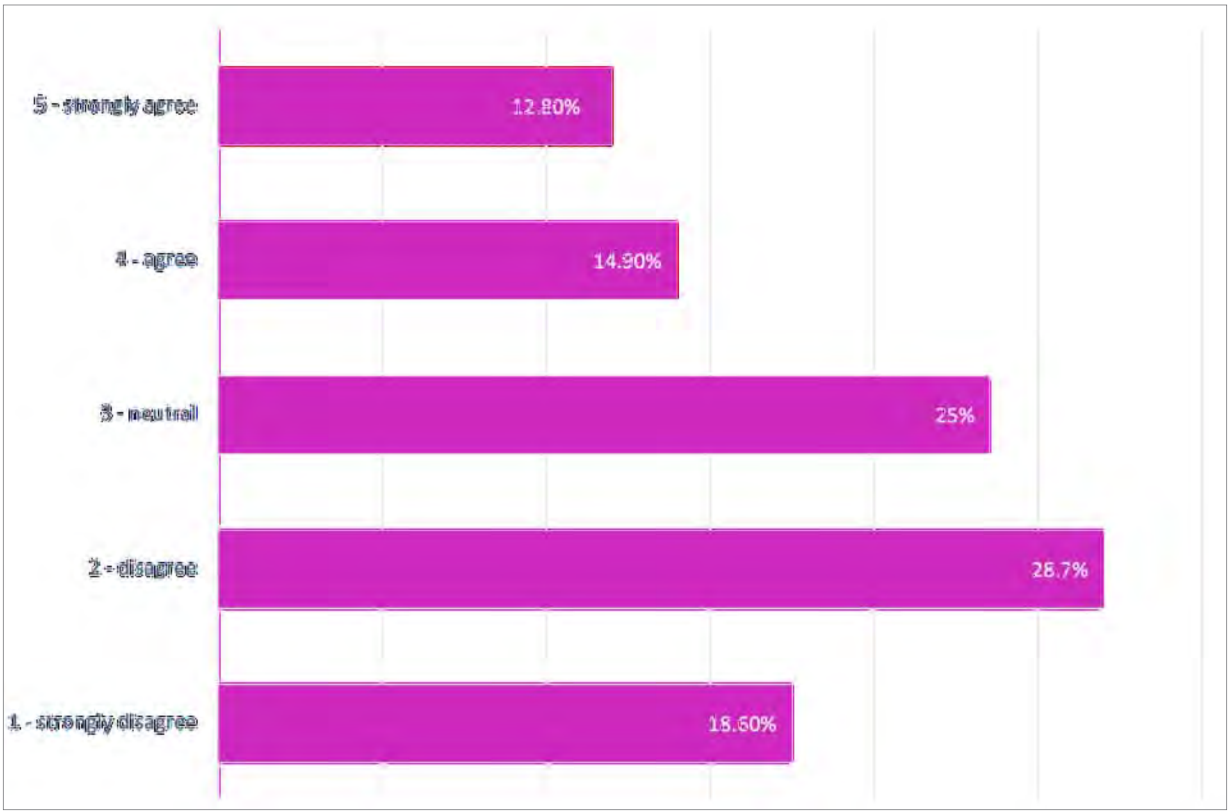


Figure 10 - Protect private property from erosion at all costs

Allow approved land uses in developed areas until erosion becomes intolerable

Respondents generally disagreed that approved land uses should be allowed in developed areas until erosion becomes intolerable.

65 respondents strongly disagreed with this management approach, and another 57 disagreed with it.

18 respondents agreed with this approach and 12 strongly agreed with this approach.

30 respondents were neutral.

This management approach will need further consideration ,and potentially discussion around how this might be progressed.

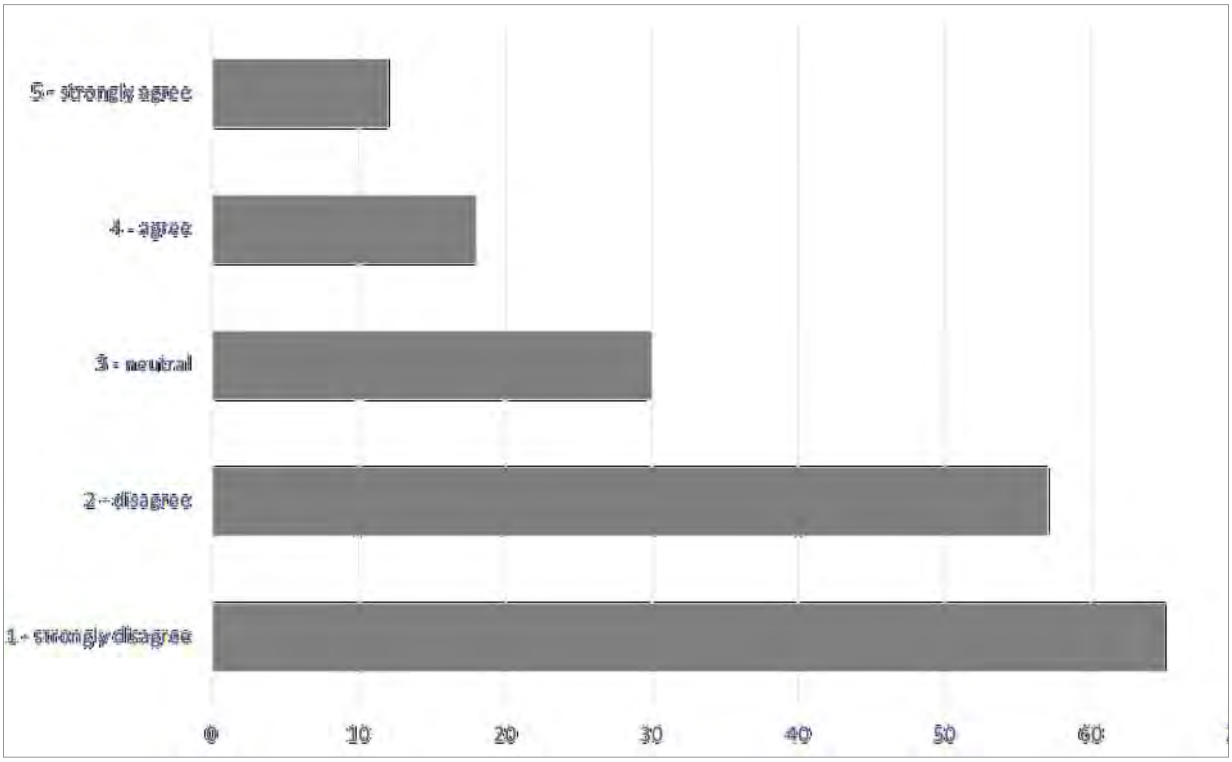


Figure 11 - Allow approved uses until erosion is intolerable

Retain public access to beaches and foreshore reserves and preserve coastal dunes and vegetation for future generations

There was strong agreement (115 polled for strongly agree and 49 polled for agree) from respondents about retaining public access to beaches and foreshore reserves and preserving coastal dunes and vegetation for future generations.

Only four respondents strongly disagreed with and six disagreed with this management approach.

Four respondents were neutral about this management approach.

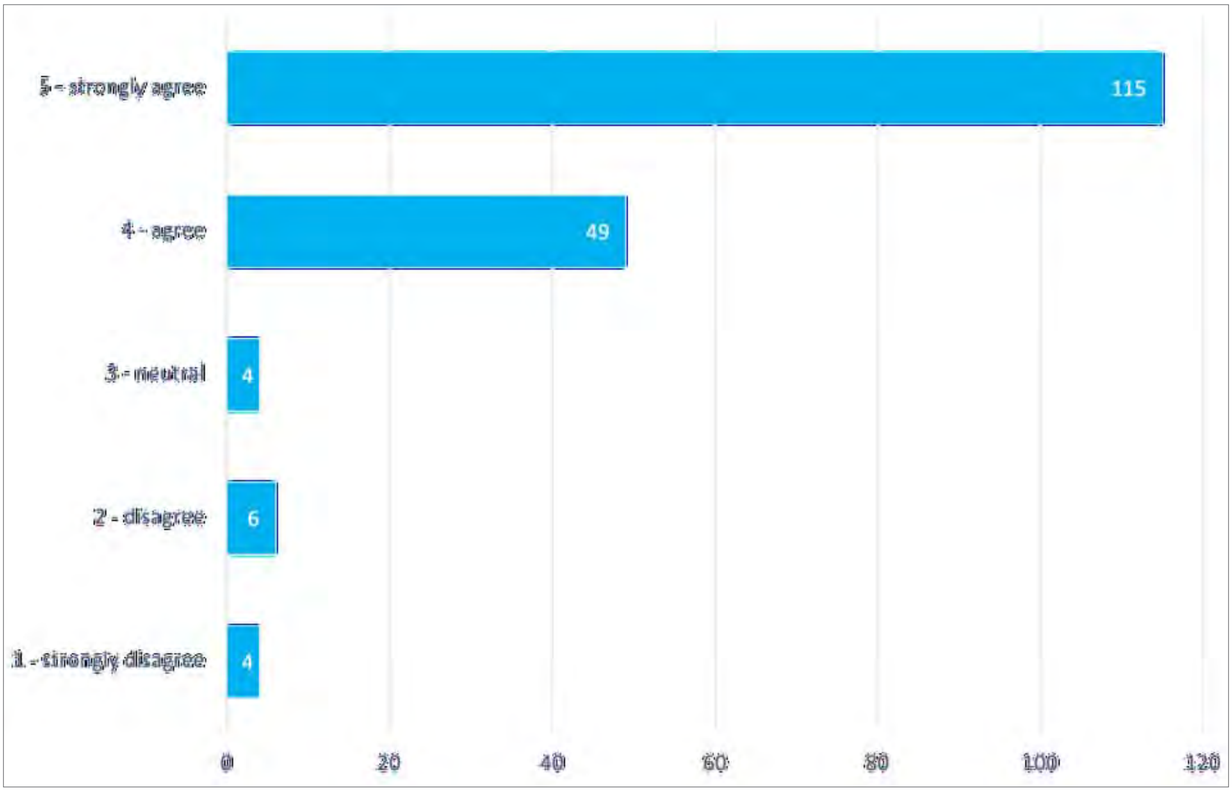


Figure 12 - Retain public access and protect dunes and vegetation for future generations

Relocate assets away from the coast and let natural processes take their course

This management approach also received a range of responses from stakeholders.

Of the 181 responses, 11% (20 votes) strongly agreed with the management approach and 26.52% (48 votes) agreed.

12.71% of respondents (23 votes) strongly disagreed with the management approach and 26% (47 votes) disagreed with it.

23.76% of responses (43 votes) were neutral about this management approach.

Relocation (retreat) is a complicated management approach and needs to be considered carefully against other community outcomes.

The project team will discuss this and other management approaches and the trade-offs involved with the community after vulnerability and risk profiles have been undertaken for the various coastal and estuarine assets in the study area.

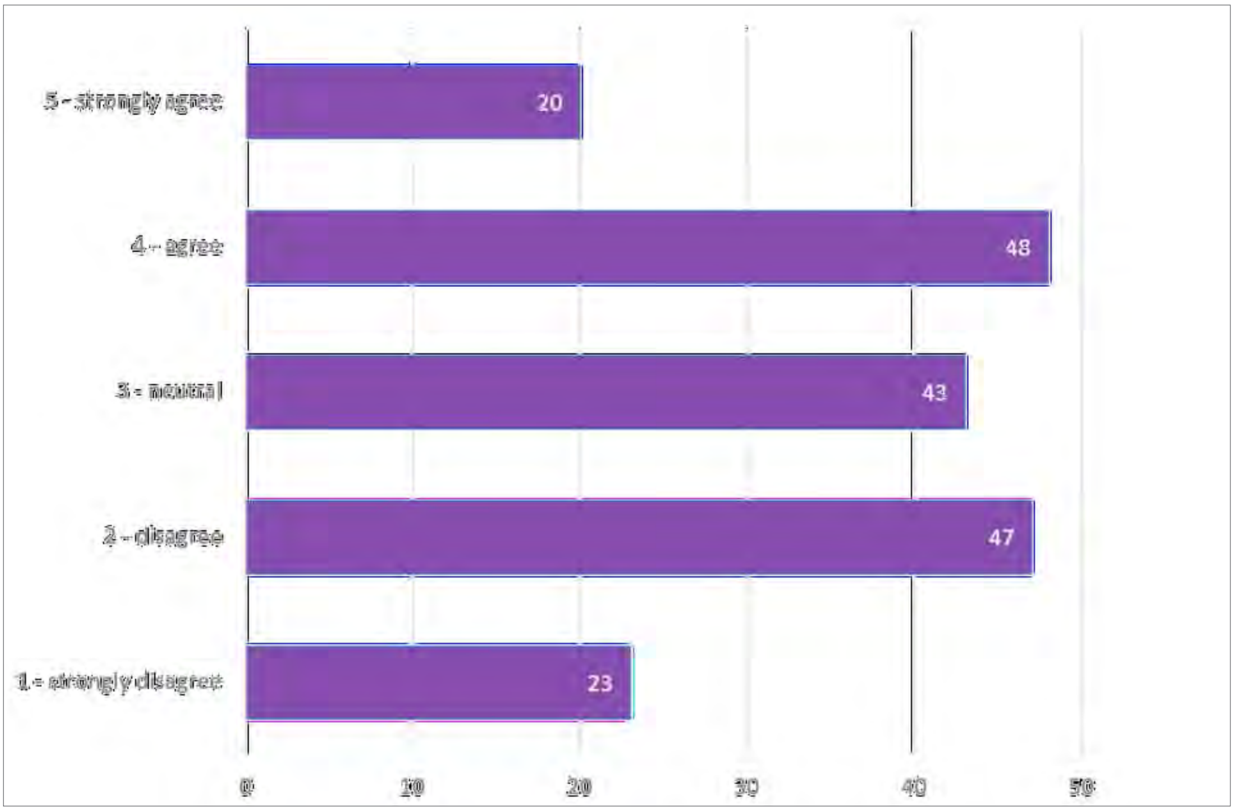


Figure 13 - Relocate assets away from coast

Do not allow more intensive development (such as units where there is a single house) in hazard areas

There was largely support for not allowing more intense development in hazard areas - 97 respondents strongly agreed and 56 agreed.

Six respondents strongly disagreed and seven disagreed with this management approach.

13 respondents were neutral about the approach.

This management approach will be discussed further when the project team consults with the community and stakeholders about adaptation options for the study area.

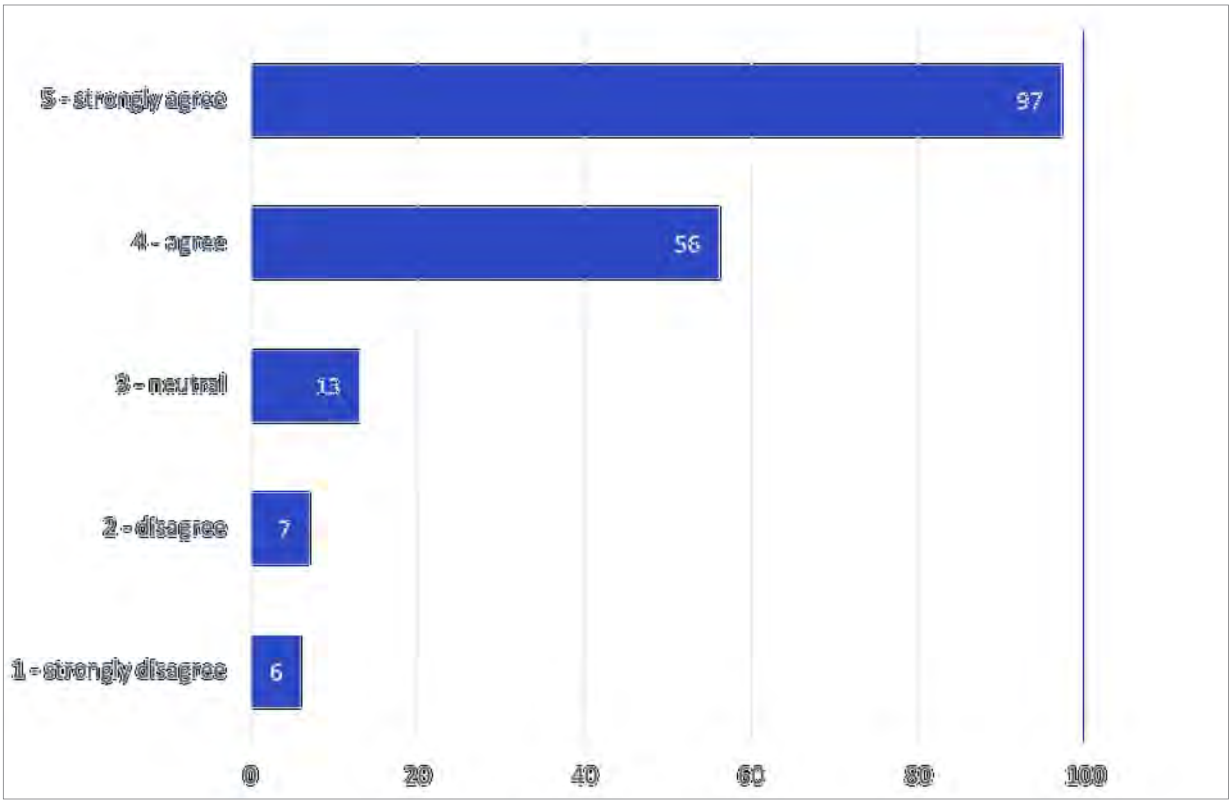


Figure 14 - Do not allow more intensive development in hazard areas

Private landowners should be informed about the risk of erosion when purchasing or developing in hazard areas

119 responses strongly agreed that private landowners should be informed about the risk of erosion when purchasing or developing in hazard areas.

53 responses agreed with this approach.

This was the vast majority of responses, with only three (3) polled strongly disagreeing with the approach, two (2) polled disagreeing and three (3) neutral polls.

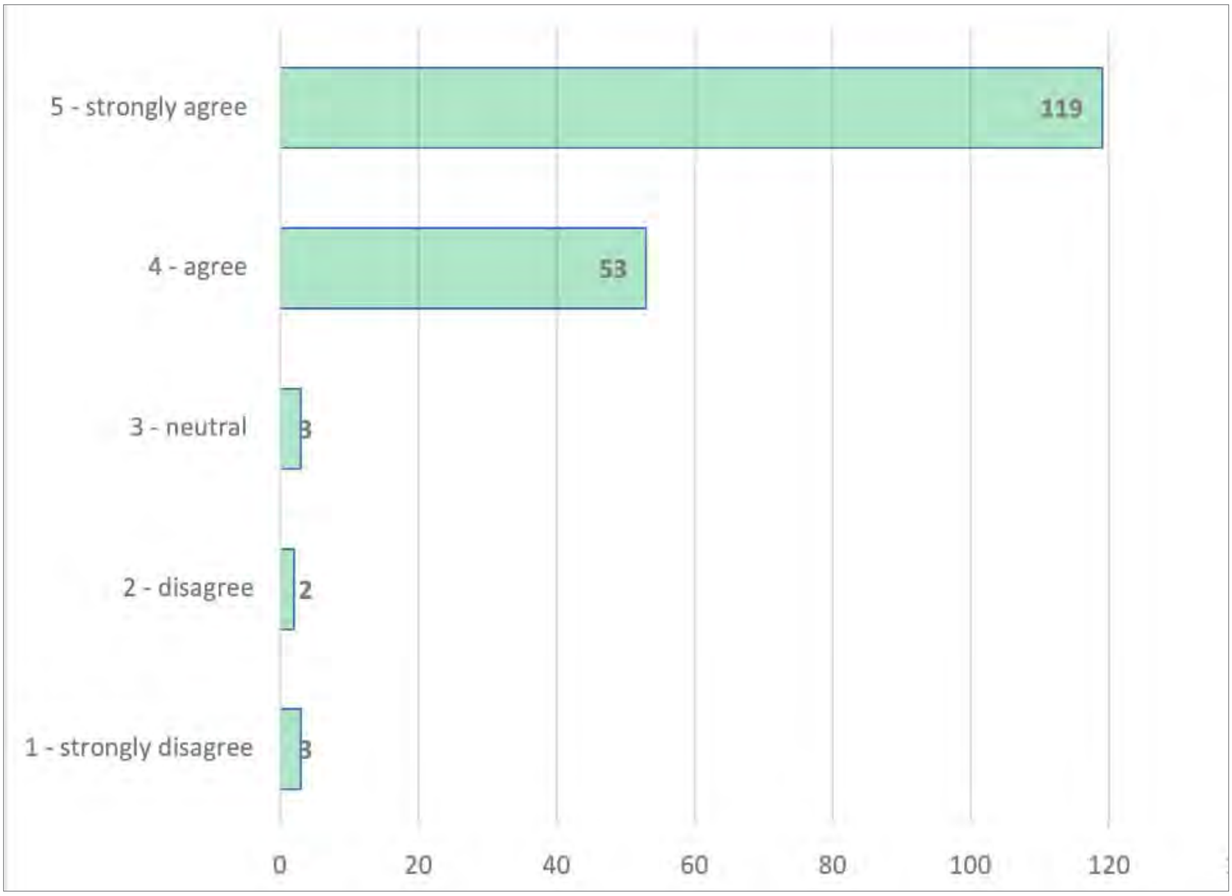


Figure 15 - Inform purchasers or developers of erosion risks in hazard areas

Q7 - How would you describe your connection to the Capel to Leschenault coast?

151 respondents to this question are landowners.

Nine respondents rent in the area, 16 are rate payers (own property but are not residents) and six work in the area.

six respondents are holidaying in the area.

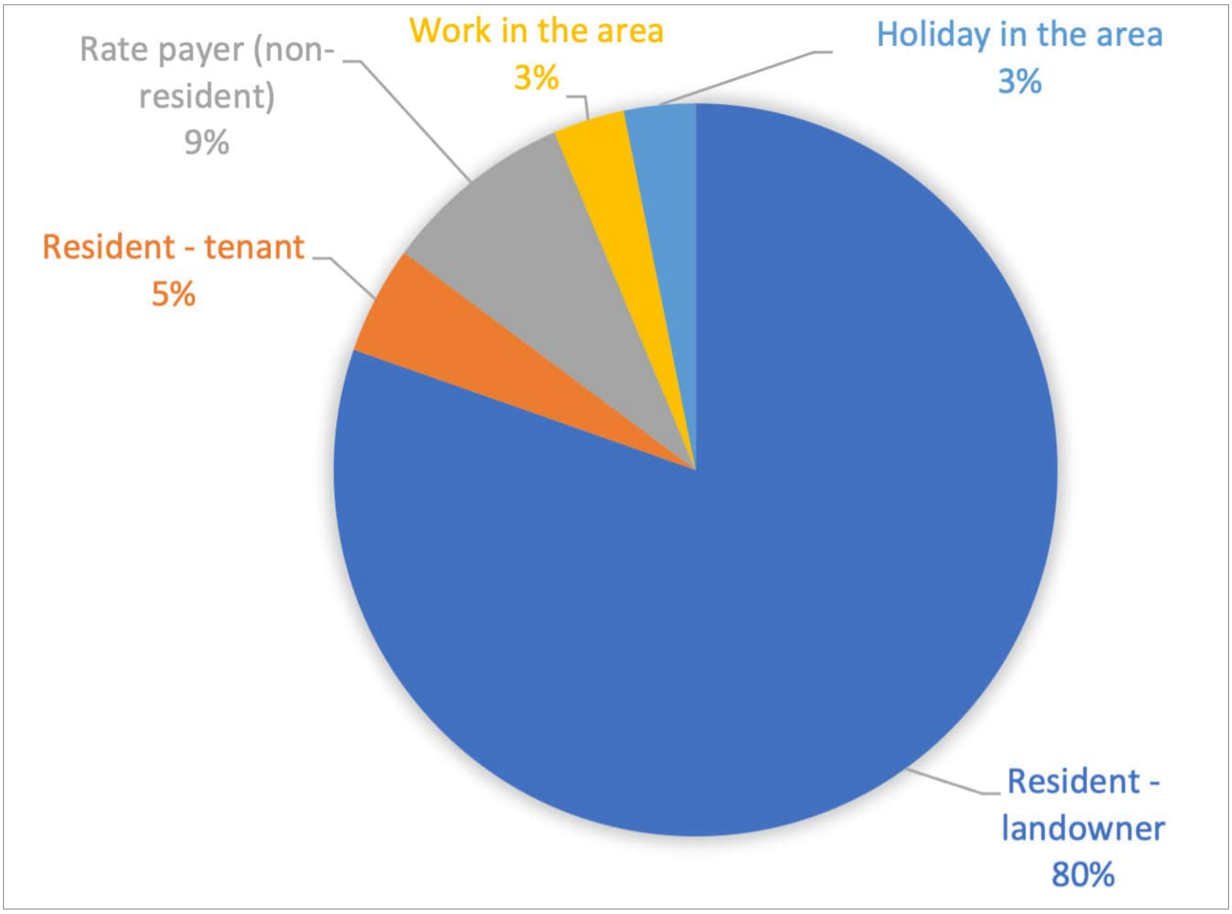


Figure 16 - Question 7

Q8 - How would you describe yourself?

81 survey respondents were female, 96 were male, one identified as non-binary and three said they would prefer not to say.

Q9 - What age bracket applies to you?

24% of respondents were 66+ years old.

32% were in the 56-65 age bracket, 20% were in the 46-55 age bracket and 12% were in the 36-45 age bracket.

7% of respondents were in the 26-35 age bracket, 1% (one person) was in the 18-25 age bracket and 1% (one) was in the 0-10 age bracket.

2% of respondents (six people) preferred not to say.

The overall sample of respondents is representative of the demographic population of the LGAs.

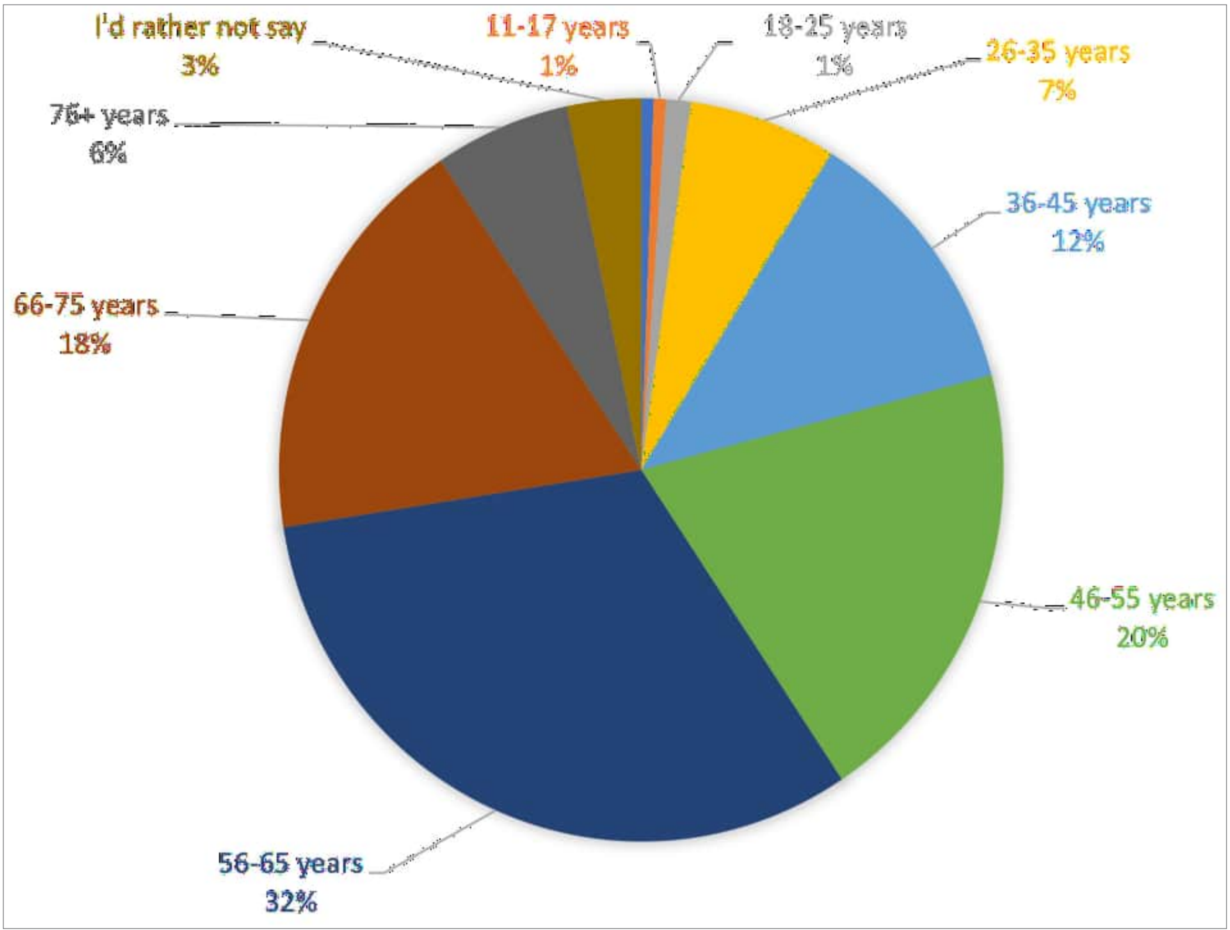


Figure 17 - Question 9

2.4 MAP AND COMMENTS

Respondents had the choice to place a 'pin' on a map provided on the project page and make a comment regarding that location.

Figure 18 illustrates the web portal mapping tool comments received. It shows where feedback was provided across a number of themes represented by the pin options.

A total of 56 comments were received on the interactive map. These were generally broadly distributed, with a larger clustering of comments around the Bunbury coastline and Peppermint Grove Beach in Capel.

The pins related to the following five category options:

- Water based activities (e.g. swimming, boating, surfing, windsurfing, fishing)
- Beach based activities (e.g. four-wheel driving)
- Foreshore based activities (e.g. walking, running, picnics, bbqs, watching sunset)
- Nature based activities (e.g wildlife watching, enjoyment of coastal vegetation)
- Something else/other (please describe)

Of the 56 comments received, these are broken down as follows:

- 15 water based comments - mainly discussing swimming, kayaking, and boating values
- Six beach based comments - with a few people discussing 4WDing, dog walking and exploring areas with the family
- 11 foreshore based comments - speaking to similar activities by respondents (walk/swim/cycle/walk dogs/watch sunset/watch wildlife)
- 14 nature based comments - largely around retention/ protection of vegetation and coastal landforms
- Nine something else/ other comments - these comments had a focus on the need for recognition of coastal erosion or protection of vegetation and the environment.

The breakdown of comments received in the different LGAs is outlined below:

- Harvey - 11 comments
- Bunbury - 27 comments
- Dardanup - three comments
- Capel - 15 comments

Key themes from the comments received are consistent with survey responses; these were around valuing the coastal and estuarine areas for activities like walking, swimming, boating, exploring with the family, and wanting to see/the need for retention of coastal vegetation and landforms and the protection of the environment.

Another strong theme was around coastal erosion and climate changes being observed by respondents.

The full list of unedited comments 'pinned' on the map can be found at Appendix A. These are broken down into the different LGAs.

Figure 18 - Interactive online mapping tool

3.0 WORKSHOP

A community workshops was held on Thursday 2 September 2021 from 5.30pm to 8pm. The workshop was a hybrid online-in person event, with the online and in person locations all linked to be run as a single session.

The in person locations were:

- Shire of Harvey Australind Council Chambers
- Shire of Dardanup Eaton Council Chambers
- City of Bunbury Council Chambers
- Shire of Capel Council Chambers

Participants nominated the location they would like to attend, with locations being hosted by staff from the respective Local Government.

Members from the consultant project team hosted the workshop online, supported by the project manager at PNP.

The workshop provided community members with the opportunity to establish and record their coastal values for their local areas and to let the project team know their issues and concerns.

3.1 WORKSHOP FORMAT

Facilitation was undertaken by Shape Urban and Water Technology presented coastal information.

At the start of the session, the project team provided attendees with basic information on CHRMAPs and coastal processes, the key coastal issues for each of the LGAs and what hierarchy of adaptation options, as provided for by the Western Australian Planning Commission's CHRMAP Guidelines (WAPC, 2019).

The project team also shared the draft key findings from the online engagement with workshop attendees.

The project team reminded participants about the coastal planning that has already been undertaken (context).

Following the presentation, the workshops comprised two interactive activities:

1. **Establishing coastal values** - workshop participants were asked to identify values important to them on a map at their table. Each location got a map that was focused on their LGA. Participants had to place blue dots on the map and link these back to numbers on a sheet. At the end of this exercise participants presented their established values back to the larger workshop group.
2. **Issues/ concerns** - the project team asked participants to mark on the same map (using orange dots) any issues or concerns they had along the coast or river frontages, or to identify things that have changed that affect them. Participants were asked to work together to create a comprehensive list. At the end of the activity, participants shared their feedback with the larger workshop group.

Section 3.3 discusses the outcomes of each of the activities.

The workshop presentation is at Appendix B.

3.2 WORKSHOP ATTENDEES

There was a total of 27 community member attendees at the workshop. In addition, members from the project team, PNP and LGAs also attended.

3.3 WORKSHOP OUTCOMES

3.3.1 Establishing coastal values

Participants were asked to think about a place that they loved to go to (in the coastal zone) and to write that on their sheet. They were asked to consider why those places are important to them, what they do there, and what physical aspects of the place are important to them.

The project team advised participants that these places and spaces can be any type of activity, e.g. an area for community use, an important cultural place, an environment that matters to them.

Participants at each location were given task sheets as templates to list these places and match numbered dots they placed on the maps.

The coastal values are broken down into the four LGAs. However, the comments and values cut across LGAs and should be read more generally to make up the study area.

Harvey

Valued places and activities, and why these are important to attendees are:

TBD

The mapped values for Harvey are at Figure 19.

The full set of unedited responses are at Appendix C.

Figure 19 - Coastal values exercise for Harvey

Bunbury and Dardanup

Important coastal values have been combined for Bunbury and Dardanup given responses on the night were marked beyond LGA boundaries. Additionally, there were only three attendees at the Dardanup location and one had to leave halfway through, so this combination of values gives a comprehensive understanding of coastal values for both LGA locations.

Valued places and activities, and why these are important to attendees are:

- Nyadup Rocks (Rocky Point) for surfing through autumn/ winter/ spring (#10)
- Northern end of Back Beach (#12)
- The Outer Harbour (inside the Port area) for surfing through winter and fishing; Dalyellup Beach for the surf club, swimming and fishing; Big Swamp for walking and running; Koombana Beach for swimming and dining (#9)
- Bunbury Cut for surfing, fishing, jet ski use, feeding point for dolphins (#4)
- The beach In the northern section of the Seabird coastline - very important to families and kids and is a regionally accessed beach (#11)
- BP Groyne for surfing and swimming (#14 and #15)
- The Bay for surfing, swimming and fishing (#16)
- Leschenault Inlet for running, walking, cafes, bird watching (#18)
- Pelican Point - important for migratory shorebirds (#52)
- Leschenault Estuary as one of the main coastal wetlands in the area with high environmental value (#21)
- Beaches and dune systems in Back Beach, Belvedere Peninsula, Dalyellup Beach, Peppermint Beach - habitat for diverse species of coastal animals and protection from impacts of sea level risk due to climate change (#23 and #24)
- Hungry Hollow for recreation (#48)
- The mouth of the Collie and Preston rivers - prime feeding areas for migratory shorebirds (#41)
- Bunbury Port (#30)
- Quindalup dune system and its ecology (#34)
- Manea Park for walking, flora and fauna, photography, orchids (#30)
- Tuart forest - a peaceful place to run and walk, unique vegetation and fauna (#112)

Other comments related to locations that people wanted to see protected in response to sea level rise and that people valued for environmental reasons.

The mapped values for Bunbury are at Figure 20.

The full set of unedited responses are at Appendix D.

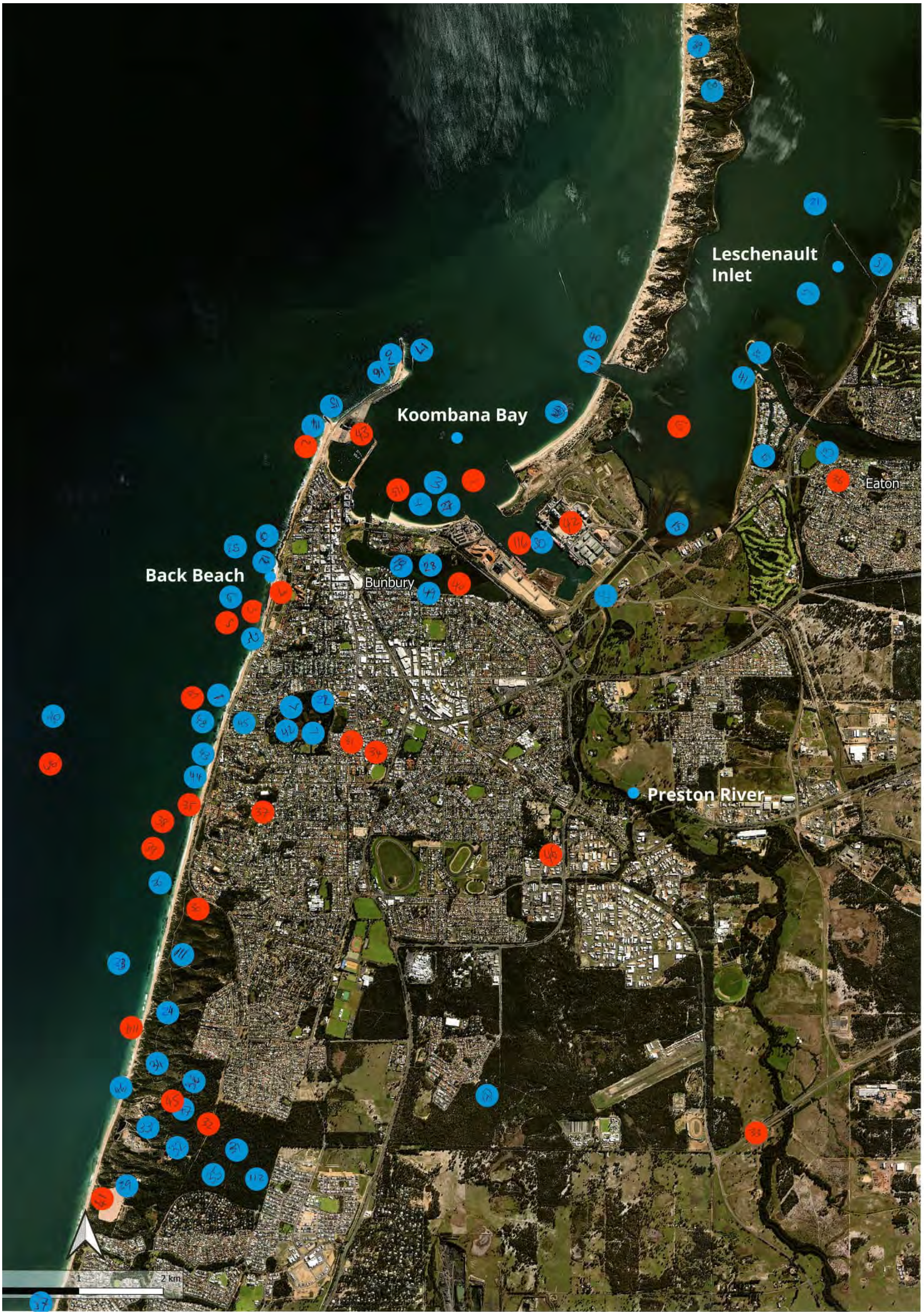


Figure 20 - Coastal values exercise for Bunbury and Dardanup

Capel

Comments made at the Capel workshop also cover some of the Bunbury LGA.

Valued places and activities, and why these are important to attendees are:

- Peppermint Grove Beach for running, walking, swimming, fishing (#B2)
- Stratham Beach for water sports, fishing and walking (#3)
- Back Beach for watersports, walking, surf life saving(#2)
- Ocean Drive for driving to work and cycling for exercise Good swimming near the lookout at the northern end of Lancelin (#2)
- Dalyellup Dunes - access to beach, however has been reducing over years - insufficient action to protect the dunes (#4)
- Tuart Forest - environment, walking, wildlife, trees (#B1)
- Capel Coast - concerns about contamination on the coast (#J2 and #J3)
- Capel Coast - sensitive Aboriginal history (#J2)
- Dalyellup Beach and Parks - 4WDing (#D5)
- Between the ocean and the drain if there is a blow out there is loss of land) (#81)
- Capel River Wetlands (Mallokup Wetlands) - important home for water birds and other communities, high aesthetic value, rich organic adjacent agricultural land (#CRW)
- Beach north of Capel River mouth - last ‘wild’ coast with reef and near shore snorkelling, bird watching, cray fishing - narrow beach needs protection from 4WDs (#P1)
- Capel River mouth and beach for walking, swimming, taking visitors to see it (value the scenery and bird life) (#B1)
- Minningup Beach for walking, swimming, value scenery and bird life (#B2)
- Stirling Wetlands - importance of historical swan nesting, vegetation for swan nesting - need for fox control (#B3)

Other comments related to revegetation by community members at Peppermint Grove Beach and observations that for the first time a primary dune has been ‘blown out’ (#77) .

The mapped values for Capel are at Figure 21.

The full set of unedited responses are at Appendix E.

Figure 21 - Coastal values exercise for Capel

Summary

The workshop identified some key coastal values for the LGAs - namely:

- Beaches and estuarine areas for activities like walking, swimming, exercise, views, fishing, surfing, 4WDing
- Wetlands and environmental areas for their flora and fauna diversity which participants could view. These places were also used for views, walks and to enjoy the scenery.
- Vegetation retention and revegetation and the need to do more to protect coastal areas from erosion came up multiple times in the different LGAs.
- Environmental protection was generally very highly valued.
- Sea level rise and climate change was also a key discussion point at the workshop, with participants wanting to see more done in this space.
- Appreciation of wildlife at various locations and the need to protect habitat for these community and species to continue to frequent these locations.

These reasons *why* workshop participants value various features provide better understanding and insight to assess what assets have the greatest need or priority for adaptation and management.

3.3.2 Issues/ Concerns

After the initial task to establish coastal values, feedback was shared by each workshop location key values were discussed. The discussion included participants' issues and concerns about some of the values and the risks participants saw to those values remaining.

The project team then asked participants to comment on issues or concerns about the coast or river frontages, or to identify things that have changed in those areas that affected participants.

Similar to Task 1, participants were asked to list issues, number those issues and then place an orange 'dot' with the same number on the same maps they had used for Task 1. Figures 19, 20 and 21 refer.

Harvey

Issues/ concerns or things that have changed that affect participants are:

- TBD

The mapped values for Harvey are at Figure 19.

The full set of unedited responses are at Appendix F.

Bunbury and Dardanup

Issues/ concerns or things that have changed that affect participants are:

- Beach erosion - eroding of sand dunes, loss of sand. Also loss of infrastructure that supports enjoying the beach and natural environment e.g. beach stairs closed off (#114)
- Beach erosion 2 - drop in value of properties - massive impact to the natural assets of Bunbury (#114)
- Seagrass - the amount of seagrass that is ripped up and deposited on the beach during storms - the loss of seagrass beds (#3)
- The Port - the effects of the port activities, like tankers coming in and out, pollution are of concern - possible risk of inundation at the port and what this would mean for Koombana Bay and the dolphin population (#116)
- Groundwater and soil contamination from the Port (#42 and #43)
- Sand movement changing ocean conditions (#5)
- Sand through carparks and gardens (#7)
- Climate change causing stronger storms causing more damage (#3)
- Pollution in the Estuary (#6)
- Estuary is critical for migratory shorebirds especially
- Impact of 4WDing on beaches
- Hungry Hollow - very little beach to walk on or swim at - worried about increasing visitors and the human and storm impact on beaches, paths and vegetation (#47)
- Destruction of natural coastal wetlands that protect from extreme events (#48)
- Contaminated lands and highly contaminant industries close to the coast (#48)
- Contaminated sites - Dalyellup Waste Residue Disposal Facility and its close proximity to the high tide line and housing development and the drinking water extraction site (#41)
- Biodiversity loss (#32)
- Habitat loss (#30)
- Urban sprawl inland (#33)
- Loss of access to beach for recreation (#35)
- Loss of cultural sites (#36)
- Human impacts e.g. litter, human movement through planted areas, development close to beach, pollution (#39)
- Impact of marine based developments on health of waterways and marine fauna (e.g. flushing of inlet) (#40)

The mapped values for Bunbury and Dardanup are at Figure 20.

The full set of unedited responses are at Appendix G.

At the Dardanup location, two of the three workshop participants spoke to the local government project staff about their concerns about possible pollution and contamination along the coastline that may impact on the groundwater quality.

Capel

Issues/ concerns or things that have changed that affect participants are:

- Human impact e.g. Driving on the beach and making new tracks through dunes. This combined with more adverse weather events is causing major erosion of dunes that protect inland vegetation and homes etc (#14)
- Dalyellup - lack of education about coastal erosion or signage/ fencing to limit erosion by informing (#A)
- Dalyellup - due to erosion from residents and storms there is a need to help re-establish vegetation to help stabilise dune systems (#B)
- Dalyellup - loss of access to beach during winter and erosion of dunes (#C)
- Shire has drainage on to beach which backfills and causes erosion (#B1)
- Wetlands and farmlands becoming saline due to drains left open at Capel River (#B2)
- Peppermint Grove Beach - primary dune attacked for the first time in 50 years (#77)
- Recognition of multiple ownership (private, government, unallocated Crown land, public open space) and how we can get them to work together
- Salt water ingress through the cuts (#PA1)
- Salting land - salinity (#PA2)
- Elimination of beach/ habitat in relatively wild coastline (#PA3)
- Capel/ Stirling Wetland inundation north and south of Capel River - need to protect bird life especially swans (#B2)
- Tuart Forest National Park still capable of natural regeneration if kangaroos kept out - also, underground water level has dropped due to sand mining projects and quotas for farming, which affects forest vegetation (#B3)

Summary

The workshop identified some key issues/ concerns across the LGAs - these are:

- Beach erosion and its environmental, social and financial impacts
- Contamination and pollution impacts from the port at Bunbury and other industrial activities along the coastline on fauna and flora and the health of waterways
- Destruction to coastal wetlands that protect from extreme events and that are home to birds and wildlife
- Biodiversity and habitat loss
- Human impact on the coastal and estuarine natural assets and values to the community

3.3.3 Other - Workshop Questions

Workshop participants across the four LGAs asked the following questions at the workshop. Project team responses are provided in italics below each question.

Are erosion and inundation the only two major risks?

The coast is shaped by many forces - the ocean, the wind, the structure of the rock and earth along different parts of the coast, and the impact of people and their activities. Coastal landscapes and risks to these therefore are a result of a combination of erosion, inundation, transportation (of coastal materials) and the impacts of humans on those coastal areas.

Climate change and sea level rise are also a risk to coastal areas.

How do you factor changes with time, flexibility in options for climate change?

State Planning Policy 2.6 - State Coastal Planning Policy (SPP 2.6) factors in a mean sea level rise of 0.9 metres over 100 years. The technical personnel from the project team will establish the sea level rise for the study area as well as vulnerabilities, levels of risk and triggers, all of which will assist with putting in place planning measures to address these risks.

Aware of any planning responses for shires that have already have CHRMAPS completed e.g. Wanneroo?

Yes, the project team has worked with other LGAs that have prepared CHRMAPs with differing planning responses to suit locations, level of risk and triggers. They will use this information as well as work with the community to develop planning responses that are appropriate for the study area requirements.

Sites are at risk from erosion and inundation. The list of the state's contaminated sites is on the Contaminated sites Register held by DWER. The interaction of ingress of sea water into contaminated groundwater at these sites could have significant impacts on contamination migration, potentially impacting Priority protection zones for drinking water areas that currently exist in the project area. As there are a number of registered contaminated sites within the project area, will the CHRMAP be considering specific impacts to these sites as a matter of importance due to the increased public and environmental health risk of impacts to these sites?

Yes, the project team will factor this into the CHRMAP process and, working with the community, propose responses that are appropriate to the study area.

Why the problem, climate change, is not included in the website introduction of the project and also it's mention like 15 minutes into to explanation of the project in the workshop? Climate Change is the problem. We are trying to adapt to the impacts, but the problem is climate change. It is important to be transparent with the community.

This has now been updated on the website. Climate change is explicit in the CHRMAP guidelines and used as a basis for determining the vulnerability and risk analysis.

Why traditional owners are not present in the workshops? Are the aboriginal heritage areas being considered and protected?

The project team are speaking to Traditional Owners separately, to establish their values and concerns in the study area.

To evaluate the risk, will storm surges and extreme sea events be considered together with SLR? Having in account that extreme events occurrence rate is increasing due to climate change.

Yes, the project team will consider these events as part of its coastal assessment.

Explain the rationale of combining areas for the CHRMAP in the face of different characteristics.

The PNP is working with four of its LGAs (Harvey, Bunbury, Dardanup and Capel) to prepare this CHRMAP in accordance with the requirements of SPP 2.6 and the State Coastal Hazard Risk Management and Adaptation Planning Guidelines (2019).

The study area is being broken up into management units (MU) that will represent a similar coastal landforms and locations so that each MU can be assessed according to associated risks and vulnerabilities, and according proposed treatments/ solutions can address specific contextual requirements.

Interest has been shown generally by the community in this stage of the planning - how will you get an idea of what is valued by those not yet paying attention?

The project team, the four LGAs and the PNP ran a range of engagement and communication activities to understand community value, including direct emails to hundreds of known contacts, social media posts, the PNP project website, the Social Pinpoint project page, community survey, and workshops to reach as broad a range of community members as possible about their values.

Hard copy surveys were also distributed at a few locations in the LGAs.

There will also be additional opportunities to be involved and provide feedback as part of this project - feedback on this engagement report, direct feedback to the LGAs, by email and on social media.

We encourage you to provide us with feedback on any values in the study area you don't believe have been covered in the engagement report. These values will help inform Stage F - Risk Evaluation and Stage G - Risk Treatment.

Updating FAQs

These questions and responses will be shared in the form of Frequently Asked Questions (FAQs) on the project website. The PNP and four LGAs will direct stakeholders and community members to these FAQs.

CONCLUSION

The engagement undertaken to date provides a strong understanding of what the community values in each of the four LGAs in the study area.

The multi-engagement approach has allowed for a thorough investigation of community values at different sections of the coastline.

There was strong alignment from stakeholders on coastal values and issues/ concerns, across the four LGAs.

This is centred around:

- Beaches and estuarine area values for activities like walking, swimming, exercise, views, fishing, surfing, 4WDing
- Wetlands and environmental area values for their flora and fauna diversity, walks and to enjoy the scenery.
- Vegetation retention and revegetation and the need to do more to protect coastal areas from erosion
- Environmental protection values
- Sea level rise and climate change concerns, and how this is being addressed by the LGAs
- Concerns around the impact of erosion and its environmental, social and financial impacts
- Concern about contamination and pollution impacts from industrial activities along the coastline on fauna and flora and the health of waterways
- Destruction to coastal wetlands that protect from extreme events and that are home to birds and wildlife
- Biodiversity and habitat loss concerns
- Concerns about human impact on the coastal and estuarine natural assets and values to the community

All of the discussions regarding values and issues/ concerns, and suggestions by stakeholders to address the priority issues will help the project team develop a suitable draft multi-criteria analysis (MCA) process.

The content provided to the stakeholders introduces the community to the complexity of the decisions that have to be made to protect the values they love. This will include things like costs, lifetimes of adaptation options, impacts and other trade-offs like private versus public asset protection.

In the following stages, the feedback provided will enable the development of a robust assessment process in line with the community feedback, with a further opportunity for the community to influence outcomes later in the project.

In particular, Stage E will involve the project team working with the community and stakeholders to review identified risks and vulnerabilities, proposed treatment options, and community preferences for different adaptation options.

NEXT STEPS

This report summarises the preliminary engagement undertaken with the community as part of Phase 1 of the project to understand community values for the study Area. It included online engagement and a workshop that was in-person and linked online to increase the opportunity to attend.

The community's values , issues/ concerns and other stakeholder feedback received will be used to inform the development of a draft MCA process for the study area.

The project team will also be looking to schedule targeted meetings with identified key stakeholders as part of this preliminary engagement stage.

This report will be updated with these outcomes and the outcomes of additional engagement as the project progresses and the community values are translated into coastal assessments, trade-offs, risks and adaptation approaches for the study area.


2P
NO TICKET
REQUIRED

APPENDICES

- Appendix A: Map Comments
- Appendix B: Workshop Presentation
- Appendix C: Harvey Task 1 Comments
- Appendix D: Bunbury and Dardanup Task 1 Comments
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- Appendix G: Bunbury and Dardanup Task 2 Comments
- Appendix H: Capel Task 2 Comments

APPENDIX A

MAP COMMENTS - HARVEY

Comment Type	Comment
Water based	Crabbing, watch amazing sunsets
Nature based	Cycling from Australind next to the Cathedral Avenue is very enjoyable. This 'cycling' path could be extended to the Leschenault Peninsula and ultimately to the Cut.
Foreshore based	Swimming cycling walking dolphin watching
Beach based	4wdriving, take family up beach with dog for picnic, swim, relax, interact with wildlife
Foreshore based	My family and I are regular campers and visitors to this spot,at least twice a week for the last 20+ years, we travel via boat and camp via boat as well as it was originally a boat only camping, lately more 4wd area driving through the fence, which I often repair, it is these types of campers that are tearing up the camps and lighting fires, such as the one that got away last year & always leave rubbish, can the fence be repaired?? I'm willing to help anyway?
Nature based	This area has been underutilised for a long time and I think it sound be improved so that it can be used and appreciated by the complete community. This doesn't include a residential canal development that can be accessed by a select few.
Nature based	Important area to preserve as part of the Kalgulup Regional Park, for flora and fauna, but there are also opportunities for recreational development (e.g. walk paths and bird watching hut)
Nature based	Migratory shorebird feeding grounds
Foreshore based	I have great concern about all the blue metal rocks that have been dumped along the river bank in this area as I believe there are much better alternatives to blue metal rocks that are totally foreign to the area and greatly diminish the beauty as well as reducing the wildlife not only on the bank but most specifically the river! Was any impact studies done before doing this??? Is the shire planning to continue to do this???
Nature based	Nice area to walk. The bushland provides an opportunity to enjoy nature close to home. It would be great if a cycle path could be developed here connecting Collie River Park with the Paris Road bridge over the Brunswick River.
Nature based	Open space often grazed by kangaroos. The scenery and wildlife can be enjoyed from Eaton Drive. More area here should be spared from urban development and included in the Kalgulup Regional Park. Great opportunity to develop a cycle/walk path from Leicester Reserve to the bridge to Treendale through a wide open area.

MAP COMMENTS - BUNBURY

Comment Type	Comment
Nature based	Bird Watching
Water based	Swimming, running the dog on the beach, scurfing, cooling off in summer
Water based	Fishing with kids, running
Water based	Swimming cycling walking running dolphin watching
Water based	Fantastic for families! Would be great to have jumping platforms or more youth activities and options in the summer
Water based	Sailing at the yacht club - Launching boats off the sandy beach area.
Water based	Surfing/swimming
Foreshore based	Walking , Bicycle , Leisure relaxation and enjoyment of outdoors , nature observations , photography and studies inclusive of citizen science habitat ecology observations recorded on iNaturalist database for reference
Nature based	Ongoing nature photography , acquiring images , identification of genus and species , seasonal processes , habitat and ecology characteristics , also with observations recorded on iNaturalist database (CSIRO) for reference purposes , particularly terrestrial Flora and Avian , avian , insects , arachnids , and currently inclusive of Mosquito identification relating to Blood Borne Disease Vector research , as well as Mangrove (Avicennia marina) Seasonal observations throughout recent 2020 , 2021
Something else/Other	Citizen Science , ongoing observations and recording of seasonal cycles and growth of Avicennia Marina (Grey Mangrove) , recording of observations on iNaturalist database (CSIRO). The Mangroves are of international interest and currently of interest for research for Climate Change / Tidal Zones and Natural Carbon Management. A.marina is recognised as Estuarine/Tidal Zone growth and is supported interdependently in conjunction with the Tidal Wetlands , also under current ongoing observations
Beach based	Love this area and exploring the rock pools with the kids. There’s grass and vegetation on the sand/beach and it feels secluded and away from the road
Water based	Surf Life Saving Competitions, Swimming, Old Boys swim races, fitness training, surfing, paddling, body surfing, interacting with dolphins
Foreshore based	Walking , Beach , outdoor leisure, activity and relaxation , also intending to make inclusive of some nature observations in future.

Comment Type	Comment
Something else/Other	Fragile and narrow dune vegetation area, infrastructure in close proximity to ocean
Foreshore based	cycling running watching the sunset
Water based	Love this area for the family & Dog
Water based	Put an artificial reef here to help with dune erosion! It will provide ecosystem restoration on land and sea, and it will create surf and diving opportunities for commercial and pubic use. Why would you not?
Nature based	Kids love exploring here
Nature based	daily connection with nature
Water based	Swimming/surfing
Water based	Paddle ski
Foreshore based	Walking along the beach with my kids and dog is a daily activity fir my family
Nature based	Great place to walk and for other kinds of outdoor recreation. This is an ideal location for orienteering, which hopefully will be allowed again.
Something else/Other	Walking , outdoor activity leisure , enjoy nature and with ongoing local wetlands habitat ecological observations
Nature based	Local Nature Study and Research on coastal Wetlands Habitat Ecology , Observations inclusive of ongoing acquisition of Images , Identification of genus and species for Flora , Avian , Pollinators , Water Birds , including insects eg wasps bees. Observations recorded and listed on iNaturalist database for reference.
Something else/Other	Citizen Science , ongoing local Wetlands habitat ecology study and research , Observations inclusive of Images and Genus / species listings recorded on iNaturalist database for reference , Seasonal processes etc
Foreshore based	Walking , outdoor activity leisure relaxation and appreciation of natural habitat

MAP COMMENTS - DARDANUP

Comment Type	Comment
Foreshore based	With regard to the proposal for car park and road realignment, is it really necessary? I believe a better option would be to have no car parking there and all parking at the club and that area regenerated back to original bush to encourage more wildlife. As putting more cars there with parking leaning towards the river will encourage oil and fuel from cars to run directly to river and contaminate, there is ample space around the club for parking.
Water based	Paddling, admiring wildlife
Water based	I'd really like to see the health of the Collie River improved to a point whereby it could be used for purposes other than boating. Having lived in Eaton for the past 45 plus years I find it disappointing to have witnessed the gradual degradation of this waterway to its current level.

MAP COMMENTS - CAPEL

Comment Type	Comment
Foreshore based	Walking , MTB , outdoor leisure relaxation among nature
Nature based	walking running mountain biking watching wildlife and native flora
Something else/Other	Seriously worried that most of the residents in this area may not have taken note of the impact coastal erosion and inundation will have on the whole area , that they think it's just about the shoreline. People need to recognise that its crucial we encourage and support the shire to plan and make provision now, make sure we are building the resources, financial and otherwise, to take action so the lifestyle we enjoy can be protected by taking constructive and less invasive steps
Foreshore based	swimming walking/running on beach watching sunset and wildlife
Beach based	Vehicle access to (driving on) the Dalyellup beach is one of the most important things in my life and in many of my friends. It is the main reason why I life in Dalyellup. It is a myth that everyone can walk long distances on sand while carry things. To enjoy the beach and engage in activities like fishing paddle boarding etc. you have a few thing to transport like chairs and SHADE. Please leave the 4x4 access at Dalyellup as is. We are happy with the way it is now.
Something else/Other	Read a lot of scaremongering lately that only the particular patch of basalt in Gelorup (despite there being a big belt of basalt right through the SW) can possibly save us from inundation. This convenient position of people wanting the BORR out of Gelorup is damaging and misleading , ignores the range of constructive steps we should all be taking, infers all we can do is duck for cover behind a high hard wall.
Beach based	Such a special place to bring my dogs and unwind. An unspoilt, looked after beach area with a wealth of wills life to enjoy
Beach based	Read a big announcement in local press in May by Cr. Southwell that council had a plan to open up the "secret" beach coast between Dalyellup and Forrest Beach for cars to drive along etc etc. He said the plan would come to council in JUne. So far, thank heavens, it hasn't. No-one else in the shire seems to know anything about it either, except the May press splurge. Hopefully such a plan will be subject to the planning you are doing. It seemed to have quite opposite intentions.
Nature based	Reef snorkelling
Beach based	swimming snorkelling wildlife watching

Comment Type	Comment
Something else/Other	Parts of these wetlands at Mallokup are at sea level in height with very salty water located at shallow depths below. They will likely further increase in salinity. New management options and development restrictions in low lying areas needs to be considered.
Water based	kayaking
Nature based	From Mt Stirling lookout you can see bird filled wetlands, the world's best Tuart forest and the famous coastline from the tip of the Geographe bay, along the Busselton coastline to the dunes of Bunbury.
Something else/Other	We are all so used to the road and drainage infrastructure through the low wetland areas behind the sandhills that we take it for granted, we think it's all about the shoreline. If there is not planning to maintain and meet challenges to infrastructure through rising water levels, then the issue wont be about recreation, we just plain won't be able to live there.
Something else/Other	This is the site of the Higgins Cut, an attempt some 120 years ago to divert water from the Capel River into the ocean. The mouth of the cut silted up very quickly but it now poses a risk to the farmland inland as a rising sea could cause erosion of the mouth of the cut and allow large volumes of seawater to flow inland

APPENDIX B

WORKSHOP PRESENTATION

CAPEL TO LESCHENAULT COASTAL HAZARD RISK MANAGEMENT ADAPTATION PLAN (CHRMAP)

VALUES WORKSHOP
SEPTEMBER 2, 2021

1

Welcome!

2

This meeting is a bit different!

Your local team will look after you and make sure the feedback is shared – your 'Host' will have welcomed you

The consultant team is online:

Shape Urban - Anna Kelderman

Water Technology – Joanna Garcia-Webb

3

Welcome

A spot of housekeeping….

- Mobile Phones
- Bathrooms
- Emergency procedures
- We will be recording this session so that others can review – please advise your 'host' if you would like us to us to obscure you when we complete the recording
- Try and be COVID safe - keep 1.5m away from others if possible, use the hand sanitiser, and please make sure you practice good hygiene if sneezing!
- Write down as much as you can!

4

Introductions

Who are you?

Where do you live?

What is your main interest?

5

6

What are we doing?

7

Our Remit

Our coast is highly valued. It provides places and spaces to live, do business, be active and enjoy.

However, the coast is vulnerable to natural coastal processes such as waves, storms and sea level rise, and to the changes that people make to the coastline (buildings, hard coastal structures and dune/beach changes).

As the coastline begins to change, it can impact the infrastructure in the 'coastal zone' and how the coast can be used.

8

Some coastal planning has already been done…

- Koombana Bay CHRMAP (2019) - will be considered in the context of the broader CHRMAP
- *Shire of Harvey Ocean coastline (north of the Cut, Belevedere Beach and Binningup etc)*
  - *Not part of this project study area*
- PNP Coastal Monitoring & Other Studies in Project Area
  - Considered and included in analysis in this project

9

Our Remit

The CHRMAP will establish adaptation options that balance the values and needs of the community along the ocean and river front coastline and consider economic, social and environmental considerations

10

Why are we doing the project?

This project will help us to understand 'coastal hazards' and 'risks' that may impact the coastal zone in the future and what the options are for managing those

The coastal zone for this project includes the coastline and low-lying areas around the Leschenault Inlet and Estuary and associated rivers including the Preston/Collie River.

11

CHRMAP…

What on earth is a CHRMAP??

- Coastal Hazard Risk Management Adaptation Plan
- Hard to say…
- Char-map, Cher-map, croomp, adaptation plan

12

CHRMAP…

A strategic plan to meet *coastal hazard challenges…*

- Identifies vulnerable public and private assets
- Aims to preserve community values for current & future generations
- Informs community and decision makers
- Required under *State Planning Policy 2.6 – Coastal Planning*

A plan for the next 100 years

13

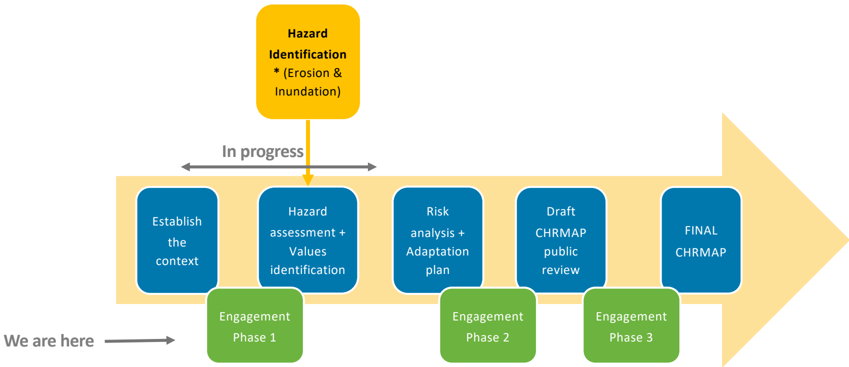
CHRMAP…

The key components of a CHRMAP are:

- Understanding the local environment and community values
- Assessing how much things can cope with the impact of climate change
- Identifying the risks (likelihood of an event occurring and the consequences of that event occurring)
- Analysing the findings and evaluating the management options
- Identifying the adaptation options
- Identifying funding options, monitoring and review of frameworks

14

CHRMAP…



15

Coastal hazard challenges

The key challenges on the coast are **erosion** and **inundation**

Predicted Sea Level Rise will increase both!

16

Sea Level Rise

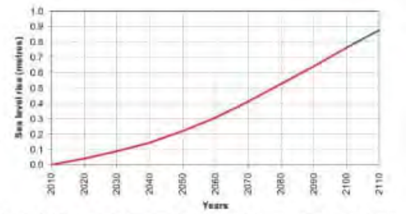
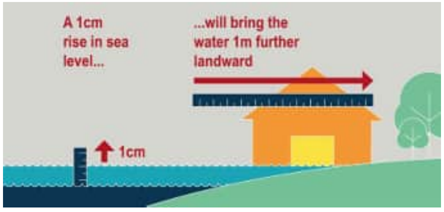


Figure 16 - Recommended allowance for sea level rise in coastal planning for WA (red line SRES scenario A1FI 95th percentile after Hunter (2009), normalised to 2010, blue line continuation of scenario to 2010)



17

Risk

18

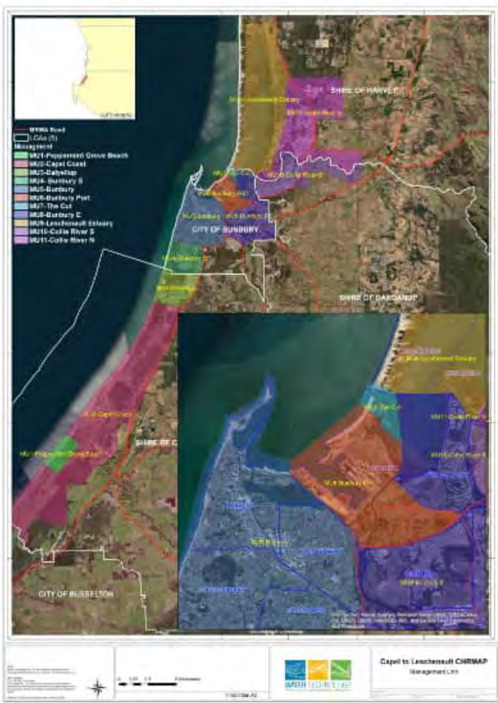
Vulnerability

19

Hazard Identification

Predicting the *risk* of **erosion** + **inundation** with sea level rise

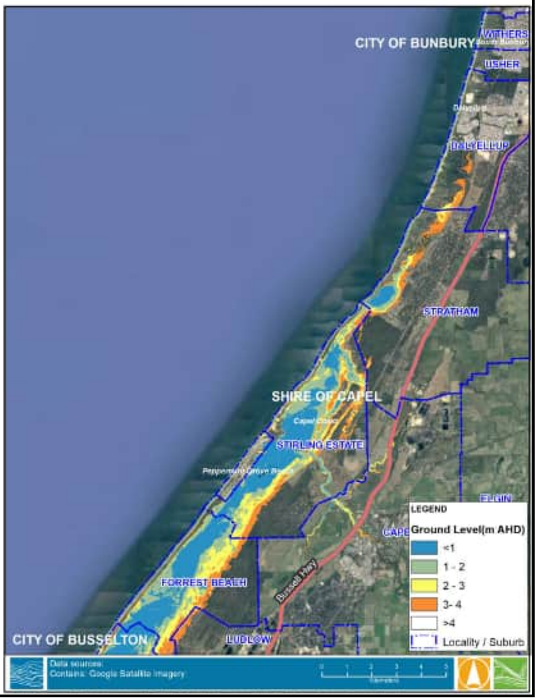
- ***In progress***
- Large study area split into Management Units for adaptation planning, primarily split by jurisdiction
    - Different coastal hazards in each unit
- Hazard mapping will indicate the **zone of risk** – not the predicted future shoreline!



20

Key Issues – Shire of Capel

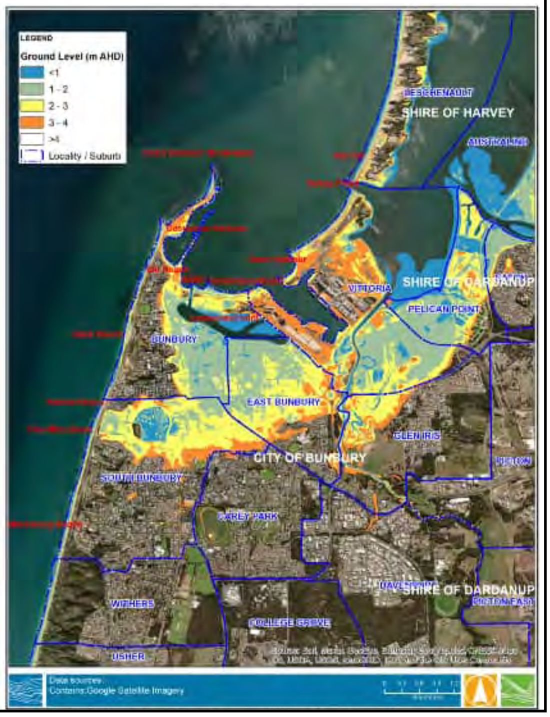
- Low lying land behind coastal dune system
- Dunes act as a natural levee at present
  - Pressure on the dunes will increase (SLR), while their ability to withstand will decrease (erosion)



21

Key Issues – City of Bunbury

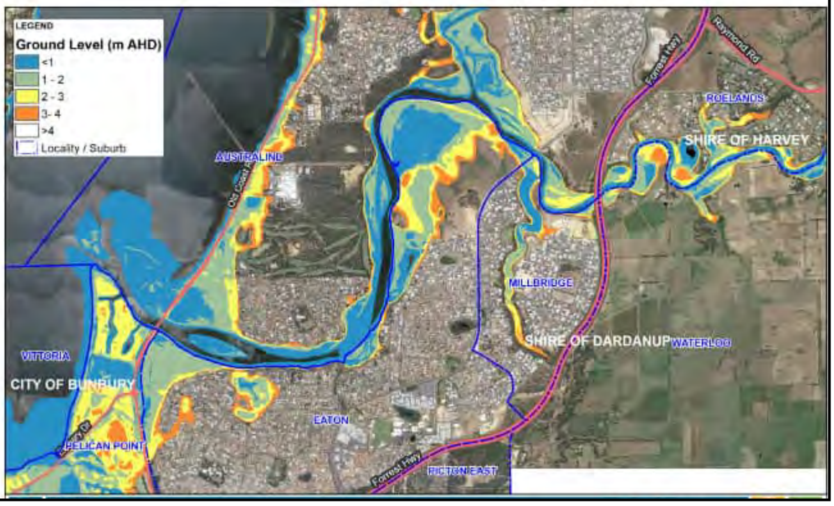
- Low lying land across much of City
- Highly developed coastline
  - Proximity of infrastructure and assets on open coast along west of LGA



22

Key Issues – Shire of Dardanup

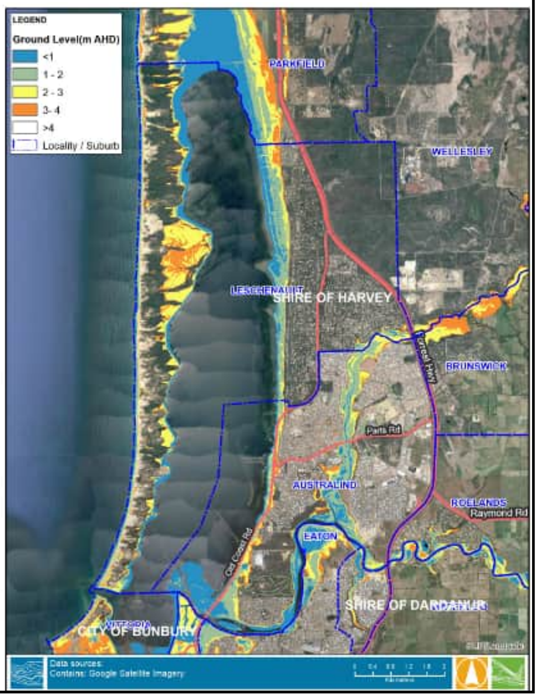
- Mobile riverbanks (potential erosion)
- Low lying land along banks of Collie River
  - Potential inundation due to SLR
  - SLR impacts not likely to extend far upstream



23

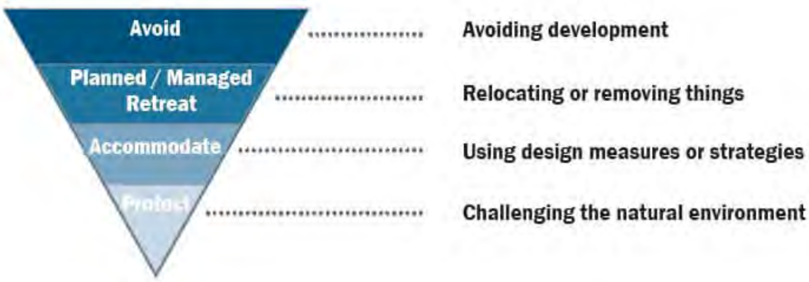
Key Issues – Shire of Harvey

- Low lying land adjacent to Leschenault Estuary
- Mobile riverbanks (potential erosion)
- Low lying land along banks of Collie River
  - Potential inundation due to SLR
  - SLR impacts not likely to extend far upstream



24

Adaptation Options



25

Adaptation Options

Hierarchy of Controls:

- **Avoid** – Options which aim to eliminate the risk of coastal hazards by avoiding development
  Managed Retreat – Options which progressive retreat/relocate development
  Accommodation – Options which seek to enhance assets to cope with the temporary impacts
  Protection – Options which seek to artificially protect the coast

26

Adaptation Options

27

Q&A

Take a moment to think of any questions for Joanna or Anna

Anna will call on each room (alphabetically) to ask questions – write down any questions you might have and give them to your host – they will type it in the Q&A box and we will answer them

28

29

So…What will you influence?

Through this process you will help us to refine:

- The preferred option for each at-risk asset
- Better understanding of community values (more measureable)
- Future information sharing, better tools for describing and explaining hazard management

30

What are we doing today?

- Discussing the places you value and why
- Getting a better idea of key issues and concerns
- Considering areas that you would prioritise for hazard management and adaptation

31

Task 1 - Values

Think about a place that you love to go – write on your sheet –
- **why it is important**
- **what do you do there**
- **what physical aspects of the place are important**

Can be an area for community use, an important cultural place, and environment that matters to you etc

(number the item on your sheet and then place a blue 'dot' with the same number on the large map on the wall – check with others to avoid doubles!)

32

Share feedback

Tell us what's important -

Anna will call on each room (alphabetically) to share feedback

33

Task 2 – Issues/Concerns

Tell us about an issue or concern that you have along our coast or river frontages or identify things that have changed that affect you

(number the item on your sheet and then place a orange 'dot' with the same number on the large map on the wall – check with others to avoid doubles!)

34

Share feedback

Tell us what's important -

Anna will call on each room (alphabetically) to share feedback

35

Next Steps…

- Finalising the engagement phase (open to September 10)

383	46	123
Unique Users	Comments	Survey Responses

- https://getinvolved.mysocialpinpoint.com.au/capel-to-leschenault-chrmap/map#/sidebar/tab/about
- Reviewing and reporting on feedback
- Providing a project update

36

Next Steps…

- Completing hazard mapping
- Identifying valued assets
- Identifying risks
- Assessing management options
- **Another opportunity for the community to be involved in the process, considering adaptation options and the implications of various solutions**

37

Thank you!!

38

APPENDIX C

HARVEY TASK 1 COMMENTS

APPENDIX D

BUNBURY AND DARDANUP TASK 1 COMMENTS

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK ONE

Think about a place that you love to go – tell us - why it is important, what do you do there, what physical aspects of the place are important

(number the item on your sheet and then place a blue 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

2) OCEAN DRIVE - Very close to the Beach Beach. BUNBORY MAJOR SERVICES ARE UNDER THIS ROAD - WATER POWER, ETC. ETC. THIS IS A MAJOR CARRAIGE WAY
8. Sand DUNES, OCEAN SIDE OF LESCH. ESTUARY - MASSIVE AMOUNTS TOXIC MUD BURRIED IN DUNES. PIPED - FROM ORIGINALLY - LA PORT. MANUFACTURER OF TITANIUM - OXIDE.
7. BIG SWAMP. HAS DRIED OUT IN RECENT SUMMERS. ~~EAST OF~~ WETLAND EAST OF BIG SWAMP. HAS MORE WATER IN IT THAN SEEN BY LONG TERM LOCALS EVER -

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK ONE

Think about a place that you love to go – tell us - why it is important, what do you do there, what physical aspects of the place are important

(number the item on your sheet and then place a blue 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

10 • Nyadup Rocks (Rocky Point) - Swim through summer 12 • Nathern End of Back Beach (Sidewash) - Surf through Autumn/Winter/Spring
9 • Outer Harbour (~~Port~~ Inside Port Area) - Surf through winter - Fishing • Dalyellup Beach - Surf Club/Swim.
• Maidens Reserve - Walking/Running • ~~The~~ Dalyellup Beach (off coast) Fishing/Free diving. • Big Swamp.
- Walking/Running • Koombana Beach. - Swimming/ ~~On Lake Boat~~ Dining 11 • Bunbury Cut. - Surfing/Fishing/Jet Ski Use.

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK ONE

Think about a place that you love to go – tell us - why it is important, what do you do there, what physical aspects of the place are important

(number the item on your sheet and then place a blue 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

14 14	• BP Beach / Groyne. (Southern Side) - Surf / Swim / Walk. 15 • BP Groyne. - Northern Side. - Surf / Swim
16	- The Bay. - Surf. / Swim / Fish. 17 - Inside Port. Northern End. - Surf / Fish / Crabbing.
18 18	Leschenault ~~[illegible]~~ Inlet. - Run around / Walk / Cafe's

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK ONE

Think about a place that you love to go – tell us - why it is important, what do you do there, what physical aspects of the place are important

(number the item on your sheet and then place a blue 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

4 KOOMBANA BAY
5 LESCHENAULT ESTUARY
6 BACK BEACH.
7 BIG SWAMP.
50 PRESTON RIVER

LEARNT TO SWIM AS A CHILD IN THE BAY, AND THE DOLPHINS.
CRABBED IN THE ESTUARY
SWAM & SURFED AT THE BACK BEACH.
THE WILDLIFE AT BIG SWAMP ARE PRECIOUS AND NEED TO BE PROTECTED
ALL THESE PLACES ARE IMPORTANT TO BUNBURY AND ITS RESIDENTS
~~#~~THEY MAKE BUNBURY WHAT IT IS.
THEY ARE ALL PART OF THE NATURAL HISTORY AND ENVIROMENT OF BUNBURY.
WITH OUT THEM BUNBURY WOULD NOT BE BUNBURY.
THE LOCAL FLORA IS ALSO OF GREAT IMPORTANCE.

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK ONE

Think about a place that you love to go – tell us - why it is important, what do you do there, what physical aspects of the place are important

(number the item on your sheet and then place a blue 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

Leschenault Inlet Birdwatching. Shorebirds - losing shoreline with full tides this winter. Critical for feeding, roosting + NESTING for at least 3 species The Mangroves as a fish nursery - inundation this winter * See *
Lesch Estuary as above Loss of fringing vegetation, casuarinas etc + samphire due to chronic erosion of sand + wind severity in winter * See *
Bunbury Back Beach Loss of beach Erosion of ~~dunes~~ dune vegetation - long established Not much coastal replanting + revegetation projects for 20 years, ~~????~~ nor encouragement to community to respect foreshore vegetation
OR 51 Venezia Lagoon 52 Pelican Pt * * Important for our migratory shorebirds for feeding, roosting, sanctuary -

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK ONE

Think about a place that you love to go – tell us - why it is important, what do you do there, what physical aspects of the place are important
(number the item on your sheet and then place a blue 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

LESCHENAULT ESTUARY 21 One of the main coastal wetlands in the area, with high environmental value. Waterbirds, dolphins, long migratory shorebirds
BIG SWAMP PARK 22 A great example of recovered degraded wetland, with ~~[illegible]~~ high numbers and diversity of waterbirds. Some of the few paperbark wetland left.
BEACHES & DUNE SYSTEMS IN BACK 23 BEACH & BELVEDIRE PENINSULA (BUFFALO BEACH) → DALYELUP BEACH, PEPERMINT BEACH ~~They are~~ Some are nearly pristine systems, offer habitat for diverse species of coastal animals and protect us (for now) from the impacts of sea level rise due to climate change.
MAIDENS DUNE SYSTEM 24 the only fully developed dune system left within the city boundaries
END OF BACK BEACH → FOR surf. 25

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK ONE

Think about a place that you love to go – tell us - why it is important, what do you do there, what physical aspects of the place are important
(number the item on your sheet and then place a blue 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

48	Area of Interest: Hungry Hollow - I have lived within 300m of this area for many years of my life. Over the time it has been a key recreational area. ← socially, emotionally, physically
	Physical aspects - VERY CONCERNED re soil erosion and the proximity of urban areas / roads etc. The erosion of the area has forced people to swim elsewhere ie Koombana
49	low lying areas of East Bunbury - lack of drainage. flooding roads - danger with traffic

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK ONE

Think about a place that you love to go – tell us - why it is important, what do you do there, what physical aspects of the place are important

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39 Belvedere bar (dunes between the Leschenault Estuary and the ocean) This is important as sea level rise and erosion may lead to new "cuts" being formed giving inflow of seawater into the Estuary and potentially significant influence on Estuary biota.

40 The cut. feeding zone for dolphins, prime influence point between Estuary and Ocean.

41 Mouth of Preston and Collie Rivers. Prime feeding areas for migratory shorebirds. Seawater incursion and erosion will impact significantly.

42 Big Swamp Bunbury. Fresh water ecosystem, Saltwater incursion will impact freshwater environment

43 Back beach Bunbury (the whole Beach) worried that engineering control options (eg. groynes) will impact natural coastal processes eg longitudinal coastal drift and seaweed wrack deposition

44 Bunbury dunes and infrastructure close to ocean - future of this infrastructure eg. Roads and houses and the cost and impact of protection options

45 Saltwater incursion on groundwater reserves and freshwater ecosystems

46 Impact of dune erosion in general on nesting sites for coastal bird life

47 Impacts on coastal veg communities eg tuart forest and fauna eg western ringtail possum

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK ONE

Think about a place that you love to go – tell us - why it is important, what do you do there, what physical aspects of the place are important
(number the item on your sheet and then place a blue 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

34 - Quindalup dune system & its ecology.
38 - Tuart forest within project area.
37 - Coastal wetlands south of Bunbury unique flora & flora.
35. - Banksia woodland within project area.

Unique to southern Swan Coastal plain.

* CONTAMINATED SITES *.

29 - Dalyellup Waste Residue Disposal facility contaminated site, contaminated groundwater beneath, UNLINED SITE.

30 - BUNBURY PORT.
31 - TRONOX PROCESSING PLANT. "

32 - DRINKING WATER EXTRACTION SITES. clean water. "

33 - BUNBURY WASTE WATER TREATMENT PLANT. - important infrastructure.

36 - Allocated development areas within local shire town planning schemes need review after CHRMAP completion.

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK ONE

Think about a place that you love to go – tell us - why it is important, what do you do there, what physical aspects of the place are important

(number the item on your sheet and then place a blue 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

26	Mindalong Beach ~ Important to ~~be~~ me as it's a local beach (close to ~~my~~ home) where I walk my dog, ride my bike & do bush walking in adjacent Maidens Reserve)
27	Koombana Bay ~ Important for recreation (on water), dolphin spotting, walks and access to cafes
28	Mangrove Cove (Leschenault Inlet) ~ Important as it contains southernmost mangrove population, bird habitat, etc. ~ I walk there, do rowing and frequent restaurants, pubs & cafes there

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK ONE

Think about a place that you love to go – tell us - why it is important, what do you do there, what physical aspects of the place are important

(number the item on your sheet and then place a blue 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

(11) Maidens Reserve - walk along trails, photography Solitude. I most value the Natural environment flora & fauna. (7) Big Swamp - walking, bird watching, photography I most value the natural environment.
(4) ~~Koombana Bay~~ - walking, dolphin Centre, Dolphin watching, visiting cafes, BBQ's, social events, triathlon. (13) Collie River walking path. Walking, photography Bird watching. (1) Back Beach - walking, sunsets
(30) Manea Park - Walking, flora & fauna, photography, orchids. (31) Tuart Forest Walk - Walking, cycling, natural environment, bird watching, photography. The majority of things I value are the natural environment for walking, solitude, flora & fauna, photography.

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK ONE

Think about a place that you love to go – tell us - why it is important, what do you do there, what physical aspects of the place are important

(number the item on your sheet and then place a blue 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

3 • Koombanay bay : Swimming & walking along the beach. 111 • Maidens reserve: I walk along the trails, enjoy the patches of bush. Sometimes I walk or run along the beach.
112 • The Tuart forest : A very peaceful place to run and/or walk. The vegetation and fauna is unique.

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK ONE

Think about a place that you love to go – tell us - why it is important, what do you do there, what physical aspects of the place are important

(number the item on your sheet and then place a blue 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

1	The Bunbury Ocean Beach - Just south of the "Hollow". I walk my dog there, take sunset photos, and enjoy the beach during the warmer months. (At Hayward Street)

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK ONE

Think about a place that you love to go – tell us - why it is important, what do you do there, what physical aspects of the place are important

(number the item on your sheet and then place a blue 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

88 SUP & crabbing around the island. Dolphins, birds & sunsets → magic!

APPENDIX E

CAPEL TASK 1 COMMENTS

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK ONE

Think about a place that you love to go – tell us - why it is important, what do you do there, what physical aspects of the place are important
(number the item on your sheet and then place a blue 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

14

I LIVE AT PEPPY BEACH, SOME 70 METRES FROM THE BEACH. I GET UP EARLY AND GO TO THE BEACH MOST MORNINGS. I RUN THE LENGTH OF THE BEACH. IN THE SUMMER MY PARTNER & I SWIM ALONG THE BEACH, SOME DAYS UP TO 4 KILOMETRES. THE WIND AND THE WAVES CHANGE THE BEACH AND THE DUNES BUT PEOPLE CLIMBING THE FRAGILE DUNES, FOUR WHEEL
DRIVES, WEEDS AND RABBITS ARE CAUSING MUCH EROSION. CLIMATE CHANGE IS ACCELERATING EROSION.

(6)

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK ONE

Think about a place that you love to go – tell us - why it is important, what do you do there, what physical aspects of the place are important

(number the item on your sheet and then place a blue 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

1 AK My Home 47 Hutt Drive on Dalyellup Dunes. (and other residential homes)	- Accomodation - Beach access → stairs, walk dog etc. - Dunes ~~[illegible]~~ ✓ (would like to know how to assist in protecting dunes + keeping people in Dalyellup know + action limiting erosion). I think a lot of people do not the level of risk to the dunes + the behaviours required to limit erosion.
2 AK Back Beach / Ocean Drive	- Water sports / walking. - Surf life saving - Drive to work - Cycle along road for exercise and with cycle club.
3 AK Stratham Beach.	- water sports - fishing - walking · Forests · Farms · Residential · Beach access.
Dalyellup Dunes 4 AK. ~~the Maidens~~	~~Cycling~~ ~~Walking~~ ~~Beach [illegible]~~ - Access to beach has been reduced over last 2 years. - Concern dunes have been eroded by 8m over last 2 winters and have not recovered during summer. - Insufficient action to protect dunes or to inform public on how to protect the dunes such as signs to inform or fencing to protect dunes or vegetation to protect dunes.

~~[illegible]~~

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK ONE

Think about a place that you love to go – tell us - why it is important, what do you do there, what physical aspects of the place are important
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TUART FORREST B1 ENVIRONMENT WALK WILDLIFE TREES. PEPPI
BEACH B2 SWIMMING, FISHING, WALKING. PEPPI.

TASK 1

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK ONE

Think about a place that you love to go – tell us - why it is important, what do you do there, what physical aspects of the place are important

My Place

(Number the item on your sheet and then place ~~a blue~~ 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

TASK 2 on LHS

Peppermint Grove Beach for swimming - walking - being	Concerns
J1 · natural · accessible · undeveloped · beautiful +++ Protect / Preserve Dunal Ecology +++	Cars + Vehicles chewing it up Car Park Inundation
Capel Coast J2	· Dalyellup People Not Paying Attention + it will impact them J2
J3	Small Shire what ~~pl~~ priority will be given to ~~the~~ Capel's needs ?? Development Continues in Dalyellup ~~the~~ proper management + planning is part of the AVOID part of the J3 the people who would VALUE it being done properly aren't there yet!!!
How is the Study collecting Info Required from LGAs eg Re Contaminated Sites	~~Death~~ Planning Regulations - What part will this map have in Decision making or is it up to the councils
	Sensitive Aboriginal History Cooperation + Collaboration + Reconciliation Action Planning

~~J2~~ 3 -

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK ONE

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~~B~~ 7/ FARM + BEACH ~~DUNE EROSION CAUSED BY VEHICLES IN DUNES - SINGLE DUNE SYSTEM POTENTIAL TO OPEN FARMLAND TO OCEAN~~
B 1

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK ONE

Think about a place that you love to go – tell us - why it is important, what do you do there, what physical aspects of the place are important

(number the item on your sheet and then place a blue 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

06 81 DALYELLUP BEACH & PARKS LAND INFILL NEW HOUSING SITES WE HAVE LAND AT DOUNGUP BETWEEN OCEAN & GOVT DRAIN IF BLOWOUT WE LOSE LAND. (4 WHEEL DRIVE)

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK ONE

Think about a place that you love to go – tell us - why it is important, what do you do there, what physical aspects of the place are important
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CRW Capel River Wetlands. Important home and refuge for thousands of water birds and other natural communities. High aesthetic value. Some walking, some canoeing, some horseriding, some photography. The adjacent agricultural land is rich organic sediments which are very productive for pasture, crops, grazing.

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK ONE

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Beach N of Capel river mouth: last "wild" coast with best near & Reef shore reef snorkelling. Very narrow beach needs protection from vehicles. (Should be no vehicles) We snorkel, watch birds, crayfish along this coastline. P1 KCRW P1
Mallokup wetland (wetlands near Capel Bridge). Great Birdwatching. Major swan nesting area. CRW P2

6

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK ONE

Think about a place that you love to go – tell us - why it is important, what do you do there, what physical aspects of the place are important

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B1	Capel river mouth and beach Visit, walk on beach, swim Take visitors there Value the natural scenery there and bird life. Swim on the reef. Sadly over last 40yrs big decline in fish and decline in ocean species on reef
B2	Minninup beach at end of Rich Rd Same points as above
B3	Stirling wetlands 1km north and south of Capel River Importance of historical swan nesting area. About 100 swans nests. Swans need to be considered - vegetation for nesting. Need for fox control Ten years ago there were 550 swans on lake Moore 1km nth of Capel River. Since then swan numbers declining. They need nesting sites

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK ONE

Think about a place that you love to go – tell us - why it is important, what do you do there, what physical aspects of the place are important

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We have lived on the waters edge (within 100mtr) for Fifty 50 years and love every aspect of it. Each year we plant six coastal trees, and place cottige on blow outs caused by Rabbits.

Between 1971 and 1973 as Exploration manager for Narsemon Titanium N.L we under took a coastal drilling programme in the Sand dunes between location 179 Stratham and Wanneroop dead water at 50ft x 50ft hole centres (excluding location 42)

"I Love every aspect of Peppermint Beach" Swimming Fishing beach fishing. walking barbecues.

This week ending 31st Aug is the first time in 50 years that a Primary dune has been attacked near the Northern Toilet Block

Rex Barber Mining Eng / Marine Eng

APPENDIX F

HARVEY TASK 2 COMMENTS

APPENDIX G

BUNBURY AND DARDANUP TASK 2 COMMENTS

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK TWO

Tell us about an issue or concern that you have along our coast or river frontages or identify things that have changed that affect you.

(number the item on your sheet and then place a orange 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

114 Beach Erosion – eroding of sand dunes, losing sand. But also loss of infrastructure that supports enjoying the beach & natural environment – beach stairs that are still closed off. Back beach.
3 Sea grass – amount of seagrass that is ripped up & deposited on beach during storms. My concern is loss of seagrass beds NOT the grass being on the beach 116 Port – the effects of the Port concern me. The effect of tankers coming in & out, pollution Possible effects of inundation at the Port & what this would mean for Koombana Bay & the Dolphin population.
Lastly, as a group, is there one issue you would say is the most important to manage in your area?

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK TWO

Tell us about an issue or concern that you have along our coast or river frontages or identify things that have changed that affect you.

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114 • Beach erosion : Drop on value of properties & of course, a massive impact to the natural assetts of Bunbury.

115 • Damage to seagrass habitats in Koombana bay.

Lastly, as a group, is there one issue you would say is the most important to manage in your area?

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK TWO

Tell us about an issue or concern that you have along our coast or river frontages or identify things that have changed that affect you.

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2 ~~1~~ • Erosion to sand dunes/ beaches

5 ~~2~~ • Sand movement changing ocean conditions

7 ~~3~~ • Sand through carparks / gardens.

~~4~~ • Beach access, is more difficult due to erosion

• Limited Beach access.

• Erosion damaging vegetation / fauna.
in general along all coastline

Lastly, as a group, is there one issue you would say is the most important to manage in your area?

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK TWO

Tell us about an issue or concern that you have along our coast or river frontages or identify things that have changed that affect you.
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3 CLIMATE CHANGE CAUSING STRONGER STORMS CAUSING MORE DAMAGE 1 POLLUTION IN KOOMBANA BAY SEA LEVEL RISE 6. POLLUTION IN THE ESTUARY
Lastly, as a group, is there one issue you would say is the most important to manage in your area?

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK TWO

Tell us about an issue or concern that you have along our coast or river frontages or identify things that have changed that affect you.

(number the item on your sheet and then place a orange 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

See previous list of comments - Task 1, can't get to the beach! Beach too short - Too many ~~rock~~ rocks exposed - uncomfortable Wind too wild + ongoing winds 2020 + 2021. winters. More severe than previous
Estuary - Pt Mornington } River deltas Pt Douro } crucial for our migratory shorebirds especially - 21+ species to Arctic Circle to nest. * Fairy Terns - nesting shorebirds - bait fish eaters * Red-capped Plovers " forage at low tide * Pied Oystercatchers "
4 WD's smashing beaches, dunes NOT ALL But there are mavericks, very damaging Driving thru beach nesting activity Destroyed Fairy Tern nesting colony at the Cut in late 2020. * Beach nesting birds are an indicator of coastal health. *
Lastly, as a group, is there one issue you would say is the most important to manage in your area? water drains on beach front

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK TWO

Tell us about an issue or concern that you have along our coast or river frontages or identify things that have changed that affect you.

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(47) Hungry Hollow - major concern personally - soon there will be very little beach to walk / swim at.

Having seen the damage of Cyclone CALBY to road / beaches / buildings previously - worried that we're not prepared for future events

Concerned that as the increasing traffic along beach front will also possibly bring more people - tramping out paths through established vegetation - particularly as many paths have been closed this winter due to storms.

Lastly, as a group, is there one issue you would say is the most important to manage in your area?

48

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK TWO

Tell us about an issue or concern that you have along our coast or river frontages or identify things that have changed that affect you.

(number the item on your sheet and then place a orange 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

DESTRUCTION OF NATURAL COASTAL WETLANDS THAT PROTECT US FROM EXTREM EVENTS AND SLR.
ALL CONTAMINATED LANDS AND HIGHLY CONTAMINANT INDUSTRIES CLOSE TO THE COAST. (TRONOX, INNER HARBOUR LAND ETC)
HARD STRUCTURES DO NOT ALLOW FOR NATURAL COASTAL WETLANDS TO RECEED?
Lastly, as a group, is there one issue you would say is the most important to manage in your area?

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK TWO

Tell us about an issue or concern that you have along our coast or river frontages or identify things that have changed that affect you.

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Contaminated sites.

41 * Dalyellup Waste Residue Disposal Facility
- unlined industrial waste disposal
- contains material that contains heavy metals and radioactive material.
- site is in very close proximity to the high tide line ~~and~~, housing development and the Dalyellup Drinking water extraction site. The ingress of seawater may impact the bio availability of contaminants increasing mobility within groundwater. The coastal aquifer is not protected in this area increasing risk.

42 * Port, Bunbury groundwater + soil contamination

43 * outer port soil contamination

44 * TRONOX site soil + groundwater contamination

45 * impacts on drinking water

46 * Proposed development within the project zone should be deferred until CHRMAP completion

Lastly, as a group, is there one issue you would say is the most important to manage in your area?

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK TWO

Tell us about an issue or concern that you have along our coast or river frontages or identify things that have changed that affect you.
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30 loss of habitat. This will impact flora and fauna population;
31 Groundwater contamination from salt water. will impact freshwater ecosystems and drinking water
32 Biodiversity loss. General detriment to environment.
33 Urban sprawl inland
34 Groundwater contamination from contaminated sites

35 loss of access to the beach for recreation
36 loss of cultural sites
37 Threats to coastal living

Lastly, as a group, is there one issue you would say is the most important to manage in your area?

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK TWO

Tell us about an issue or concern that you have along our coast or river frontages or identify things that have changed that affect you.
(number the item on your sheet and then place a orange 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

38	Erosion (eg through storm events) – limiting access & enjoyment
39	Human impacts – evidence of (eg litter, human movement through planted areas, development close to beach, pollution)
40	Impact of marine-based developments on health of waterways (eg flushing of Inlet) & marine fauna
	Lastly, as a group, is there one issue you would say is the most important to manage in your area?

APPENDIX H

CAPEL TASK 2 COMMENTS

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK TWO

Tell us about an issue or concern that you have along our coast or river frontages or identify things that have changed that affect you.

(number the item on your sheet and then place a orange 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

POPULATION PRESSURE MEANS THE SMALL PERCENTAGE OF PEOPLE WHO DO THE WRONG THING IS BECOMING A LOT OF PEOPLE. THESE ARE THE ONES DRIVING ON THE BEACH AND MAKING NEW TRACKS THROUGH THE DUNES AND THIS COMBINED WITH MORE ADVERSE WEATHER EVENTS ARE CAUSING MAJOR EROSION OF DUNES THAT PROTECT INLAND ENVIRONMENT AND HOMES ETC.

14

Lastly, as a group, is there one issue you would say is the most important to manage in your area?

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK TWO

Tell us about an issue or concern that you have along our coast or river frontages or identify things that have changed that affect you.

(number the item on your sheet and then place a orange 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

Dalyellup. (A) Lack of education about coastal erosion and signage / fencing to limit erosion to inform
Dalyellup (B) Re-Vegetation - due to erosion from residents and from storm erosion There is a need to help ree-establish vegetation to help stabilise the ~~dunes~~ systems.
Dalyellup (C) Loss of access to beach during winter (e.g. (stairs)) and erosion of dunes (about 5m to 10m over last 2 years ~~depending on~~ along the beach in Dalyellup
Lastly, as a group, is there one issue you would say is the most important to manage in your area?

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK TWO

Tell us about an issue or concern that you have along our coast or river frontages or identify things that have changed that affect you.

(number the item on your sheet and then place a orange 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

SHIRE HAS DRAINAGE ONTO BEACH - IT BACK FILLS & CAUSES EROSION B1
DUNE PLANTING & REVEGETATION DOES NOT HAPPEN EROSION GETS WORSE B2
HAVE YOU DONE A SEISMIC SURVEY OF COAST ?? DETERMINE ROCK TYPE
Lastly, as a group, is there one issue you would say is the most important to manage in your area?

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK TWO

Tell us about an issue or concern that you have along our coast or river frontages or identify things that have changed that affect you.

(number the item on your sheet and then place a orange 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

8 1 SINGLE DUNE SYSTEM SERIOUS DUNE BLOW OUT CAUSED BY VEHICLES ~~&~~ COMING OFF BEACH
8 2 WETLANDS + FARMLAND BECAME SALINE BECAUSE OF DRAINS LEFT OPEN AT CAPEL RIVER - IT IS IMPROVING
Lastly, as a group, is there one issue you would say is the most important to manage in your area?

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK TWO

Tell us about an issue or concern that you have along our coast or river frontages or identify things that have changed that affect you.
(number the item on your sheet and then place a orange 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

BEACH BLOW OUT 81
Lastly, as a group, is there one issue you would say is the most important to manage in your area?

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK TWO

Tell us about an issue or concern that you have along our coast or river frontages or identify things that have changed that affect you.
(number the item on your sheet and then place a orange 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

77

17

Right now! the sea has attacked a primary dune the first we have seen in 50 years at Peppermint Grove Beach

My biggest concern is what this study intends to do about rising sea levels "Concrete Turnbacks"? "Groins" Groynes.

Lastly, as a group, is there one issue you would say is the most important to manage in your area?

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK TWO

Tell us about an issue or concern that you have along our coast or river frontages or identify things that have changed that affect you.

(number the item on your sheet and then place a orange 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

Recognition of multiple ownership of beach land & how can we get them all working together

- private landowners
- government property
- unallocated crown land
- public open space

Lastly, as a group, is there one issue you would say is the most important to manage in your area?

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK TWO

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~~Wa~~ Salt water ingress through the cuts. (eg. Capel) PA1
Salt water ~~rla~~ rising from ground behind dunes ~~eg~~ salting land. PA2
Elimination of Beach / habitat in. relatively wild coastline. PA3
Lastly, as a group, is there one issue you would say is the most important to manage in your area?

PNP Leschenault to Capel Coastal Hazard Risk Management Adaptation Plan – Workshop - TASK TWO

Tell us about an issue or concern that you have along our coast or river frontages or identify things that have changed that affect you.

(number the item on your sheet and then place a orange 'dot' with the same number on the large map on the wall – check with others to make there are no doubles!)

B1	Capel River mouth and saltwater surge upstream
B2	Capel/Stirling wetland inundation south and north of Capel River Need for protection of bird life especially swans which return for decades of where they were hatched.
B3	Tuart Forest National Park Mininup Forest is still capable of natural regeneration if Kangaroos are kept out in last 30 years Underground water leve has dropped due to 3 sandmining projects + huge quotas for farming Lower water table affects forest vegetation

Lastly, as a group, is there one issue you would say is the most important to manage in your area?

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WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Capel to Leschenault CHRMAP

Chapter Report: Vulnerability Analysis

Peron Naturaliste Partnership

1 July 2022

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1 July 2022

Joanne Ludbrook
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Peron Naturaliste Partnership
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Via email: peronnaturalistepartnership@mandurah.wa.gov.au

Dear Joanne

Chapter Report: Vulnerability Analysis

We are pleased to present the Capel to Leschenault Coastal Hazard Risk Management and Adaptation Plan Chapter Report: Vulnerability Analysis. If you have any queries, please do not hesitate to contact me on (08) 6555 0105.

Yours sincerely

Joanna Garcia-Webb
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WATER TECHNOLOGY PTY LTD

EXECUTIVE SUMMARY

It is internationally recognised that the mean sea level has been rising globally since the nineteenth century and is predicted to rise at an increasing rate in the future (IPCC 2021). Rising sea levels and intensifying storm activity will increase the risk of coastal inundation (temporary coastal flooding), storm erosion and long-term shoreline recession. State governments across Australia have introduced statutory obligations that require local governments to consider and plan for these hazards. In Western Australia (WA), the governing policy is the Western Australian Planning Commission's (WAPC) State Planning Policy No. 2.6: State Coastal Planning Policy (WAPC, 2013, herein referred to as "SPP2.6"). SPP2.6 recommends management authorities develop a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for land use or development that is potentially vulnerable to coastal hazards. Specific guidelines have been developed to assist in this process (WAPC, 2019).

SPP2.6 requires adequate risk management planning is undertaken where existing or proposed development is in an area at risk of being affected by coastal hazards over the 100-year planning timeframe. SPP2.6 and the CHRMAP Guidelines provide the risk assessment framework to be applied to identify risks that are intolerable to the community, and other stakeholders such as local governments, indigenous and cultural interests, and private enterprise. Risk Management measures are then developed according to the adaptation hierarchy outlined in SPP2.6.

The Peron Naturaliste Partnership (PNP) comprises membership of nine local government authorities. The PNP's Coastal Adaptation Pathways Project identified the coastal areas of Capel, Leschenault and Greater Bunbury as being particularly exposed to coastal hazards and climate change, which triggered the need for this CHRMAP. The aim of the present study is therefore to investigate the nature and severity of coastal hazards which are likely to affect these regions from Capel to Leschenault over future planning horizons. Refer Figure 1-1 for locality and study area extent.

The objective of this CHRMAP project is to increase knowledge and understanding of coastal hazard risks, and identify risk management and adaptation measures for implementation. The outcomes will be used to inform local and state government policies, strategies and plans, including (but not limited to); planning strategies, community strategic plans, drainage strategies, asset management plans, emergency management plans, and foreshore management plans. The project will adhere to the WAPC (2019) guidelines with scope and deliverables to be consistent with the objectives identified by these guidelines and SPP2.6. The project will identify the strategic direction for coastal adaptation scenarios from the present-day to 2120 (100 yrs. management time frame), and identify an implementation plan to achieve this direction. Overall, this CHRMAP will develop a flexible adaptation pathway for the region and serve as a key reference for management, planning and policy making for the short-term (0-15 years), medium-term (15-30 years), and long-term (100 years).

This report presents the Vulnerability Analysis Chapter Report, which constitutes the second stage of the risk identification process. The flow chart displayed in Figure 1-2 indicates where this component sits with reference to the greater study; the 'Vulnerability Analysis' phase corresponds to the bubble shaded in red, presented below.

Vulnerability Analysis
- Prepare Likelihood and Consequence Scales
- Develop Level of Risk Matrix and Risk Tolerance Scale, Adaptive Capacity and Asset
- Risk Assessment of each vulnerable asset: likelihood, consequence, vulnerability & risk rating for each scenario

Likelihood, consequence, level of risk, adaptive capacity and vulnerability scales are developed for 9 asset categories:

- Roads
- Residential
- Commercial
- Public and community assets not located in the foreshore reserve
- Developed foreshore reserve
- Undeveloped foreshore reserve
- Environmental
- Agricultural / rural lands
- Aboriginal Heritage

All identified at-risk assets within the 11 management units (refer Figure 2-1) are then assigned vulnerability ratings, according to the various scales. The vulnerability results are presented in full in Appendix A and Appendix B; a summary is presented in Section 4. These are presented by management unit and asset category, for the planning horizons of present day, 2035, 2050 and 2120.

Extreme vulnerability has been identified from the present day onwards. Most of this extreme vulnerability is predicted to be from erosion, with the exception of residential and commercial inundation.

The enormous number of at-risk assets, a total of approximately 48,000, means grouping and summarising is the only meaningful method of assessing the risk at this stage of the planning process. All identified assets and ratings will be supplied in GIS format so relevant governing bodies can review and assign asset-specific actions once the CHRMAP is complete.

The next report will present the risk evaluation, which updates the risk priorities in context of any physical and planning controls. Risk treatment options will also be identified and assessed with a multi-criteria analysis. Risk treatment options will be considered for each management unit as a whole, with consideration to the categories and number of assets at risk.

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1 INTRODUCTION

It is internationally recognised that the mean sea level has been rising globally since the nineteenth century and is predicted to rise at an increasing rate in the future (IPCC, 2021). Rising sea levels and intensifying storm activity will increase the risk of coastal inundation (temporary coastal flooding), storm erosion and long-term shoreline recession. State governments across Australia have introduced obligations that require local governments to consider and plan for these hazards. In Western Australia (WA), the governing policy is the Western Australian Planning Commission's State Planning Policy No. 2.6: State Coastal Planning Policy (WAPC, 2013, herein referred to as "SPP2.6"). SPP2.6 recommends management authorities develop a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for land use or development that is vulnerable to coastal hazards. Specific guidelines have been developed to assist in this process (WAPC, 2019).

One of the key objectives of SPP2.6 is to establish coastal foreshore reserves which include allowances for the protection, conservation and enhancement of coastal values across the state. Risk assessment processes are then utilised to identify risks that are intolerable to the community, and other stakeholders such as local governments, indigenous and cultural interests, and private enterprise. Adaptation measures are then developed according to the preferential adaptation hierarchy outlined in SPP2.6.

The Peron Naturaliste Partnership (PNP) comprises membership of nine local government authorities. The PNP's Coastal Adaptation Pathways Project identified the coastal areas of Capel, Leschenault and Greater Bunbury as being particularly exposed to coastal hazards and climate change, which triggered the need for this CHRMAP. The aim of the present study is therefore to investigate and plan for coastal hazards which are likely to affect these regions from Capel to Leschenault – refer Figure 1-1 for locality and study area extent.

This CHRMAP project is expected to increase knowledge and understanding of coastal hazard risks and identify risk management and adaptation measures for implementation. The outcomes will be used to inform local government policies, strategies and plans, including (but not limited to); planning strategies, community strategic plans, drainage strategies, asset management plans, emergency management plans, and foreshore management plans. The project will adhere to the WAPC (2019) guidelines with scope and deliverables to be consistent with the objectives identified by these guidelines and SPP2.6. The project will identify the strategic direction for coastal adaptation scenarios from the present to 2120 (100-year management time frame), and identify an implementation plan to achieve this direction. Overall, this CHRMAP will develop a flexible adaptation pathway for the region and serve as a key reference for management, planning and policy making for the short-term (0-15 years), medium-term (15-30 years), and long-term (100 years).

This report presents the Vulnerability Analysis Chapter Report, which assess the vulnerability of the assets within the coastal hazard zone. The flow chart displayed in Figure 1-2 indicates where this component sits with reference to the greater study; the 'Vulnerability Analysis' phase corresponds to the bubble shaded in red.

Delivery of this project will occur over 9 stages (as summarised in Figure 1-2), each of which represents a key hold point. The staged approached is developed according to the PNP's scope and is in line with the CHRMAP Guidelines (WAPC, 2019).

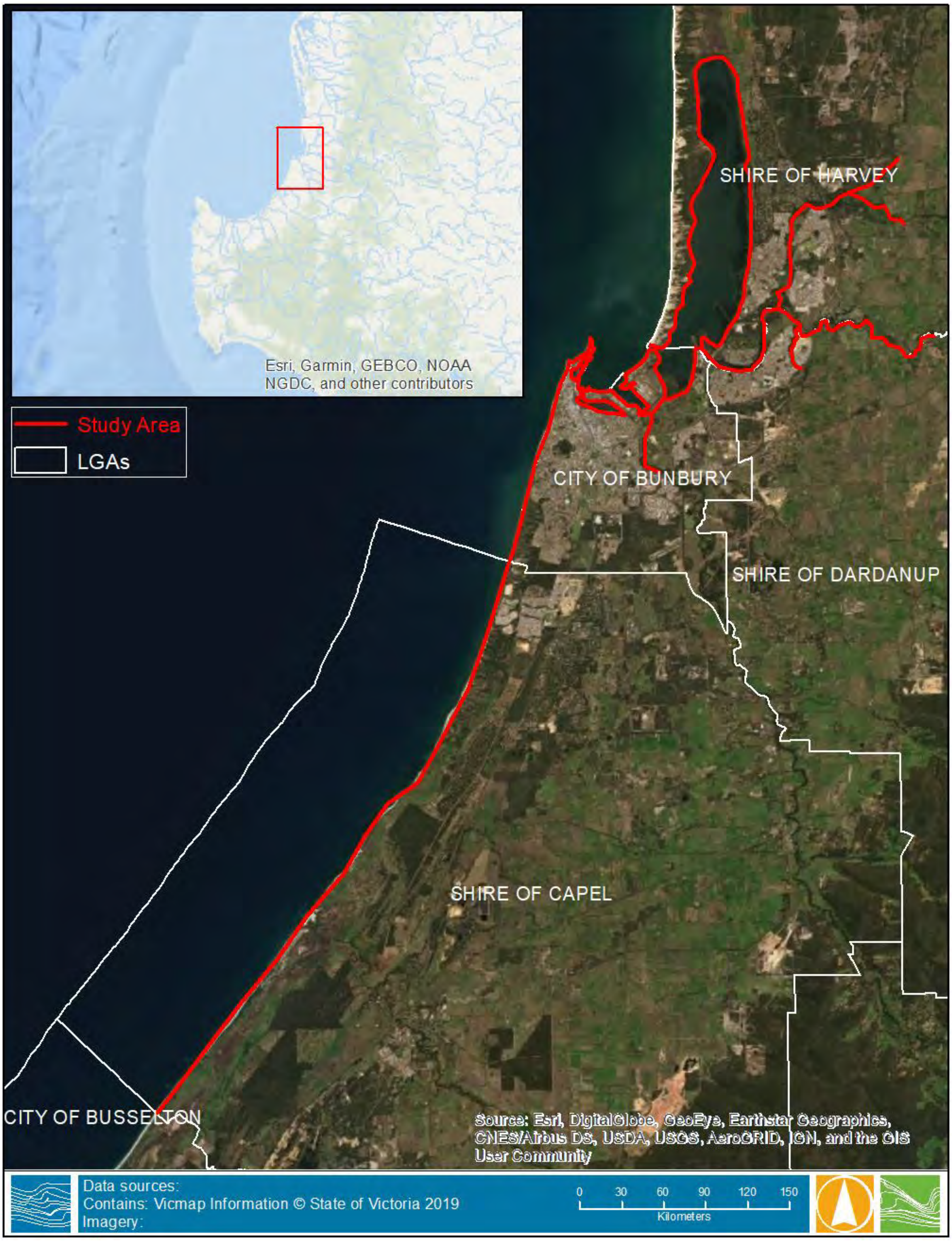

Figure 1-1 Project Area

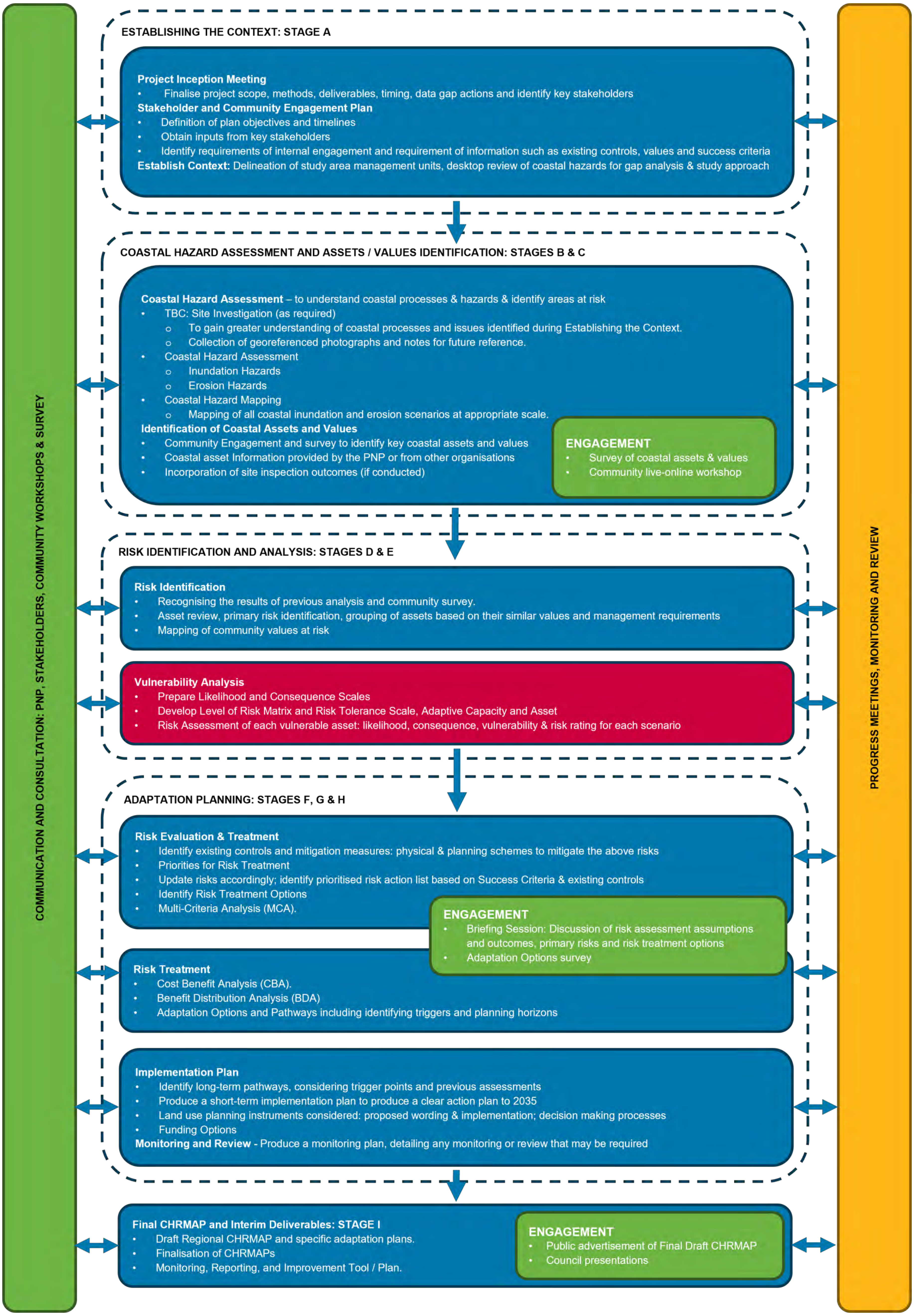

Figure 1-2 CHRMAP Methodology Flow Chart (adapted from WAPC, 2019)

2 MANAGEMENT UNITS

A project Steering Group has been established to oversee preparation and completion of the CHRMAP, including review of project deliverables. The Steering Group plays an advisory role in the project and consists of various representatives. The members of project steering group and key stakeholders are summarised in Table 2-1.

Table 2-1 Steering Group members

Organisation	Role of organisation in study area
PNP	Regional facilitator and client project manager.
Shire of Capel (SoC)	Local coastal land and riverine shoreline manager.
City of Bunbury (CoB)	Local coastal, riverine shoreline, and estuarine/inlet land manager.
Shire of Harvey (SoH)	Local coastal, riverine shoreline, and estuarine land manager.
Shire of Dardanup (SoD)	Local riverine shoreline land manager.
Department of Biodiversity, Conservation & Attractions (DBCA)	Local coastal, riverine shoreline, and estuarine land manager. Data custodian.
Southern Ports, Bunbury	Local coastal land manager; data custodians.
Department of Planning, Lands & Heritage (DPLH)	Technical scoping, advice and review; data custodians, presence required by funding agreement for project
Department of Transport (DoT)	Casuarina Boat Harbour manager; technical scoping, advice and review; data custodians.
Department of Water & Environmental Regulation (DWER)	Technical scoping, advice and review; data custodians.

To facilitate the coastal hazard assessment and development of adaptation options, the study area is delineated into several management units which are determined according to a set of factors:

- Jurisdiction boundaries
- Presence of coastal assets and relevant stakeholders
- Coastal processes and potential hazard types.

For Shire of Capel, the shoreline can be divided into three primary management units:

- MU1 - Peppermint Grove Beach
- MU2 - Capel Coast (coastal reserve and farmland)
- MU3 - Dalyellup Beach

For City of Bunbury, the shoreline can be divided into five primary management units:

- MU4 - Bunbury S
- MU5 - Bunbury (including Five Mile Brook district, Koombana Bay, Leschenault Inlet)
- MU6 - Bunbury Port

- *Note: the boundaries of this MU have shifted slightly so that land contained in this MU consists almost entirely of port assigned land, as per the regional scheme*.

- MU7 - The Cut
- MU8 – Bunbury E

Shire of Dardanup does not have an open coast. Primary hazards are potential riverbank erosion and inundation of lowlands along the Collie River. The area is defined as an individual management unit:

- MU10 - Collie River S.

For Shire of Harvey, the shoreline can be subdivided into two primary management units:

- MU9 - Leschenault Estuary
- MU11 - Collie River N, consisting of lands on the northern side of Collie River and along the Wellesley River and Brunswick River

The open ocean coast within the Shire of Harvey is excluded from the scope of this CHRMAP.

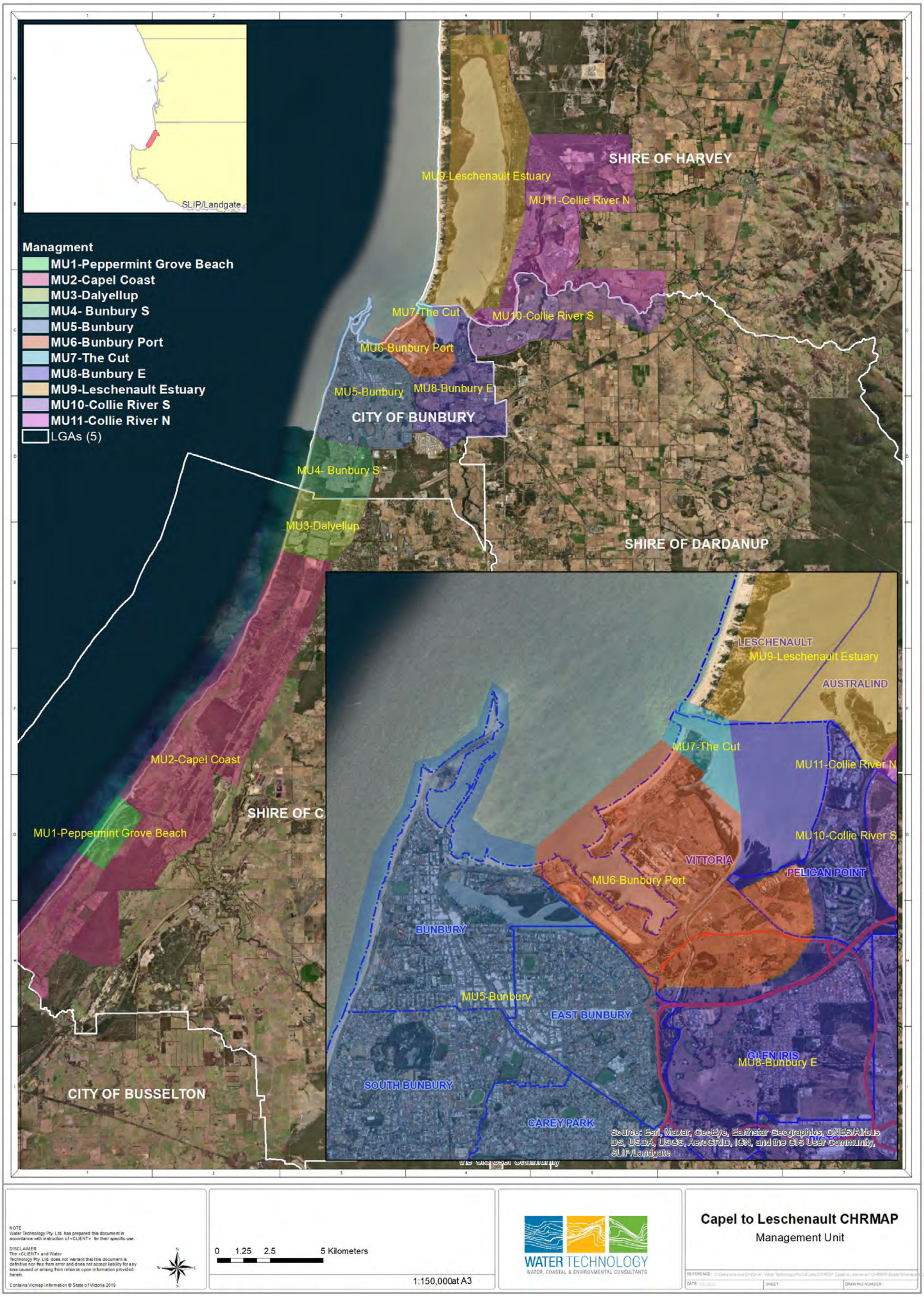

Figure 2-1 Study Area and Management Units

3 VULNERABILITY ANALYSIS METHOD

A vulnerability assessment defines the degree of impact coastal hazards are likely to have on coastal assets over the planning timeframe. The vulnerability of coastal assets to coastal hazards is related to its exposure to the hazard, its sensitivity to that exposure, and the ability of the asset to be modified or adapted to manage this exposure. This is displayed diagrammatically in Figure 3-1; the input components are displayed in blue.

In the sub-chapters below, the asset ratings to the hazards are discussed and a vulnerability rating assigned. Inundation and erosion hazards are considered separately. Assets are grouped according to classification for ease of interpretation. Ratings were discussed with the Steering Committee to ensure they are reflective of community views.

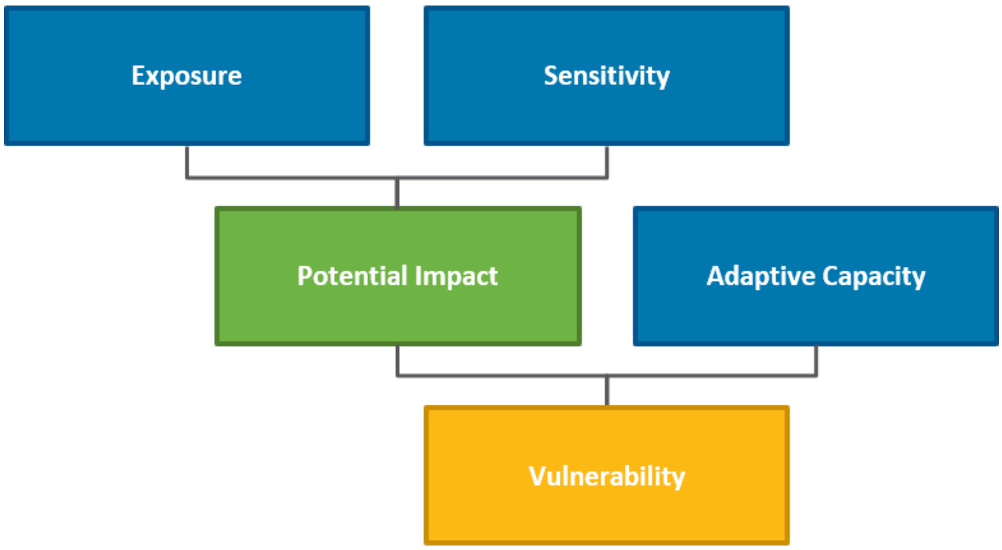

Figure 3-1 Vulnerability assessment components (reproduced from Allen Consulting, 2005)

3.1 Identification of Assets

The link below presents the hazard and asset information together overlain on an aerial photograph for ease of viewing (refer Water Technology 2021b, 2021c for coastal hazard assessment and asset identification reports respectively). All information layers can be turned on and off, and it is possible to zoom in on sites within the study area. Clicking on an asset displays its category, planning horizon in which it is predicted to become affected and the Management Unit. It is recommended that each Steering Committee member view the link to gain further understanding of assets at risk within their jurisdictions.

https://watech.maps.arcgis.com/apps/webappviewer/index.html?id=d43c39fda97d426ea6192d1a7a8543cf

3.1.1 Asset Classifications

Assets have been grouped as follows:

- Roads
- Residential land including both occupied and vacant land
- Commercial land and assets e.g., Bars, shops, markets etc.
- Public and community assets not located in the foreshore reserve e.g., car parks, recreational facilities

- Developed foreshore reserve, including coastal, estuary and river foreshore areas:
  - Reserve containing public assets, e.g., car parks, public ablutions, playgrounds, walkway, access structures
- Undeveloped foreshore reserve, including coastal, estuary and river foreshore areas
- Environmental, specifically:
  - Contaminated Sites
  - DBCA Data. This includes habitat areas potentially suitable for Matters of National Environmental Significance (such as Carnaby's Cockatoo's and Western Ringtail Possums), Threatened and Priority Ecological Communities, and known locations of threatened flora.
- Agricultural / rural lands
- Aboriginal Heritage

One of the main challenges of this CHRMAP is the numerous assets and management zones. This asset classification was developed to address the main coastal adaptation issues and key locations, and enable a simple yet effective method for adaptation planning.

3.2 Exposure/Likelihood

The **exposure/likelihood** of identified assets represents the likelihood of coastal hazards impacting on an asset. That is, the chance of erosion and / or storm surge inundation impacting on existing and future assets and their values (WAPC, 2019). The likelihood scale adopted for this study is presented in Table 3-1.

Table 3-1 Exposure/Likelihood Rating

Likelihood Rating	Description	Annual Exceedance Probability
Almost Certain	Expected to occur in most circumstances	>90%
Likely	Impact to asset shoreline for a given planning timeframe is likely	50-90%
Possible	Impact to asset shoreline for a given planning timeframe is possible	10-50%
Unlikely	Impact to asset shoreline for a given planning timeframe is unlikely	1-10%
Rare	May occur in exceptional circumstances	<1%

Over the years, there has been significant variation in defining the likelihood ratings based on coastal hazard assessment outcomes. The erosion hazard lines (Water Technology, 2022) were developed based on a number of components, each of which has its own assumptions and degree of uncertainty. For instance, the assessment of S1 erosion risk has considered a few different likelihood storm events which, by themselves, represent their likelihood of occurrence, however such occurrences change over the different planning timeframes. Likelihood of sea level rise (SLR) and historic shoreline movement are very difficult to define quantitatively by scientific terms. It is therefore important to adopt a straight-forward approach to transfer the information presented in the coastal hazard maps into likelihood of impact to assets.

Through internal discussion and review, Water Technology has adopted the approach recommended by WAPC (2019) as demonstrated in Figure 3-2 below for the likelihood of erosion hazard. The likelihood of the current study for erosion is thereby determined by the Table 3-3.

For the purposes of the inundation assessment, a combination of the 1-year, 10-year, 100-year and 500-year ARI inundation scenarios was applied. Table 3-2 presents the probability of each of these events occurring over the planning timeframe. By applying the definitions of the likelihood scale of Table 3-1, the likelihood of inundation for the current study is presented in Table 3-4. For each affected asset, the likelihood of all four events was applied to each asset, and the "worst" for each planning timeframe selected for the vulnerability / risk assessment. For example, if an asset is affected by both the 10-year and 500-year event in the present day, the likelihood (unlikely and rare respectively) and consequence for each is investigated, and the worst risk level selected. It may be that because the 10-year event has a higher likelihood of occurring, this could lead to a higher risk level. The 1 and 10-year ARI events have a much higher likelihood of occurring over the planning timeframe for example (essentially 100% chance of occurring), and this should be accounted for in the risk assessment.

Calculation of the probabilities behind the likelihood ratings is extremely complex and simplification is necessary in order to carry out the vulnerability and risk assessments. Any adaptation measures will consider applying triggers before implementation which reduces the risk of this simplification process. For example, a trigger might be reached by an inundation event with certain consequences occurring twice in a given year.

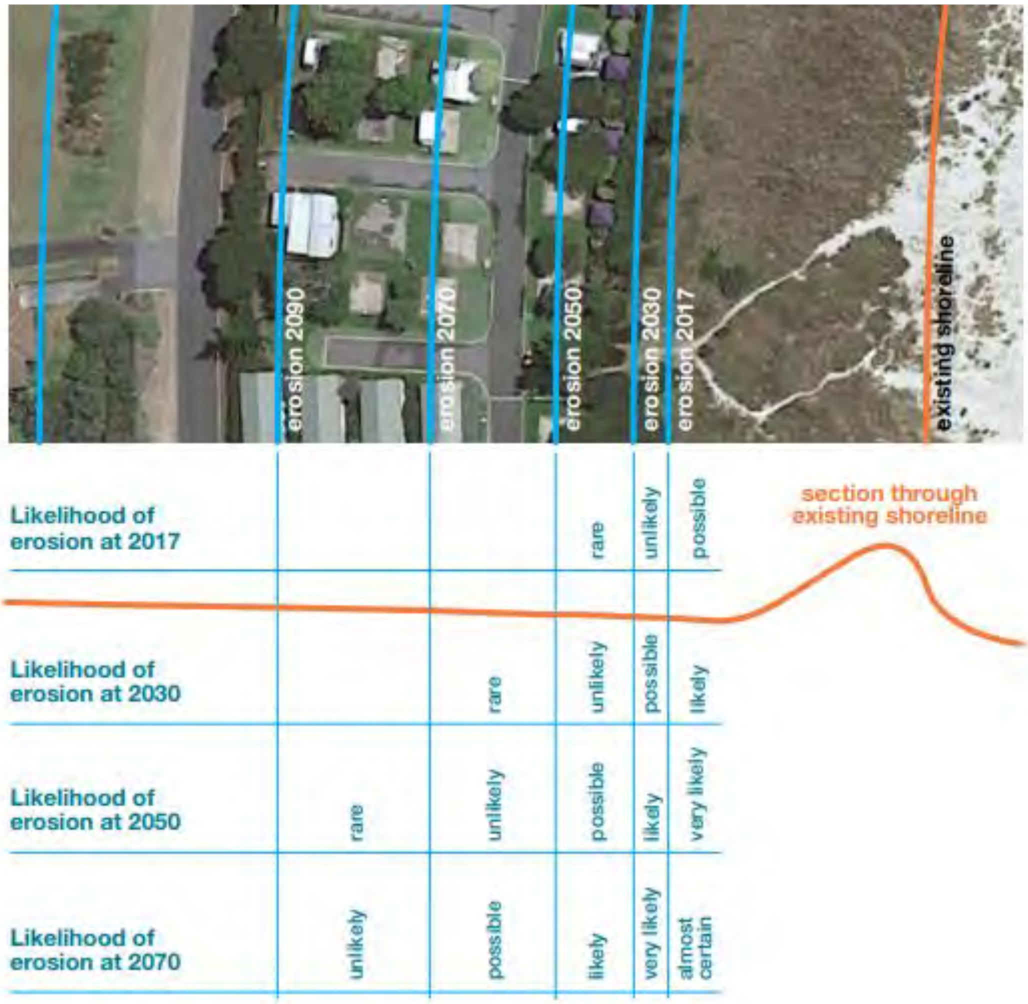

Figure 3-2 Example of likelihood rating based on erosion hazard lines (adapted from WAPC, 2019)

Table 3-2 Inundation event probabilities over planning timeframes

Timeframe	Probability			
	1-year ARI	10-year ARI	100-year ARI	500-year ARI
Present Day	63%	10%	1%	0.2%
2035	100%	78%	14%	3%
2070	100%	95%	26%	6%
2120	100%	100%	63%	18%

Table 3-3 Exposure / Likelihood of coastal erosion hazards across the planning timeframe

Erosion Hazard Line Location	Likelihood of Erosion					
	2020	2035	2050	2070	2090	2120
HSD-2020	Possible	Likely	Almost Certain	Almost Certain	Almost Certain	Almost Certain
2020-2035	Unlikely	Possible	Likely	Almost Certain	Almost Certain	Almost Certain
2030-2050	Rare	Unlikely	Possible	Likely	Almost Certain	Almost Certain
2050-2070	Rare	Rare	Unlikely	Possible	Likely	Almost Certain
2070-2090	Rare	Rare	Rare	Unlikely	Possible	Likely
2090-2120	Rare	Rare	Rare	Rare	Unlikely	Possible
Beyond 2120	*Not assessed*					

Table 3-4 Exposure / Likelihood of inundation hazards across the planning timeframe

Timeframe	1-year ARI Inundation Event	10-year ARI Inundation Event	100-year ARI Inundation Event	500-year ARI Inundation Event
Present Day	Likely	Unlikely	Rare	Rare
2035	Almost Certain	Likely	Possible	Unlikely
2050	Almost Certain	Almost Certain	Possible	Unlikely
2120	Almost Certain	Almost Certain	Likely	Possible

3.3 Sensitivity/Consequence

The **sensitivity/consequence** is an asset's responsiveness to a coastal hazard. This could be a gradual response or a stepped change in response to discrete events (WAPC, 2019). The sensitivity can be applied to the asset itself, or to the asset's function and the criticality of the service it provides (CoastAdapt, 2017).

The consequence ranking presented in Table 3-6 constitutes the physical impact of the event to the asset, as well as that of the values attributed to it by the success criteria defined earlier in the study (replicated below in Table 3-5, for reference). The success criteria were generated (Water Technology, 2021b) from the coastal values assessment, which was undertaken by stakeholder and community engagement. Table 3-6 can be interpreted as follows:

- The Physical, Financial column considers the physical impact as well as a qualitative assessment of the economic costs associated with the various consequences. These will be assessed in more detail in the cost benefit analysis as part of the adaptation options assessment component of the study (Stage G Chapter Report, as per Figure 1-2).
- The remaining columns include the application of the success criteria. The success criteria highlight the importance of the environment and coastal recreation to the community:
  - Environment column considers how the environment may be impacted through an erosion or inundation event, including consideration of if a similar habitat may exist elsewhere.
  - Community / Social & Cultural column considers how impacts to an asset may affect the community, also allowing for if alternatives assets / functions exist elsewhere. Consideration of community safety is also included

For each hazard, the consequence is assessed against the criteria qualitatively, based on experience of the impacts of coastal erosion and inundation, and the examples presented in the consequence scale. The purpose of assigning vulnerability is to identify and prioritise what requires adaptation. The consequence rankings differ to traditional internal local government risk assessment rankings as they are to be applied for a different purpose. Local governments will still apply their internal risk assessment processes when considering adaptation actions such as the removal or repair of assets. The rankings presented within this report are purely to aid the adaptation plan.

Table 3-5 Success criteria

- Conserve, enhance and maintain the natural environment and character of the study area
- Facilitate and promote public usage and enjoyment of the natural environment, coast, estuaries and rivers
- Protection of the cultural values of the coastline
- Manage impacts to the existing residential areas from erosion and inundation
- Maintain critical infrastructure supporting the community (roads, utilities).
- Manage and maintain coastal infrastructure that provides access to the water and supports the lifestyle enjoyed by people in the region
- Retain the widest possible range of risk management options for future users of the coast

Table 3-6 Sensitivity / Consequence ranking

Consequence Level	Physical, Financial	Environment	Community / Social & Cultural
Insignificant	No or minimal damage , perhaps requiring increased maintenance Financial loss less than $20,000	Negligible to no impact to environment	Minimal short-term inconvenience to asset, services and function, <5% of community affected. Many alternatives exist
Minor	Minor damage to assets resulting in restrictions in capability , financial loss of $20,000 to $200,000	Short term damage to environment. Recovery will be strong. Local or regional alternate habitat exists	Isolated but noticeable (short term) decline or disruption to asset, services and function, <10% of community affected. Alternative sites exist
Moderate	Damage to assets resulting in isolated loss of capability, financial loss of $200,000 to $2 million	Medium term loss of environmental assets. Recovery is likely. Local or regional alternate habitats exist	Moderate (short to medium term) decline or disruption to assets, services and function, <25% of community affected. No convenient alternative exists
Major	Significant damage to many assets resulting in very limited capability, financial loss of $2 million to $5 million	Long-term damage to environmental assets. Limited chance of recovery. No local alternate habitat(s) exist. Regional habitats exist	Severe (medium-term) decline or disruption to asset, services and function, <50% of community affected. No convenient alternative exists
Catastrophic	Significant damage to most assets resulting in loss of capability, financial loss of over $5 million	Permanent damage to environmental assets. No chance of recovery. No alternate habitat(s) exist.	Long term or permanent loss of asset, services and function >75% of community affected. No alternative exists

Each asset category is assigned a sensitivity / consequence rating, presented in Table 3-7 and Table 3-8 for erosion and inundation respectively. The GIS approach to vulnerability analysis is practical for the study area size and complexity. This involves an “averaging" process, by applying blanket analysis on categories; suitable for delineation of vulnerabilities within a Management Unit, as well as comparisons between Management Units. Assets, hazards and / or areas of significance will be considered case-by-case during the implementation plan stage. A rating is assigned to each of the consequence columns, and then the overall rating assigned as the worst of the ratings. This applies a conservative factor to this large-scale approach.

Table 3-7 Sensitivity / consequence rating by asset category: erosion

Asset Category	Physical, Financial	Environment	Community / Social & Culture	Overall Rating
Roads	Catastrophic	Minor	Major	Catastrophic
Residential	Catastrophic	Minor	Major	Catastrophic
Commercial	Catastrophic	Minor	Major	Catastrophic
Public & community	Major	Moderate	Moderate	Major
Developed foreshore reserve	Moderate	Moderate	Moderate	Moderate
Undeveloped foreshore reserve	Moderate	Major	Major	Major
Environmental	Moderate	Major	Major	Major
Agricultural / rural	Major	Moderate	Moderate	Major
Aboriginal heritage	Major	Major	Major	Major

Table 3-8 Sensitivity / consequence rating by asset category: inundation

Asset Category	Physical, Financial	Environment	Community / Social & Culture	Overall Rating
Roads	Minor	Minor	Minor	Minor
Residential	Major	Minor	Moderate	Major
Commercial	Major	Minor	Moderate	Major
Public & community	Moderate	Minor	Moderate	Moderate
Developed foreshore reserve	Moderate	Minor	Moderate	Moderate
Undeveloped foreshore reserve	Minor	Moderate	Minor	Moderate
Environmental	Minor	Moderate	Minor	Moderate
Agricultural / rural	Moderate	Minor	Minor	Moderate
Aboriginal heritage	Moderate	Moderate	Moderate	Moderate

3.4 Potential Impact (Level of Risk)

Risk level, or **potential impact**, is calculated as the **product** of exposure and sensitivity (see Table 3-9). It provides a classification of the potential impact of coastal hazards on identified assets, which should be determined for each considered planning timeframes. Level of risk is evaluated mainly based on its tolerability (i.e., consequence). Definitions are provided in Table 3-10.

Table 3-9 Risk Level (Potential Impact) Matrix as Product of Sensitivity (Consequence) and Exposure (Likelihood)

Sensitivity / Consequence	Exposure / Likelihood				
	Rare	Unlikely	Possible	Likely	Almost Certain
Catastrophic	Medium	High	Extreme	Extreme	Extreme
Major	Medium	Medium	High	Extreme	Extreme
Moderate	Low	Medium	Medium	High	High
Minor	Low	Low	Low	Medium	Medium
Insignificant	Low	Low	Low	Low	Low

Table 3-10 Risk profile definition

Risk Profile	Definition
Low	Tolerable risk. A level of risk that is low and manageable without intervention outside routine asset maintenance.
Medium	A level of risk that may require intervention to mitigate, such as changes to design standards or asset maintenance. Short to medium term action required.
High	A level of risk requiring significant intervention to mitigate in the immediate to short term.
Extreme	Immediate action required to reduce risk to acceptable levels

3.5 Adaptive Capacity

The **adaptive capacity** is the asset's ability to adjust/adapt to the identified hazard. It is determined based on the potential for the system to be modified to cope with the impacts from coastal hazards. Assets with high adaptive capacity can easily be adapted or one that has some capacity to self-adapt with changing conditions. For instance, beach and dune systems often have higher adaptive capacity than coastal infrastructure and residential land. The scale of adaptive capacity is provided in Table 3-11. Rating of adaptive capacity is determined by assets/asset groups as well as opinions from the stakeholders and communities.

Table 3-11 Adaptive Capacity

Adaptive Capacity	Description
No adaptation required	Potential impact has insignificant effect on asset. Controls are re-established naturally or with ease before more damage would likely occur.
Very High	Good adaptive capacity. Functionality restored easily. Adaptive systems restored at a relatively low cost or naturally over time.
High	Decent adaptive capacity. Functionality can be restored, although additional adaptive measures should still be considered. Natural adaptive capacity restored slowly over time under average conditions

Adaptive Capacity	Description
Moderate	Small amount of adaptive capacity. Difficult but possible to restore functionality through repair and redesign.
Low	Little or no adaptive capacity. Potential impact would destroy all functionality. Redesign required.

Assigned adaptive capacity ratings by category are presented in Table 3-12 for both erosion and inundation.

Table 3-12 Adaptive capacity rating by asset category

Asset Category	Adaptive Capacity: Erosion	Adaptive Capacity: Inundation
Roads	Low	Moderate
Residential	Low	Moderate
Commercial	Low	Moderate
Public & community	Low	Moderate
Developed foreshore reserve	High	High
Undeveloped foreshore reserve	Moderate	High
Environmental	Low	High
Agricultural / rural	Moderate	High
Aboriginal heritage	Low	Moderate

3.6 Vulnerability

Vulnerability is calculated as the **product** of potential impact (risk level) and the adaptive capacity. As per WAPC (2019), four levels of vulnerability are considered in this study which should be assessed for each of the planning timeframes considered by this CHRMAP.

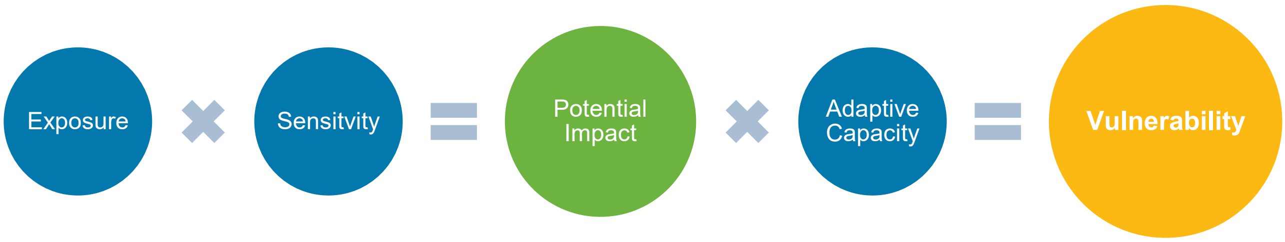

Figure 3-3 Vulnerability relationship

Table 3-13 Vulnerability Matrix as a Product of Risk Level and Adaptive Capacity

Risk Level	Adaptive Capacity			
	Low	Moderate	High	Very High
Extreme	**Extreme**	**Extreme**	**High**	**Medium**
High	**Extreme**	**High**	**Medium**	**Medium**
Medium	**High**	**Medium**	**Medium**	**Low**
Low	**Medium**	**Medium**	**Low**	**Low**

Applying the described methodology, assets in all management units are identified and categorised in the sections below. **Exposure** level is rated as AC (Almost Certain), L (Likely), P (Possible), U (Unlikely) and R (Rare). **Sensitivity** is rated as IN (Insignificant), MI (Minor), MO (Moderate), MA (Major) and CA (Catastrophic). **Risk / potential impact** and **vulnerability** are rated as EX (extreme), HI (High), ME (Medium) and LO (Low). **Adaptive capacity** is rated as VH (Very High), High (HI), Moderate (MO) and Low (LO).

4 VULNERABILITY ANALYSIS

The method discussed in Section 3 was applied to all identified assets. Results by management unit, category and planning horizon are presented for erosion in Appendix A and inundation in Appendix B. These tables present the numbers of each asset type that receive each vulnerability rating.

For each planning horizon, each category was then assigned an overall vulnerability rating. The most conservative rating for each category for each horizon was selected, except when there are less than 5 assets in the highest rating, with the majority in lower ratings. In those cases, the next highest rating has been selected, with the small number in brackets indicating the assets in the rating above. For example, in MU1 there are 18 roads with a High vulnerability rating in 2020, and only 3 with an Extreme rating. So, the overall rating is High (3Ex). In all other cases, the ratings do not consider the number of assets in each rating. For example, there is 1 commercial asset in MU3 that has an extreme rating, so the category receives an extreme rating.

The overall vulnerability rating for each category within each management unit for each planning horizon is presented in Table 4-1 and Table 4-2 below for erosion and inundation respectively. Extreme vulnerability has been identified from the present day onwards. Most of this extreme vulnerability is predicted to be from erosion, with the exception of residential and commercial inundation.

The enormous number of at-risk assets, a total of approximately 48,000, means grouping and summarising is the only meaningful method of assessing the risk at this stage of the planning process. All identified assets and ratings will be supplied in GIS format so relevant governing bodies can review and assign asset-specific actions once the CHRMAP is complete.

Table 4-1 Erosion vulnerability ratings, grouped by management unit & planning horizon

Management Unit	2020	2035	2050	2120	Summary
MU1-Peppermint Grove Beach					
Roads	High (3Ex)	High (3Ex)	Extreme	Extreme	Erosion is a key risk for 5 of the 9 categories within this management unit. Adaptation in some form is required from the present day.
Residential	High (3Ex)	High (3Ex)	Extreme	Extreme	
Public and Community	High	Extreme	Extreme	Extreme	
Foreshore - Undeveloped	High	Extreme	Extreme	Extreme	
Environmental	Extreme	Extreme	Extreme	Extreme	
MU2-Capel Coast					
Roads	High	High	Extreme	Extreme	Erosion is a key risk for 6 of the 9 categories within this management unit. Adaptation in some form is required from the present day.
Public and Community	High	High (1Ex)	Extreme	Extreme	
Foreshore - Undeveloped	High	Extreme	Extreme	Extreme	
Environmental	Extreme	Extreme	Extreme	Extreme	
Agricultural / Rural	High	Extreme	Extreme	Extreme	
Aboriginal Heritage	Extreme	Extreme	Extreme	Extreme	
MU3-Dalyellup					
Residential	High (4Ex)	High (4Ex)	Extreme	Extreme	Erosion is a key risk for 6 of the 9 categories within this management unit. Adaptation in some form is required from the present day.
Commercial	Extreme	Extreme	Extreme	Extreme	
Public and Community	High	Extreme	Extreme	Extreme	
Foreshore - Developed	Medium	Medium	Medium	Medium	
Foreshore - Undeveloped	High	Extreme	Extreme	Extreme	
Environmental	Extreme	Extreme	Extreme	Extreme	
MU4- Bunbury S					
Public and Community	High	High	High	Extreme	Erosion is a key risk for 4 of the 9 categories within this management unit. Adaptation in some form is required from the present day.
Foreshore - Developed	Medium	Medium	Medium	Medium	
Foreshore - Undeveloped	High	Extreme	Extreme	Extreme	
Environmental	Extreme	Extreme	Extreme	Extreme	
MU5-Bunbury					
Roads	Extreme	Extreme	Extreme	Extreme	Erosion is a key risk for 8 of the 9 categories within this management unit. Adaptation in some form is required from the present day.
Residential	High (4Ex)	Extreme	Extreme	Extreme	
Commercial	High (3Ex)	Extreme	Extreme	Extreme	
Public and Community	High (5Ex)	High (5Ex)	Extreme	Extreme	
Foreshore - Developed	Medium	Medium	Medium	Medium	
Foreshore - Undeveloped	High	Extreme	Extreme	Extreme	
Environmental	Extreme	Extreme	Extreme	Extreme	
Aboriginal Heritage	Extreme	Extreme	Extreme	Extreme	
MU6-Bunbury Port					
Roads	Extreme	Extreme	Extreme	Extreme	Erosion is a key risk for 6 of the 9 categories within this management unit. Adaptation in some form is required from the present day.
Commercial	Extreme	Extreme	Extreme	Extreme	

Management Unit	2020	2035	2050	2120	Summary
Public and Community	Extreme	Extreme	Extreme	Extreme	
Foreshore - Undeveloped	High	Extreme	Extreme	Extreme	
Environmental	Extreme	Extreme	Extreme	Extreme	
Agricultural / Rural	Medium	Medium	Medium	Extreme	
MU7-The Cut					
Foreshore - Undeveloped	High	Extreme	Extreme	Extreme	Erosion is a key risk for 2 of the 9 categories within this management unit. Adaptation in some form is required from the present day.
Environmental	Extreme	Extreme	Extreme	Extreme	
MU8-Bunbury E					
Roads	Extreme	Extreme	Extreme	Extreme	Erosion is a key risk for 8 of the 9 categories within this management unit. Adaptation in some form is required from the present day.
Residential	High (3Ex)	Extreme	Extreme	Extreme	
Commercial	Extreme	Extreme	Extreme	Extreme	
Public and Community	Extreme	Extreme	Extreme	Extreme	
Foreshore - Developed	Medium	Medium	Medium	Medium	
Foreshore - Undeveloped	High	Extreme	Extreme	Extreme	
Environmental	Extreme	Extreme	Extreme	Extreme	
Aboriginal Heritage	Extreme	Extreme	Extreme	Extreme	
MU9-Leschenault Estuary					
Roads	Extreme	Extreme	Extreme	Extreme	Erosion is a key risk for 8 of the 9 categories within this management unit. Adaptation in some form is required from the present day.
Residential	High (1Ex)	Extreme	Extreme	Extreme	
Commercial	High	High	Extreme	Extreme	
Public and Community	High	High	Extreme	Extreme	
Foreshore - Undeveloped	High	Extreme	Extreme	Extreme	
Environmental	Extreme	Extreme	Extreme	Extreme	
Agricultural / Rural	Medium (1Hi)	High (1Ex)	Extreme	Extreme	
Aboriginal Heritage	Extreme	Extreme	Extreme	Extreme	
MU10-Collie River S					
Roads	Extreme	Extreme	Extreme	Extreme	Erosion is a key risk for 4 of the 9 categories within this management unit. Adaptation in some form is required from the present day.
Residential	High	Extreme	Extreme	Extreme	
Public and Community	Extreme	Extreme	Extreme	Extreme	
Environmental	Extreme	Extreme	Extreme	Extreme	
MU11-Collie River N					
Roads	High (4Ex)	Extreme	Extreme	Extreme	Erosion is a key risk for 5 of the 9 categories within this management unit. Adaptation in some form is required from the present day.
Residential	High (1Ex)	Extreme	Extreme	Extreme	
Public and Community	Extreme	Extreme	Extreme	Extreme	
Foreshore - Undeveloped	High	Extreme	Extreme	Extreme	
Environmental	Extreme	Extreme	Extreme	Extreme	

Table 4-2 Inundation vulnerability ratings, grouped by management unit & planning horizon

Management Unit	2020	2035	2050	2120	Summary
MU1-Peppermint Grove Beach					
Roads	Medium	Medium	Medium	Medium	▪ Inundation is a medium risk for 5 of the 9 categories within this management unit. Adaptation in some form may be required from the present day (public & community has a high vulnerability rating in 2120). ▪ Inundation is an extreme risk for residential and commercial assets. For these categories, adaptation in some form is required from the present day.
Residential	Extreme	Extreme	Extreme	Extreme	
Commercial	Extreme	Extreme	Extreme	Extreme	
Public and Community	Medium	Medium	Medium	High	
Foreshore - Undeveloped	Medium	Medium	Medium	Medium	
Environmental	Medium	Medium	Medium	Medium	
Agricultural / Rural	Medium	Medium	Medium	Medium	
MU2-Capel Coast					
Roads	Medium	Medium	Medium	Medium	▪ Inundation is a medium / high risk for 7 of the 9 categories within this management unit. Adaptation in some form may be required from the present day. ▪ Inundation is an extreme risk for 1 commercial asset in 2120.
Commercial	Medium	High	High	Extreme	
Public and Community	Medium (1Hi)	Medium (1Hi)	Medium (1Hi)	High	
Foreshore - Undeveloped	Medium	Medium	Medium	Medium	
Environmental	Medium	Medium	Medium	Medium	
Agricultural / Rural	Medium	Medium	Medium	Medium	
Aboriginal Heritage	High	High	High	High	
MU3-Dalyellup					
Environmental	Medium	Medium	Medium	Medium	Inundation is of medium risk to environmental assets from the present day. Adaptation in some form may be required.
MU4- Bunbury S					
Foreshore - Developed	Medium	Medium	Medium	Medium	Inundation is a medium risk for 3 of the 9 categories within this management unit. Adaptation in some form may be required from the present day.
Foreshore - Undeveloped	Medium	Medium	Medium	Medium	
Environmental	Medium	Medium	Medium	Medium	
MU5-Bunbury					
Roads	Medium	Medium	Medium	Medium	▪ Inundation is a medium / high risk for 6 of the 9 categories within this management unit. Adaptation in some form may be required from the present day. ▪ Inundation is an extreme risk for residential and commercial assets. For these categories, adaptation in some form is required from the present day.
Residential	Extreme	Extreme	Extreme	Extreme	
Commercial	Extreme	Extreme	Extreme	Extreme	
Public and Community	High	High	High	High	
Foreshore - Developed	Medium	Medium	Medium	Medium	
Foreshore - Undeveloped	Medium	Medium	Medium	Medium	
Environmental	Medium	Medium	Medium	Medium	
Aboriginal Heritage	High	High	High	High	
MU6-Bunbury Port					
Roads	Medium	Medium	Medium	Medium	▪ Inundation is a medium / high risk for 5 of the 9 categories within this management unit. Adaptation in some form may be required from the present day. ▪ Inundation is an extreme risk for commercial assets. For these categories, Adaptation in some form is required from the present day.
Commercial	Extreme	Extreme	Extreme	Extreme	
Public and Community	Medium	Medium	Medium	High	
Foreshore - Undeveloped	Medium	Medium	Medium	Medium	
Environmental	Medium	Medium	Medium	Medium	

Management Unit	2020	2035	2050	2120	Summary
Agricultural / Rural	Medium	Medium	Medium	Medium	
MU7-The Cut					
Foreshore - Undeveloped	Medium	Medium	Medium	Medium	Inundation is a medium risk for 2 of the 9 categories within this management unit. Adaptation in some form may be required from the present day.
Environmental	Medium	Medium	Medium	Medium	
MU8-Bunbury E					
Roads	Medium	Medium	Medium	Medium	▪ Inundation is a medium / high risk for 7 of the 9 categories within this management unit. Adaptation in some form may be required from the present day. ▪ Inundation is an extreme risk for residential and commercial assets. For these categories, adaptation in some form is required from the present day.
Residential	Extreme	Extreme	Extreme	Extreme	
Commercial	Extreme	Extreme	Extreme	Extreme	
Public and Community	High	High	High	High	
Foreshore - Developed	Medium	Medium	Medium	Medium	
Foreshore - Undeveloped	Medium	Medium	Medium	Medium	
Environmental	Medium	Medium	Medium	Medium	
Agricultural / Rural	Low	Medium	Medium	Medium	
Aboriginal Heritage	High	High	High	High	
MU9-Leschenault Estuary					
Roads	Medium	Medium	Medium	Medium	▪ Inundation is a medium / high risk for 6 of the 9 categories within this management unit. Adaptation in some form may be required from the present day. ▪ Inundation is an extreme risk for residential assets. Adaptation in some form is required from the present day. ▪ By 2050, inundation is an extreme risk for commercial assets. Adaptation in some form is required from the present day.
Residential	Extreme	Extreme	Extreme	Extreme	
Commercial	Medium	High (1Ex)	Extreme	Extreme	
Public and Community	High	High	High	High	
Foreshore - Undeveloped	Medium	Medium	Medium	Medium	
Environmental	Medium	Medium	Medium	Medium	
Agricultural / Rural	Medium	Medium	Medium	Medium	
Aboriginal Heritage	High	High	High	High	
MU10-Collie River S					
Roads	Medium	Medium	Medium	Medium	▪ Inundation is a medium / high risk for 4 of the 9 categories within this management unit. Adaptation in some form may be required from the present day. ▪ Inundation is an extreme risk for residential and commercial assets from 2035. For these categories, adaptation in some form is required from the present day / 2035.
Residential	Medium	Extreme	Extreme	Extreme	
Commercial	Medium	Extreme	Extreme	Extreme	
Public and Community	High	High	High	High	
Environmental	Medium	Medium	Medium	Medium	
Aboriginal Heritage	Medium	High	High	High	
MU11-Collie River N					
Roads	Medium	Medium	Medium	Medium	▪ Inundation is a medium / high risk for 4 of the 9 categories within this management unit. Adaptation in some form may be required from the present day. ▪ Inundation is an extreme risk for some residential assets. Adaptation in some form is required from the present day.
Residential	Medium (3Ex)	High (3Ex)	High (3Ex)	Extreme	
Public and Community	High	High	High	High	
Foreshore - Undeveloped	Medium	Medium	Medium	Medium	
Environmental	Medium	Medium	Medium	Medium	

5 SUMMARY

This report presents the vulnerability analysis for the Capel to Leschenault CHRMAP. The vulnerability results are presented in full in Appendix A and Appendix B; a summary is presented in Section 4.

The next report will present the risk evaluation, which updates the risk priorities in context of any physical and planning controls. Risk treatment options will also be identified and assessed with a multi-criteria analysis. Risk treatment options will be considered for each management unit as a whole, with consideration to the categories and number of assets at risk.

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APPENDIX A
VULNERABILITY RESULTS: EROSION

Table A-1 Erosion vulnerability ratings for present day, grouped by management unit & asset category

Management Unit	Low	Medium	High	Extreme	Overall Rating
MU1-Peppermint Grove Beach		**5**	**192**	**34**	
Roads			18	3	High (3Ex)
Residential			151	3	High (3Ex)
Public and Community			2		High
Foreshore - Undeveloped		5	10		High
Environmental			11	28	Extreme
MU2-Capel Coast		**38**	**82**	**77**	
Roads			6		High
Public and Community			4		High
Foreshore - Undeveloped		3	7		High
Environmental			45	71	Extreme
Agricultural / Rural		35	20		High
Aboriginal Heritage				6	Extreme
MU3-Dalyellup		**1**	**89**	**22**	
Residential			60	4	High (4Ex)
Commercial				1	Extreme
Public and Community			3		High
Foreshore - Developed		1			Medium
Foreshore - Undeveloped			1		High
Environmental			25	17	Extreme
MU4- Bunbury S		**1**	**7**	**8**	
Public and Community			2		High
Foreshore - Developed		1			Medium
Foreshore - Undeveloped			1		High
Environmental			4	8	Extreme
MU5-Bunbury	**5**	**17**	**450**	**92**	
Roads			41	16	Extreme
Residential			263	4	High (4Ex)
Commercial			5	3	High (3Ex)
Public and Community			45	5	High (5Ex)
Foreshore - Developed	5	15			Medium
Foreshore - Undeveloped		2	14		High
Environmental			81	60	Extreme
Aboriginal Heritage			1	4	Extreme
MU6-Bunbury Port		**2**	**47**	**67**	
Roads				3	Extreme
Commercial				13	Extreme
Public and Community				2	Extreme
Foreshore - Undeveloped			6		High

Management Unit	Low	Medium	High	Extreme	Overall Rating
Environmental			41	49	Extreme
Agricultural / Rural		2			Medium
MU7-The Cut			**102**	**28**	
Foreshore - Undeveloped			1		High
Environmental			101	28	Extreme
MU8-Bunbury E	**1**	**4**	**142**	**110**	
Roads			9	10	Extreme
Residential			89	3	High (3Ex)
Commercial				2	Extreme
Public and Community			6	16	Extreme
Foreshore - Developed	1	4			Medium
Foreshore - Undeveloped			8		High
Environmental			28	76	Extreme
Aboriginal Heritage			2	3	Extreme
MU9-Leschenault Estuary		**33**	**280**	**278**	
Roads			28	9	Extreme
Residential			85	1	High (1Ex)
Commercial			5		High
Public and Community			27		High
Foreshore - Undeveloped		1	41		High
Environmental			93	266	Extreme
Agricultural / Rural		32	1		Medium (1Hi)
Aboriginal Heritage				2	Extreme
MU10-Collie River S			**37**	**67**	
Roads			3	4	Extreme
Residential			14		High
Public and Community			2	6	Extreme
Environmental			18	57	Extreme
MU11-Collie River N			**71**	**57**	
Roads			9	4	High (4Ex)
Residential			48	1	High (1Ex)
Public and Community			3	3	Extreme
Foreshore - Undeveloped			3		High
Environmental			8	49	Extreme

Table A-2 Erosion vulnerability ratings for 2035, grouped by management unit & asset category

Management Unit	Low	Medium	High	Extreme	Overall Rating
MU1-Peppermint Grove Beach			**184**	**47**	
Roads			18	3	High (3Ex)
Residential			151	3	High (3Ex)
Public and Community			1	1	Extreme
Foreshore - Undeveloped			5	10	Extreme
Environmental			9	30	Extreme
MU2-Capel Coast		**37**	**47**	**113**	
Roads			6		High
Public and Community			3	1	High (1Ex)
Foreshore - Undeveloped		3		7	Extreme
Environmental			37	79	Extreme
Agricultural / Rural		34	1	20	Extreme
Aboriginal Heritage				6	Extreme
MU3-Dalyellup		**1**	**82**	**29**	
Residential			60	4	High (4Ex)
Commercial				1	Extreme
Public and Community				3	Extreme
Foreshore - Developed		1			Medium
Foreshore - Undeveloped				1	Extreme
Environmental			22	20	Extreme
MU4- Bunbury S		**1**	**5**	**10**	
Public and Community			2		High
Foreshore - Developed		1			Medium
Foreshore - Undeveloped				1	Extreme
Environmental			3	9	Extreme
MU5-Bunbury	**2**	**19**	**394**	**149**	
Roads			36	21	Extreme
Residential			234	33	Extreme
Commercial			4	4	Extreme
Public and Community			45	5	High (5Ex)
Foreshore - Developed	2	18			Medium
Foreshore - Undeveloped		1	1	14	Extreme
Environmental			73	68	Extreme
Aboriginal Heritage			1	4	Extreme
MU6-Bunbury Port		**2**	**34**	**80**	
Roads				3	Extreme
Commercial				13	Extreme
Public and Community				2	Extreme
Foreshore - Undeveloped				6	Extreme

Management Unit	Low	Medium	High	Extreme	Overall Rating
Environmental			34	56	Extreme
Agricultural / Rural		2			Medium
MU7-The Cut			**11**	**119**	
Foreshore - Undeveloped				1	Extreme
Environmental			11	118	Extreme
MU8-Bunbury E	**1**	**4**	**118**	**134**	
Roads			6	13	Extreme
Residential			81	11	Extreme
Commercial				2	Extreme
Public and Community			5	17	Extreme
Foreshore - Developed	1	4			Medium
Foreshore - Undeveloped				8	Extreme
Environmental			24	80	Extreme
Aboriginal Heritage			2	3	Extreme
MU9-Leschenault Estuary		**30**	**201**	**360**	
Roads			21	16	Extreme
Residential			71	15	Extreme
Commercial			5		High
Public and Community			27		High
Foreshore - Undeveloped		1		41	Extreme
Environmental			74	285	Extreme
Agricultural / Rural		29	3	1	High (1Ex)
Aboriginal Heritage				2	Extreme
MU10-Collie River S			**21**	**83**	
Roads			3	4	Extreme
Residential			8	6	Extreme
Public and Community			1	7	Extreme
Environmental			9	66	Extreme
MU11-Collie River N			**49**	**79**	
Roads			7	6	Extreme
Residential			32	17	Extreme
Public and Community			3	3	Extreme
Foreshore - Undeveloped				3	Extreme
Environmental			7	50	Extreme

Table A-3 Erosion vulnerability ratings for 2050, grouped by management unit & asset category

Management Unit	Low	Medium	High	Extreme	Overall Rating
MU1-Peppermint Grove Beach			**8**	**223**	
Roads				21	Extreme
Residential				154	Extreme
Public and Community			1	1	Extreme
Foreshore - Undeveloped				15	Extreme
Environmental			7	32	Extreme
MU2-Capel Coast		**35**	**37**	**125**	
Roads				6	Extreme
Public and Community			1	3	Extreme
Foreshore - Undeveloped		1	2	7	Extreme
Environmental			34	82	Extreme
Agricultural / Rural		34		21	Extreme
Aboriginal Heritage				6	Extreme
MU3-Dalyellup		**1**	**21**	**90**	
Residential				64	Extreme
Commercial				1	Extreme
Public and Community				3	Extreme
Foreshore - Developed		1			Medium
Foreshore - Undeveloped				1	Extreme
Environmental			21	21	Extreme
MU4- Bunbury S		**1**	**5**	**10**	
Public and Community			2		High
Foreshore - Developed		1			Medium
Foreshore - Undeveloped				1	Extreme
Environmental			3	9	Extreme
MU5-Bunbury		**21**	**104**	**439**	
Roads				57	Extreme
Residential				267	Extreme
Commercial				8	Extreme
Public and Community			36	14	Extreme
Foreshore - Developed		20			Medium
Foreshore - Undeveloped		1		15	Extreme
Environmental			67	74	Extreme
Aboriginal Heritage			1	4	Extreme
MU6-Bunbury Port		**2**	**34**	**80**	
Roads				3	Extreme
Commercial				13	Extreme
Public and Community				2	Extreme
Foreshore - Undeveloped				6	Extreme

Management Unit	Low	Medium	High	Extreme	Overall Rating
Environmental			34	56	Extreme
Agricultural / Rural		2			Medium
MU7-The Cut			**11**	**119**	
Foreshore - Undeveloped				1	Extreme
Environmental			11	118	Extreme
MU8-Bunbury E		**5**	**28**	**224**	
Roads				19	Extreme
Residential				92	Extreme
Commercial				2	Extreme
Public and Community			5	17	Extreme
Foreshore - Developed		5			Medium
Foreshore - Undeveloped				8	Extreme
Environmental			22	82	Extreme
Aboriginal Heritage			1	4	Extreme
MU9-Leschenault Estuary		**26**	**88**	**477**	
Roads				37	Extreme
Residential				86	Extreme
Commercial				5	Extreme
Public and Community			21	6	Extreme
Foreshore - Undeveloped		1		41	Extreme
Environmental			63	296	Extreme
Agricultural / Rural		25	4	4	Extreme
Aboriginal Heritage				2	Extreme
MU10-Collie River S			**7**	**97**	
Roads				7	Extreme
Residential				14	Extreme
Public and Community			1	7	Extreme
Environmental			6	69	Extreme
MU11-Collie River N			**10**	**118**	
Roads				13	Extreme
Residential				49	Extreme
Public and Community			3	3	Extreme
Foreshore - Undeveloped				3	Extreme
Environmental			7	50	Extreme

Table A-4 Erosion vulnerability ratings for 2120, grouped by management unit & asset category

Management Unit	Low	Medium	High	Extreme	Overall Rating
MU1-Peppermint Grove Beach				**231**	
Roads				21	Extreme
Residential				154	Extreme
Public and Community				2	Extreme
Foreshore - Undeveloped				15	Extreme
Environmental				39	Extreme
MU2-Capel Coast				**197**	
Roads				6	Extreme
Public and Community				4	Extreme
Foreshore - Undeveloped				10	Extreme
Environmental				116	Extreme
Agricultural / Rural				55	Extreme
Aboriginal Heritage				6	Extreme
MU3-Dalyellup		**1**		**111**	
Residential				64	Extreme
Commercial				1	Extreme
Public and Community				3	Extreme
Foreshore - Developed		1			Medium
Foreshore - Undeveloped				1	Extreme
Environmental				42	Extreme
MU4- Bunbury S		**1**		**15**	
Public and Community				2	Extreme
Foreshore - Developed		1			Medium
Foreshore - Undeveloped				1	Extreme
Environmental				12	Extreme
MU5-Bunbury		**20**		**544**	
Roads				57	Extreme
Residential				267	Extreme
Commercial				8	Extreme
Public and Community				50	Extreme
Foreshore - Developed		20			Medium
Foreshore - Undeveloped				16	Extreme
Environmental				141	Extreme
Aboriginal Heritage				5	Extreme
MU6-Bunbury Port				**116**	
Roads				3	Extreme
Commercial				13	Extreme
Public and Community				2	Extreme
Foreshore - Undeveloped				6	Extreme

Management Unit	Low	Medium	High	Extreme	Overall Rating
Environmental				90	Extreme
Agricultural / Rural				2	Extreme
MU7-The Cut				**130**	
Foreshore - Undeveloped				1	Extreme
Environmental				129	Extreme
MU8-Bunbury E		**5**		**252**	
Roads				19	Extreme
Residential				92	Extreme
Commercial				2	Extreme
Public and Community				22	Extreme
Foreshore - Developed		5			Medium
Foreshore - Undeveloped				8	Extreme
Environmental				104	Extreme
Aboriginal Heritage				5	Extreme
MU9-Leschenault Estuary				**591**	
Roads				37	Extreme
Residential				86	Extreme
Commercial				5	Extreme
Public and Community				27	Extreme
Foreshore - Undeveloped				42	Extreme
Environmental				359	Extreme
Agricultural / Rural				33	Extreme
Aboriginal Heritage				2	Extreme
MU10-Collie River S				**104**	
Roads				7	Extreme
Residential				14	Extreme
Public and Community				8	Extreme
Environmental				75	Extreme
MU11-Collie River N				**128**	
Roads				13	Extreme
Residential				49	Extreme
Public and Community				6	Extreme
Foreshore - Undeveloped				3	Extreme
Environmental				57	Extreme

APPENDIX B
VULNERABILITY RESULTS: INUNDATION

Table B-5 Inundation vulnerability ratings for present day, grouped by management unit & asset category

Management Unit	Low	Medium	High	Extreme	Overall Rating
MU1-Peppermint Grove Beach	**35**	**92**		**3**	
Roads		2			Medium
Residential		4		2	Extreme
Commercial				1	Extreme
Public and Community		3			Medium
Foreshore - Undeveloped	4	2			Medium
Environmental	29	58			Medium
Agricultural / Rural	2	23			Medium
MU2-Capel Coast	**247**	**515**	**7**		
Roads		64			Medium
Commercial		1			Medium
Public and Community		4	1		Medium (1Hi)
Foreshore - Undeveloped		5			Medium
Environmental	175	275			Medium
Agricultural / Rural	72	165			Medium
Aboriginal Heritage		1	6		High
MU3-Dalyellup		**5**			
Environmental		5			Medium
MU4- Bunbury S		**9**			
Foreshore - Developed		1			Medium
Foreshore - Undeveloped		1			Medium
Environmental		7			Medium
MU5-Bunbury	**232**	**1710**	**46**	**28**	
Roads		211			Medium
Residential		1160		20	Extreme
Commercial		113		8	Extreme
Public and Community		121	42		High
Foreshore - Developed	17	19			Medium
Foreshore - Undeveloped	1	16			Medium
Environmental	214	69			Medium
Aboriginal Heritage		1	4		High
MU6-Bunbury Port	**68**	**93**		**8**	
Roads		13			Medium
Commercial		9		8	Extreme
Public and Community		6			Medium
Foreshore - Undeveloped		6			Medium
Environmental	62	58			Medium
Agricultural / Rural	6	1			Medium
MU7-The Cut	**94**	**33**			

Management Unit	Low	Medium	High	Extreme	Overall Rating
Foreshore - Undeveloped		1			Medium
Environmental	94	32			Medium
MU8-Bunbury E	**77**	**743**	**33**	**19**	
Roads		97			Medium
Residential		423		10	Extreme
Commercial		7		9	Extreme
Public and Community		39	27		High
Foreshore - Developed	1	5			Medium
Foreshore - Undeveloped		8			Medium
Environmental	63	157			Medium
Agricultural / Rural	13				Low
Aboriginal Heritage		7	6		High
MU9-Leschenault Estuary	**80**	**660**	**8**	**5**	
Roads		48			Medium
Residential		137		5	Extreme
Commercial		5			Medium
Public and Community		21	6		High
Foreshore - Undeveloped		41			Medium
Environmental	63	359			Medium
Agricultural / Rural	17	49			Medium
Aboriginal Heritage			2		High
MU10-Collie River S	**30**	**137**	**6**		
Roads		6			Medium
Residential		53			Medium
Commercial		3			Medium
Public and Community		13	6		High
Environmental	30	60			Medium
Aboriginal Heritage		2			Medium
MU11-Collie River N	**13**	**112**	**4**	**3**	
Roads		11			Medium
Residential		35		3	Medium (3Ex)
Public and Community		4	4		High
Foreshore - Undeveloped		3			Medium
Environmental	13	59			Medium

Table B-6 Inundation vulnerability ratings for 2035, grouped by management unit & asset category

Management Unit	Low	Medium	High	Extreme	Overall Rating
MU1-Peppermint Grove Beach		**131**	**1**	**3**	
Roads		3			Medium
Residential		3	1	2	Extreme
Commercial				1	Extreme
Public and Community		3			Medium
Foreshore - Undeveloped		7			Medium
Environmental		90			Medium
Agricultural / Rural		25			Medium
MU2-Capel Coast		**766**	**8**		
Roads		65			Medium
Commercial			1		High
Public and Community		4	1		Medium (1Hi)
Foreshore - Undeveloped		5			Medium
Environmental		452			Medium
Agricultural / Rural		239			Medium
Aboriginal Heritage		1	6		High
MU3-Dalyellup		**5**			
Environmental		5			Medium
MU4- Bunbury S		**9**			
Foreshore - Developed		1			Medium
Foreshore - Undeveloped		1			Medium
Environmental		7			Medium
MU5-Bunbury		**1983**	**145**	**65**	
Roads		221			Medium
Residential		1166	96	57	Extreme
Commercial		115	1	8	Extreme
Public and Community		122	44		High
Foreshore - Developed		40			Medium
Foreshore - Undeveloped		17			Medium
Environmental		301			Medium
Aboriginal Heritage		1	4		High
MU6-Bunbury Port		**152**	**3**	**14**	
Roads		13			Medium
Commercial			3	14	Extreme
Public and Community		6			Medium
Foreshore - Undeveloped		6			Medium
Environmental		120			Medium
Agricultural / Rural		7			Medium
MU7-The Cut		**127**			

Management Unit	Low	Medium	High	Extreme	Overall Rating
Foreshore - Undeveloped		1			Medium
Environmental		126			Medium
MU8-Bunbury E		**499**	**261**	**118**	
Roads		97			Medium
Residential		112	218	109	Extreme
Commercial		4	3	9	Extreme
Public and Community		36	30		High
Foreshore - Developed		6			Medium
Foreshore - Undeveloped		8			Medium
Environmental		220			Medium
Agricultural / Rural		13			Medium
Aboriginal Heritage		3	10		High
MU9-Leschenault Estuary		**607**	**126**	**51**	
Roads		51			Medium
Residential		2	102	50	Extreme
Commercial			4	1	High (1Ex)
Public and Community		13	18		High
Foreshore - Undeveloped		41			Medium
Environmental		434			Medium
Agricultural / Rural		66			Medium
Aboriginal Heritage			2		High
MU10-Collie River S		**117**	**44**	**12**	
Roads		6			Medium
Residential		19	25	9	Extreme
Commercial				3	Extreme
Public and Community		2	17		High
Environmental		90			Medium
Aboriginal Heritage			2		High
MU11-Collie River N		**115**	**14**	**3**	
Roads		11			Medium
Residential		26	9	3	High (3Ex)
Public and Community		3	5		High
Foreshore - Undeveloped		3			Medium
Environmental		72			Medium

Table B-7 Inundation vulnerability ratings for 2050, grouped by management unit & asset category

Management Unit	Low	Medium	High	Extreme	Overall Rating
MU1-Peppermint Grove Beach		**135**	**1**	**3**	
Roads		4			Medium
Residential		3	1	2	Extreme
Commercial				1	Extreme
Public and Community		4			Medium
Foreshore - Undeveloped		8			Medium
Environmental		91			Medium
Agricultural / Rural		25			Medium
MU2-Capel Coast		**783**	**8**		
Roads		67			Medium
Commercial			1		High
Public and Community		4	1		Medium (1Hi)
Foreshore - Undeveloped		5			Medium
Environmental		465			Medium
Agricultural / Rural		241			Medium
Aboriginal Heritage		1	6		High
MU3-Dalyellup		**5**			
Environmental		5			Medium
MU4- Bunbury S		**9**			
Foreshore - Developed		1			Medium
Foreshore - Undeveloped		1			Medium
Environmental		7			Medium
MU5-Bunbury		**2337**	**160**	**67**	
Roads		256			Medium
Residential		1445	111	58	Extreme
Commercial		132	1	9	Extreme
Public and Community		143	44		High
Foreshore - Developed		40			Medium
Foreshore - Undeveloped		17			Medium
Environmental		303			Medium
Aboriginal Heritage		1	4		High
MU6-Bunbury Port		**152**	**2**	**15**	
Roads		13			Medium
Commercial			2	15	Extreme
Public and Community		6			Medium
Foreshore - Undeveloped		6			Medium
Environmental		120			Medium
Agricultural / Rural		7			Medium
MU7-The Cut		**127**			

Management Unit	Low	Medium	High	Extreme	Overall Rating
Foreshore - Undeveloped		1			Medium
Environmental		126			Medium
MU8-Bunbury E		**480**	**251**	**159**	
Roads		97			Medium
Residential		98	203	150	Extreme
Commercial		1	6	9	Extreme
Public and Community		35	31		High
Foreshore - Developed		6			Medium
Foreshore - Undeveloped		8			Medium
Environmental		220			Medium
Agricultural / Rural		13			Medium
Aboriginal Heritage		2	11		High
MU9-Leschenault Estuary		**609**	**139**	**65**	
Roads		54			Medium
Residential			113	61	Extreme
Commercial			1	4	Extreme
Public and Community		9	23		High
Foreshore - Undeveloped		41			Medium
Environmental		439			Medium
Agricultural / Rural		66			Medium
Aboriginal Heritage			2		High
MU10-Collie River S		**112**	**43**	**18**	
Roads		6			Medium
Residential		14	24	15	Extreme
Commercial				3	Extreme
Public and Community		2	17		High
Environmental		90			Medium
Aboriginal Heritage			2		High
MU11-Collie River N		**101**	**28**	**3**	
Roads		11			Medium
Residential		13	22	3	High (3Ex)
Public and Community		2	6		High
Foreshore - Undeveloped		3			Medium
Environmental		72			Medium

Table B-8 Inundation vulnerability ratings for 2120, grouped by management unit & asset category

Management Unit	Low	Medium	High	Extreme	Overall Rating
MU1-Peppermint Grove Beach		**151**	**31**	**7**	
Roads		12			Medium
Residential			27	6	Extreme
Commercial				1	Extreme
Public and Community		1	4		High
Foreshore - Undeveloped		14			Medium
Environmental		99			Medium
Agricultural / Rural		25			Medium
MU2-Capel Coast		**873**	**12**	**1**	
Roads		82			Medium
Commercial				1	Extreme
Public and Community		3	5		High
Foreshore - Undeveloped		7			Medium
Environmental		529			Medium
Agricultural / Rural		252			Medium
Aboriginal Heritage			7		High
MU3-Dalyellup		**5**			
Environmental		5			Medium
MU4- Bunbury S		**9**			
Foreshore - Developed		1			Medium
Foreshore - Undeveloped		1			Medium
Environmental		7			Medium
MU5-Bunbury		**982**	**1429**	**2192**	
Roads		476			Medium
Residential			849	1672	Extreme
Commercial			376	520	Extreme
Public and Community		37	199		High
Foreshore - Developed		42			Medium
Foreshore - Undeveloped		17			Medium
Environmental		410			Medium
Aboriginal Heritage			5		High
MU6-Bunbury Port		**175**	**6**	**17**	
Roads		15			Medium
Commercial				17	Extreme
Public and Community			6		High
Foreshore - Undeveloped		6			Medium
Environmental		147			Medium
Agricultural / Rural		7			Medium
MU7-The Cut		**128**			

Management Unit	Low	Medium	High	Extreme	Overall Rating
Foreshore - Undeveloped		1			Medium
Environmental		127			Medium
MU8-Bunbury E		**380**	**139**	**562**	
Roads		117			Medium
Residential			53	545	Extreme
Commercial			4	17	Extreme
Public and Community		5	68		High
Foreshore - Developed		6			Medium
Foreshore - Undeveloped		8			Medium
Environmental		231			Medium
Agricultural / Rural		13			Medium
Aboriginal Heritage			14		High
MU9-Leschenault Estuary		**661**	**43**	**254**	
Roads		59			Medium
Residential				245	Extreme
Commercial				9	Extreme
Public and Community			41		High
Foreshore - Undeveloped		42			Medium
Environmental		488			Medium
Agricultural / Rural		72			Medium
Aboriginal Heritage			2		High
MU10-Collie River S		**99**	**22**	**59**	
Roads		6			Medium
Residential				56	Extreme
Commercial				3	Extreme
Public and Community		1	20		High
Environmental		92			Medium
Aboriginal Heritage			2		High
MU11-Collie River N		**87**	**10**	**50**	
Roads		12			Medium
Residential			2	50	Extreme
Public and Community			8		High
Foreshore - Undeveloped		3			Medium
Environmental		72			Medium

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Appendix E

Capel to Leschenault CHRMAP

Chapter Report: Risk Evaluation and Treatment

Peron Naturaliste Partnership

30 August 2022

Document Status

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Project Details

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EXECUTIVE SUMMARY

It is internationally recognised that the mean sea level has been rising globally since the nineteenth century and is predicted to rise at an increasing rate in the future (IPCC 2021). Rising sea levels and intensifying storm activity will increase the risk of coastal inundation (temporary coastal flooding), storm erosion and long-term shoreline recession. State governments across Australia have introduced statutory obligations that require local governments to consider and plan for these hazards. In Western Australia (WA), the governing policy is the Western Australian Planning Commission's (WAPC) State Planning Policy No. 2.6: State Coastal Planning Policy (WAPC, 2013, herein referred to as "SPP2.6"). SPP2.6 recommends management authorities develop a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for land use or development that is potentially vulnerable to coastal hazards. Specific guidelines have been developed to assist in this process (WAPC, 2019).

SPP2.6 requires adequate risk management planning is undertaken where existing or proposed development is in an area at risk of being affected by coastal hazards over the 100-year planning timeframe. SPP2.6 and the CHRMAP Guidelines provide the risk assessment framework to be applied to identify risks that are intolerable to the community, and other stakeholders such as local governments, indigenous and cultural interests, and private enterprise. Risk Management measures are then developed according to the adaptation hierarchy outlined in SPP2.6.

The Peron Naturaliste Partnership (PNP) comprises membership of nine local government authorities. The PNP's Coastal Adaptation Pathways Project identified the coastal areas of Capel, Leschenault and Greater Bunbury as being particularly exposed to coastal hazards and climate change, which triggered the need for this CHRMAP. The aim of the present study is therefore to investigate the nature and severity of coastal hazards which are likely to affect these regions from Capel to Leschenault over future planning horizons. Refer Figure 1-2 for locality and study area extent.

The objective of this CHRMAP project is to increase knowledge and understanding of coastal hazard risks, and identify risk management and adaptation measures for implementation. The outcomes will be used to inform local and state government policies, strategies and plans, including (but not limited to); planning strategies, community strategic plans, drainage strategies, asset management plans, emergency management plans, and foreshore management plans. The project will adhere to the WAPC (2019) guidelines with scope and deliverables to be consistent with the objectives identified by these guidelines and SPP2.6. The project will identify the strategic direction for coastal adaptation scenarios from the present-day to 2120 (100 yrs. management time frame), and identify an implementation plan to achieve this direction. Overall, this CHRMAP will develop a flexible adaptation pathway for the region and serve as a key reference for management, planning and policy making for the short-term (0-15 years), medium-term (15-30 years), and long-term (100 years).

This report presents the Risk Evaluation and Treatment Chapter Report, which identifies risks and presents and assesses treatment options using multi-criteria analysis. The flow chart displayed in Figure 1-1 indicates where this component sits with reference to the greater study; this analysis corresponds to the red bubble, also presented below.

Risk Evaluation & Treatment

- Identify existing controls and mitigation measures: physical & planning schemes to mitigate the above risks
- Priorities for Risk Treatment
- Update risks accordingly; identify prioritised risk action list based on Success Criteria & existing controls
- Identify Risk Treatment Options
- Multi-Criteria Analysis (MCA).

The vulnerability ratings assigned in the previous chapter report (Water Technology, 2022b) were assessed against any available controls. No changes to the vulnerability results are required: existing vulnerability results become final results.

The erosion and inundation vulnerability ratings were considered for each MU as a whole by averaging the vulnerability ratings of individual asset categories; see Table 2-1 and Table 2-2. All MUs at all planning horizons have unacceptable levels of vulnerability for both erosion and inundation (medium or above) and therefore need to be considered for risk treatment options. The tables depict the greater vulnerabilities to erosion in the study area compared to inundation, and the relativity of vulnerability to each hazard between MUs.

Potential risk treatment options are described in Sections 3 to 6 with context to the adaptation hierarchy and site-specific conditions. All relevant options are then assessed using a multi-criteria analysis in Section 7, with full results presented in Appendix B. The results summary table is replicated below.

The next report will present the cost benefit analysis and benefit distribution analysis of the positively scored adaptation options. Their adaptation pathways, including identifying triggers, will also be presented.

Table 1-1 MCA summary by MU: Options recommended for further investigation (+ve scores, green), unclear options (0 score, amber) & options not recommended (-ve scores, red).

Option	MU1	MU2	MU3	MU4	MU5	MU6	MU7	MU8	MU9	MU10	MU11
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	11	11	11	11	11	11	11	11	11	11	11
Leaving assets unprotected (PMR1)	2	2	2	2	2	2	2	2	2	2	2
Demolition / removal / relocation of asset from inside hazard area (PMR2)	7	7	7	7	7	7	7	7	7	7	7
Prevention of further development / prohibit expansion of existing use rights (PMR3)	5	6	6	10	6	6	N/A	6	6	9	6
Voluntary acquisition (PMR4)	4	4	5	N/A	5	5	N/A	5	5	7	5
Design assets to withstand impacts (AC1)	9	10	N/A	10	9	10	12	9	9	9	9
Beach nourishment or replenishment (PR1)	3	-4	3	-7	3	4	4	2	3	3	3
Groynes (PR2)	0	-6	0	-11	1	3	3	0	0	-1	-1
Seawalls (PR3)	-6	-10	-6	-12	-2	0	0	0	0	-1	-1
Artificial reef (PR4)	-3	-6	-4	-10	-3	-4	-4	-5	-4	N/A	N/A
Offshore breakwater (PR5)	-5	-7	-6	-12	0	-3	-4	-1	0	N/A	N/A
Levy / Weir / Storm Surge Barrier (PR6)	4	6	N/A	N/A	4	3	N/A	1	1	1	1
Monitoring (NR1)	7	7	7	7	7	7	7	7	7	7	7
Protection Structure Audit (NR2)	N/A	N/A	N/A	N/A	6	6	6	6	6	N/A	N/A
Notification on title (NR3)	7	7	7	7	7	7	7	6	6	6	6
Emergency evacuation plans (NR4)	6	6	N/A	N/A	6	6	N/A	7	6	7	7
Do nothing (DN1)	-10	-8	-8	-8	-8	-8	-8	-8	-11	-8	-8

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APPENDICES

LIST OF FIGURES

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1 INTRODUCTION

It is internationally recognised that the mean sea level has been rising globally since the nineteenth century and is predicted to rise at an increasing rate in the future (IPCC 2021). Rising sea levels and intensifying storm activity will increase the risk of coastal inundation (temporary coastal flooding), storm erosion and long-term shoreline recession. State governments across Australia have introduced obligations that require local governments to consider and plan for these hazards. In Western Australia (WA), the governing policy is the Western Australian Planning Commission's (WAPC) State Planning Policy No. 2.6: State Coastal Planning Policy (WAPC, 2013, herein referred to as "SPP2.6"). SPP2.6 recommends management authorities develop a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for land use or development that is potentially vulnerable to coastal hazards. Specific guidelines have been developed to assist in this process (WAPC, 2019).

SPP2.6 requires adequate risk management planning is undertaken where existing or proposed development is in an area at risk of being affected by coastal hazards over the 100-years planning timeframe. SPP2.6 and the CHRMAP Guidelines provide the risk assessment framework to be applied to identify risks that are intolerable to the community, and other stakeholders such as local governments, indigenous and cultural interests, and private enterprise. Risk management measures are then developed according to the adaptation hierarchy outlined in SPP2.6.

The Peron Naturaliste Partnership (PNP) comprises membership of nine local government authorities. The PNP's Coastal Adaptation Pathways Project identified the coastal areas of Capel, Leschenault and Greater Bunbury as being particularly exposed to coastal hazards and climate change, which triggered the need for this CHRMAP. The aim of the present study is therefore to investigate the nature and severity of coastal hazards which are likely to affect these regions from Capel to Leschenault over future planning horizons. Refer Figure 1-2 for locality and study area extent.

The objective of this CHRMAP project is to increase knowledge and understanding of coastal hazard risks, and identify risk management and adaptation measures for implementation. The outcomes will be used to inform local and state government policies, strategies and plans, including (but not limited to); planning strategies, community strategic plans, drainage strategies, asset management plans, emergency management plans, and foreshore management plans. The project will adhere to the WAPC (2019) guidelines with scope and deliverables to be consistent with the objectives identified by these guidelines and SPP2.6. The project will identify the strategic direction for coastal adaptation scenarios from the present-day to 2120 (100 yrs. management time frame), and identify an implementation plan to achieve this direction. Overall, this CHRMAP will develop a flexible adaptation pathway for the region and serve as a key reference for management, planning and policy making for the short-term (0-15 years), medium-term (15-30 years), and long-term (100 years).

Delivery of this project will occur over 9 stages (as summarised in Figure 1-1), each of which represents a key hold point. The staged approached is developed according to the PNP's scope and is in line with the CHRMAP Guidelines (WAPC, 2019).

This report presents the Stage F: Risk Evaluation and Treatment Report, which identifies risks and presents and assesses treatment options using multi-criteria analysis. The red bubble displayed in Figure 1-1, indicates where this component sits with reference to the greater study.

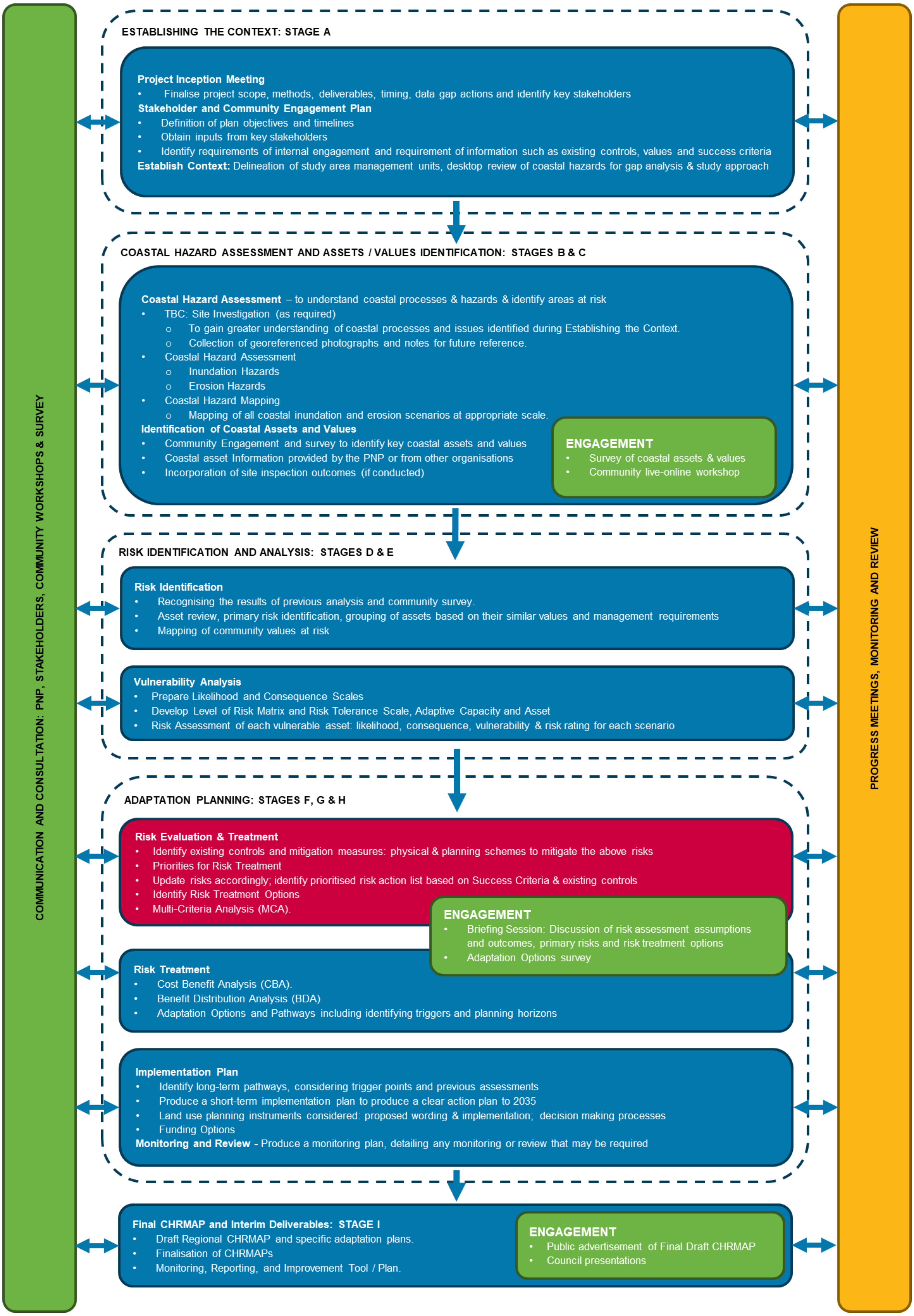

Figure 1-1 Methodology

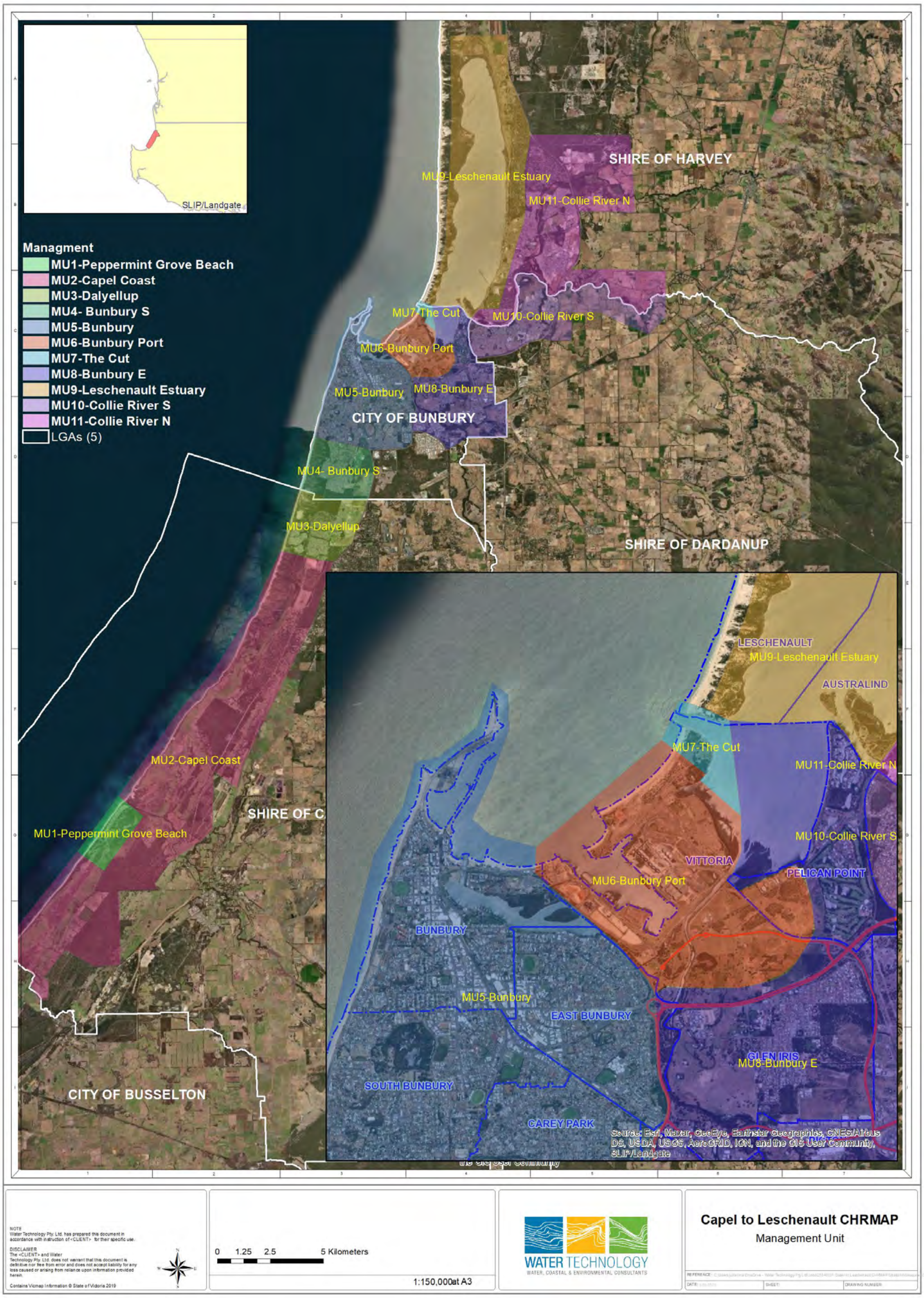

Figure 1-2 Study Area and Management Units

2 RISK EVALUATION

This section assesses any available controls against the vulnerability ratings assigned in the previous chapter report (Water Technology, 2022b). The coastal hazard assessment (Water Technology, 2022a) has already assigned any relevant physical controls.

2.1 Existing Controls

2.1.1 Planning Controls

A summary of relevant planning controls for the study area is provided in Water Technology (2021a). The study area contains a large array of planning documentation, most of which makes mention of coastal hazards, or values which will provide input into the CHRMAP process. With the exception of the Shire of Harvey however, none of the existing documents contain planning instruments that can be used to adapt to coastal hazards. As such, these planning controls do not change the assigned vulnerability ratings for the PNP CHRMAP study area.

This CHRMAP will consider what planning controls (existing or required) may be appropriate as adaptation measures within each management unit.

2.1.2 Physical Controls

The existing physical controls in the study area are reported in Water Technology (2021a and 2022a) and include coastal protection structures such as groynes/breakwaters and seawalls, preventative inundation structures such as the storm surge barrier and one way drainage valves and current management activities. Where appropriate, these have already been considered in the hazard and vulnerability assessment. As such, the vulnerability results remain the same as previously reported. No changes to the vulnerability results are required.

2.2 Priorities for Treatment

The erosion and inundation vulnerability ratings presented in the previous report have been considered for each MU as a whole by averaging the vulnerability ratings of individual asset categories; see Table 2-1 and Table 2-2. All MUs at all planning horizons have unacceptable levels of vulnerability for both erosion and inundation (medium or above) for one or more asset categories, and therefore need to be considered for risk treatment options. Table 2-1 and Table 2-2 depict the greater vulnerabilities to erosion in the study area compared to inundation, and the relativity of vulnerability to each hazard between MUs.

Table 2-1 Erosion vulnerability ratings by management unit & planning horizon

Management Unit	2020	2035	2050	2120
MU1 – Peppermint Grove Beach	High	Extreme	Extreme	Extreme
MU2 – Capel Coast	High	Extreme	Extreme	Extreme
MU3 - Dalyellup	High	Extreme	Extreme	Extreme
MU4 – Bunbury S	High	High	High	Extreme
MU5 - Bunbury	High	Extreme	Extreme	Extreme
MU6 – Bunbury Port	Extreme	Extreme	Extreme	Extreme
MU7 – The Cut	Extreme	Extreme	Extreme	Extreme
MU8 – Bunbury E	Extreme	Extreme	Extreme	Extreme
MU9 – Leschenault Estuary	High	Extreme	Extreme	Extreme
MU10 – Collie River S	Extreme	Extreme	Extreme	Extreme
MU11 – Collie River N	High	Extreme	Extreme	Extreme

Table 2-2 Inundation vulnerability ratings by management unit & planning horizon

Management Unit	2020	2035	2050	2120
MU1 – Peppermint Grove Beach	High	High	High	High
MU2 – Capel Coast	Medium	Medium	Medium	High
MU3 - Dalyellup	Medium	Medium	Medium	Medium
MU4 – Bunbury S	Medium	Medium	Medium	Medium
MU5 - Bunbury	High	High	High	High
MU6 – Bunbury Port	Medium	Medium	Medium	High
MU7 – The Cut	Medium	Medium	Medium	Medium
MU8 – Bunbury E	High	High	High	High
MU9 – Leschenault Estuary	High	High	High	High
MU10 – Collie River S	Medium	High	High	High
MU11 – Collie River N	Medium	Medium	Medium	High

3 RISK TREATMENT APPROACH

3.1 Risk Management and Adaptation Hierarchy

SPP2.6 provides a hierarchy of adaptation pathways to guide decision making in coastal areas. This should be used by planning authorities and development proponents when considering adaptation options to minimise coastal hazard risks at the local level. The hierarchy, presented in Figure 3-1, indicates a clear preference against the adoption of 'protect' as a long-term adaptation pathway. This preference is re-emphasised in SPP2.6, the policy guidelines, the CHRMAP Guidelines and the WA Coastal Zone Strategy. This hierarchy is discussed further below.

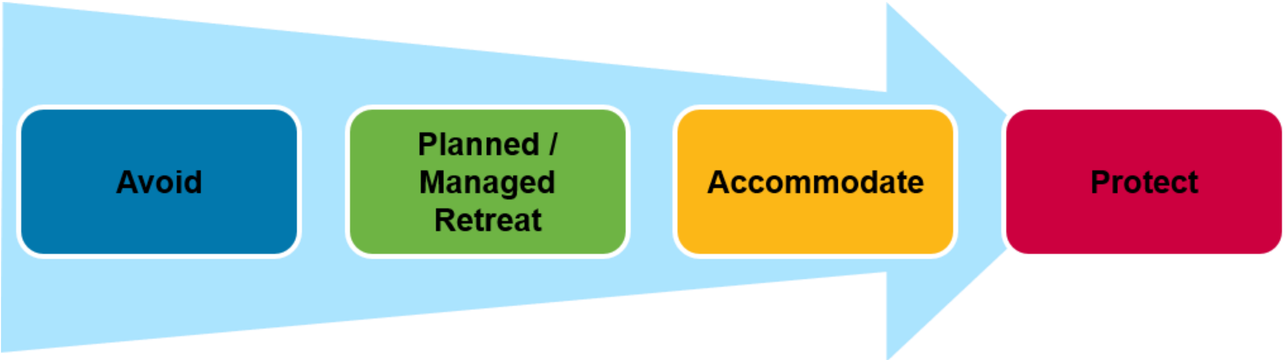

Figure 3-1 Coastal hazard risk management and adaptation planning hierarchy (adapted from WAPC, 2019)

3.2 Avoid

This option aims to avoid the construction of new public and private assets within areas identified to be affected by coastal hazards. The project lifetime of a new asset should be a key consideration in deciding the suitability of locating new assets in coastal hazard areas. For example, the construction of new public assets, such as picnic facilities and public toilets, should be avoided where these assets are likely to be impacted by coastal hazards within the lifetime of the asset. Similarly, the construction of new private assets which are likely to be affected by coastal hazards over their projected lifetimes should not be permitted. The option of avoid can be applied to manage coastal erosion and inundation hazard risks.

3.3 Planned or Managed Retreat

This option aims to relocate or remove assets which are located in hazard areas, in an orderly manner, where hazard risks are likely to be intolerable over relevant planning timeframes. In recognition of the increased risk to assets in the coastal zone, the DPLH, together with the Western Australian Planning Commission, provides guidance on how to implement a policy of planned or managed retreat through property acquisitions (WAPC, 2019).

Planned or managed retreat is mostly applicable to developed areas, where there is less potential to adapt to coastal hazards through development planning controls, such as setbacks in Greenfield areas. The strategy of retreat is based on social, environmental and economic sustainability, and ties into the SPP2.6 objectives and adaptation hierarchy (refer Figure 3-1). It allows for continuing public access to beaches, beach amenity, and the provision of a coastal foreshore reserve.

The CHRMAP Guidelines (WAPC, 2019) suggest a range of mechanisms for achieving managed retreat in developed areas, using compulsory or voluntary acquisition provisions outlined in state legislation. Alternatively, planned or managed retreat can be achieved through the early acquisition and leaseback of private property. This alternative can help to reduce overall implementation costs.

Planned or managed retreat is an option that can be applied to manage coastal erosion and inundation hazards; however, this option requires a significant investment of public resources to fund acquisitions. For implementation of managed retreat to be undertaken at scale, a significant funding contribution may need to be sought from the State or Commonwealth. At the time of writing such an undertaking has not known to have been successful for WA coastal projects. Therefore, landholders and the broader public should be aware of the risks in any decisions they make about purchasing or developing lands in coastal areas.

3.4 Accommodate

This option aims to utilise design and management strategies which render the risks from identified coastal hazards as acceptable. Design and management strategies include minimum finished floor levels (FFLs) and elevated electrical circuitry to minimise inundation risks. In this way, the 'Accommodate' option allows landholders to continue to use land until hazard risks become intolerable, while minimising the current and future risk of legal and financial liability for Council.

Accommodate is an option that can be applied to help minimise the effect of coastal inundation hazards on development and infrastructure. It should be noted that the current State legislative framework means that permanently inundated private land does not become Crown land, unlike in other Australian states (Robb et al 2017, Robb et al 2018). Therefore, if the shoreline is allowed to recede beyond private property boundaries, issues of public access and trespass may arise. This should be a key consideration when assessing the appropriateness of this option.

3.5 Protect

This option aims to stabilise the position of the shoreline using hard or soft coastal protection measures such as seawalls, groynes, offshore breakwaters, geotextile sand-containers, sand renourishment and levee banks. Protection is an option that can be applied to manage coastal erosion and inundation hazards.

The adaptation hierarchy considers the construction of new protection measures as the least preferred option of all potential options listed in the hierarchy. Protection measures, particularly hard measures such as rock groynes and seawalls, interfere with local coastal processes and can have detrimental effects on local ecological systems. Protection measures can also inflate property values in hazard areas, create expectations that protection measures will be maintained into the future, and may limit the capacity of future decision makers to change strategies as situations change.

Over the short to medium term, public authorities may need to consider the appropriateness of using interim protection measures to delay shoreline recession. This might be achieved through measures such as geotextile sand containers which may be less costly to remove than rock structures, regular sand renourishment, and revegetating coastal dunes. Where public and private assets are proposed to be constructed inland of interim protection measures, the design life of the protection measure should be a key factor in determining the appropriateness of the proposed asset or development.

3.6 No Regrets

No regrets risk treatment options allow for the undertaking of measures which improve resilience and preparedness for vulnerable assets. They are often undertaken at the same time as further investigations to finalise preferred risk treatment options, given the long lead time for the implementation of such decisions.

Management strategies can be facilitated through active monitoring and management tasks and modifications to local planning frameworks. Coastal monitoring can improve the understanding of hazards, risks and vulnerabilities as well as the effective life of existing coastal structures.

Modified planning frameworks need to provide clear direction for planning authorities when assessing applications for new development and for affected landholders. Planning frameworks might include the introduction or modification of the following instruments:

- Special control areas, to ensure planning discretion over new development
- Clear development assessment criteria, to ensure that new development gives due regard to coastal processes
- Notifications on title, to inform current and future property owners of hazard risks
- Time or event limited planning permits, to allow the continued use of land until hazards become intolerable
- Requirements for emergency evacuation plans (also relevant to some Accommodate scenarios)

3.7 Do Nothing

The do-nothing option assumes that no action will be taken, and all levels of risk are accepted. It is useful for baseline comparisons with other options but is often considered unacceptable because most developed sections of coastline require at least safety management of impacts and the continuation of basic public services.

3.8 Hierarchy Summary

Maintaining public access to the coast in developed areas is one of the main objectives of SPP2.6. The current State legislative framework means that where the shoreline recedes beyond private property boundaries, issues of public access and trespass are likely to arise. This situation means that public authorities have two main adaptation options available to them for preserving public coastal access:

- **Planned or Managed Retreat** i.e., maintaining a foreshore reserve through public acquisition of private property; or,
- **Protect** i.e., preventing the shoreline from receding beyond private property boundaries by stabilising the current shoreline position using various protection measures

Where public authorities cannot commit to either of these options over the long term, it is likely that public authorities will need to **Accommodate**, by modifying local planning frameworks to help ensure that new development is appropriately designed and located. Public authorities in this situation may also choose to consider the appropriateness of interim Protection measures to preserve public interests by delaying shoreline recession and minimising the effect of regular nuisance inundation events on existing development and infrastructure.

3.9 Site Constraints

The success criteria for the study identified in the Coastal Assets & Community Values Chapter Report are presented in Table 3-1. These criteria demonstrate that the stakeholder and community values in the study area reflect the requirements of the state, regional and local planning controls. The success criteria highlight the need for continuing public access to beaches, beach amenity, and the provision of a coastal foreshore reserve. They also identify protecting the natural environment.

Table 3-1 Success criteria

- Conserve, enhance and maintain the natural environment and character of the study area
- Facilitate and promote public usage and enjoyment of the natural environment, coast, estuaries and rivers
- Protection of the cultural values of the coastline
- Manage impacts to the existing residential areas from erosion and inundation
- Maintain critical infrastructure supporting the community (roads, utilities).
- Manage and maintain coastal infrastructure that provides access to the water and supports the lifestyle enjoyed by people in the region
- Retain the widest possible range of risk management options for future users of the coast

3.10 Summary for Decision Makers

Table 3-2 presents a summary of the relevant information for adaptation. It is important to note that there is no law requiring public authorities to provide protection of private property from natural hazards, nor compensation when land is lost due to coastal hazards. The CHRMAP process aims to minimise coastal hazard risks and maximise beneficial use of the coast.

Table 3-2 Adaptation consideration summary

- Adaptation options should minimise coastal process interference and legacy issues
  - The adaptation hierarchy is presented in Figure 3-1.
- Coastal development must be sustainable in the long term, and must balance the community, economic, environmental and cultural needs
- Local Governments are responsible for managing risks to **public assets** and any assets they manage. They should also:
  - Develop local policies and regulations consistent with state legislation and policy
  - Facilitate building resilience and adaptive capacity within the local community
  - Work in partnership with community to identity and manage risks / impacts
- Management strategies that preserve the natural coastline and move development away from the active coastal zone in an orderly manner are considered ideal. Of particular relevance to the CHRMAP process is the user pays principle, whereby those who benefit most from protection must provide the greatest financial contribution
- Adaptation options should maintain future flexibility, in order to build resilient coastal communities.
- A key adaptation option will be the use of planning instruments, including managed retreat.

4 RISK TREATMENT OPTIONS

4.1 General Options

Table 4-1 below presents a list of generally available adaptation options suitable for most coastal sites. These relate to both short term and long-term adaptation to coastal hazards in general, not just in relation to planning for climate change impacts. The column on the right-hand side provides some discussion as to the possibility of its application for the study area.

Whilst the risks and their corresponding adaptation options are assessed separately, triggers to adapt can occur at any time from either erosion or inundation.

4.2 Planning Control Options

This section outlines the key planning instruments which should be considered for incorporation into the LGAs' local planning frameworks. These instruments are particularly useful for implementing Accommodate and Planned or Managed Retreat options.

4.2.1 Special Control Area

Amend the local planning scheme to introduce a Special Control Area (SCA) over all land identified as being at risk of coastal erosion and/or inundation. The SCA would be delimited by the position of either the 2120 coastal processes setback line or the inundation extent of the 500-year ARI event in the year 2120, whichever is the more landward.

An SCA could be designed to cover erosion or inundation separately, or both as presented above. An SCA is an overlay that applies in addition to the underlying classification of the land and identifies planning controls that apply in addition to any other requirements relevant to the underlying zone. Development that might otherwise be exempt from development approval would then be required to obtain a planning approval in addition to building approval. An SCA can facilitate land use changes and development control within that area.

An SCA should be applied to relate specifically to land subject to coastal processes (as recommended in WAPC, 2019).

Each SCA is allocated a number and depicted on the Scheme Map.

WAPC (2019) provides draft amendment text including the purpose, objectives and provisions (see below). The purpose of the SCA is to provide guidance as to the appropriate scope of land use and development to be permitted within a coastal erosion and inundation hazard risk area. Its objectives would be:

a. To ensure land in the coastal zone is continuously provided for coastal foreshore management, public access, recreation and conservation.

b. To ensure public safety and reduce risk associated with coastal erosion and inundation.

c. To avoid inappropriate land use and development of land at risk from coastal erosion and inundation.

d. To ensure land use and development does not accelerate coastal erosion or inundation risks; or have a detrimental impact on the functions of public reserves.

e. To ensure that development addresses the PNP CHRMAP prepared in accordance with SPP 2.6.

The SCA would include additional provisions (over and above or overriding provisions for development not within the SCA), such as:

a. All proposed development within the SCA requires approval. (This would include development that would not ordinarily require development approval under the scheme).

b. Approval to be issued on a temporary or time limited basis. (The applicant could later apply for a further approval, which could be granted if the risk from coastal processes was still considered acceptable).

c. Referral of applications. (Any planning application should be referred to the Department of Transport, the Western Australian Planning Commission and any other relevant authority for advice and comment on the coastal risk.)

d. Minimum finished floor levels and/or other development standards.

4.2.2 Coastal /Waterway Local Planning Policy

Prepare/update a local planning policy (LPP) to clarify its attitude and expectations in relation to coastal development within an identified area, including the type of permanent or temporary assets it is prepared to accept within the coastal reserve and/or on land subject to coastal processes.

LPPs are prepared and adopted according to the provisions in Part 2 Division 2 of the Deemed Provisions of the relevant local planning scheme within each LGA. LGAs may prepare an LPP in respect of any matter related to the planning and development of the Scheme area. The LPP may apply to a particular class or classes of matter specified in the policy and may apply to the whole of the Scheme area or to parts specified in the policy.

An LPP can provide more detail and guidance on what sort of development would be acceptable and will also assist each Council in making planning decisions on coastal development requiring the exercise of discretion. For example, on land at risk of erosion within the life of a proposed development the LPP may encourage use of structures that can be disassembled and/or transported should erosion come within a specified distance of the structure. The policy would also identify the Council's intention to require notifications on title as a condition of development approval.

4.2.3 Notifications on Title

All freehold land identified as being at risk of impact from coastal processes should have a notification placed on its certificate of title/s to make the owner and future landholders aware of the potential for the land to be impacted.

Section 165 of the Planning and Development Act 2005 enables a local government or public authority to place a notification on the certificate of title of land. This aims to make owners and future owners of land aware of being within or proximate to a future coastal hazard that may affect the use and enjoyment of the land, as determined in accordance with SPP2.6 and an endorsed CHRMAP. The process requires the written consent of the landholder and payment of a fee, so it is usual for the requirement for placement of a notification to be a condition of development or subdivision approval. However, placement of a notification on the title does not have to be tied to an application and could take place at any time with owner consent.

Current wording recommended by the WAPC and in accordance with SPP2.6 is as follows:

This lot is located in an area likely to be subject to coastal erosion and/or inundation over the next 100 years from the date this notification is registered.

With regard to the above wording, the WAPC notes that a shorter timeframe than 100 years may be appropriate where identified in an endorsed CHRMAP.

4.2.4 Other Instruments

Other instruments may be useful for implementing adaptation options. These include:

- Restrictive Covenants, which can be used to restrict present and future landholders from constructing protection structures and, to internalise the risk of building in inherently hazardous locations.
- Special Area Rates, which can be used to ensure that the costs associated with protection options are equitably distributed across beneficiaries.
- The requirement for a structure plan could be considered, setting out development provisions and planning controls consistent with SPP2.6 for vulnerable areas with new development/subdivision proposed.
- Update of Local Planning Strategies to inform amendments to other related planning instruments.
- Implementation of LGA internal procedures, to provide a note to settlement agencies when they seek a property report linked to the sale of land (settlement agencies typically request these and they include details of rates paid, outstanding issues, approved development etc). This would elevate the potential impact to the prospective purchaser, ensuring that later planning controls are not a surprise.

The intent of these instruments aligns with guidance provided in the WA Coastal Zone Strategy, noting that private parties are responsible for managing risks to their private assets and incomes which might arise from coastal erosion and inundation hazards.

Table 4-1 Risk treatment options from WAPC (2019)

Option Category	Option Name	Option Code	Description of how it will help
Avoid	Locating assets in areas that will not be vulnerable to coastal hazards	AV	Assets will not be vulnerable to risk arising from coastal hazards.
Planned / Managed Retreat	Leaving assets unprotected	PMR1	Accept loss following hazard event. Only implement repairs to maintain public safety. Allow for retreat that allows natural recession of the shoreline over the long-term.
	Demolition / removal / relocation of asset from inside hazard area.	PMR2	Relevant for assets of low value where it is impractical both technically and financially to design the asset to withstand the impact of the coastal hazards instead of relocating it.
	Prevention of further development / prohibit expansion of existing use rights	PMR3	This risk treatment option would enable existing development and use rights to continue without increasing them, until such time that risk arising from coastal hazards is intolerable. Specified in a local planning scheme.
	Voluntary acquisition	PMR4	This risk treatment option would require the acquisition of affected properties, on a voluntary basis.
Accommodate	Design assets to withstand impacts	AC1	Where avoiding or relocating an asset is not an option, design of assets to withstand the impact of inundation.
Protect	Beach nourishment or replenishment	PR1	Placement of sand on the upper beach face and dunes to re-establish the sandy beach and provide a sediment supply.
	Groyne	PR2	Construction of groynes to stop or restrict the movement of sand around the end of the structure, to provide protection to assets behind the beach/foreshore reserve. They are primarily effective where there is longshore sand supply or when partnered with sand nourishment.
	Seawall	PR3	Construction of a seawall usually along an entire section of shoreline. Where a beach is to be retained, this risk treatment option should generally be accompanied with beach nourishment or replenishment.
	Artificial reef	PR4	Construction of a submerged artificial reef offshore, to dissipate wave energy impacting the shore by causing waves to break on their seaward side and reducing wave energy on the leeward side. Artificial reefs do not block waves and during storm events water depths over the reef may be sufficient to allow waves to pass over the reef without breaking, reducing their effectiveness in protecting the beach from erosion.
	Offshore breakwater	PR5	Construction of an emergent offshore barrier (often referred to as an offshore breakwater). Offshore breakwaters effectively block wave energy by absorbing wave impact on their seaward side. They create a lower wave energy section of beach immediately in its lee, which is characterised by a salient where sand accretes in the low energy environment.
	Levy / Weir / Storm Surge Barrier	PR6	Inundation protection to minimise inundation on low-lying land. This could be a levy on the banks of a river, a storm surge barrier at the entrance to an inlet / estuary and so on. Details would be specific to the relevant conditions of each MU.
No Regrets	Monitoring	NR1	Involves long term baseline monitoring and event-based monitoring following storm erosion events.
	Protection Structure Audit	NR2	Involves undertaking an audit of existing protection structures, to determine their current condition, effectiveness and future protection potential.
	Notification on title	NR3	Indicates to current and future landowners that an asset is likely to be affected by coastal erosion and/or inundation over the planning timeframe. Helps current and future owners make informed decisions about level of risk they are/may be willing to accept, and that risk management is likely to be required at some stage within the planning timeframe.
	Emergency evacuation plans	NR4	Where existing assets may be affected by inundation and are not already identified in an existing emergency evacuation management plan. Such plans are important in managing the safety of community and stakeholders.
Do Nothing	Do Nothing	DN1	Assumes all levels of risk are accepted and assumes that there is no change in existing planning controls, and no actions are implemented (i.e., no controls are implemented to treat known coastal risks).

5 RISK TREATMENT OPTIONS: INUNDATION

This section discusses adaptation options identified to respond to inundation hazards.

5.1 All Management Units – Present Day

It is recommended for all LGAs to implement adaptation options in the present day that will facilitate flexible adaptation in the future:

- Prevention of further development / limiting existing use rights
  - Introduce 'Special Control Area - Coastal Hazard: Inundation' with a requirement for new development to achieve a minimum FFL of 3.1-3.9m AHD (depending on location) for habitable areas of buildings. Depending on the nature of development proposed, approval may be time limited or require structures to be removed by a specified date or when a specified trigger is reached.
  - Introduce a local planning policy outlining the LGAs' requirements for building construction, land fill, and other relevant matters within the Special Control Area, noting requirements will be slightly different for erosion and inundation.
- Any new assets should avoid the hazard zone. If they must be located within the hazard zone, they should be designed to withstand the inundation hazard. For example, new buildings to be constructed with permeable lower levels (e.g., a stilt arrangement), and services located above the flood level. This avoids the need to use fill to raise the FFL. Fill is expensive, and also alters the flood flow, which could lead to increased hazards.

5.2 All Management Units – Future Timeframe

The adaptation options discussed below in Section 7 are in addition to those discussed for the Present Day above. Economically, relocation or managed retreat options may be triggered by the physical costs of repair exceeding the relocation costs. As per the success criteria and adaptation hierarchy, consideration should be given to the continued allowance for a recreational reserve. This may mean relocating buildings ahead of their risk rating in order to continue to allow this space.

6 RISK TREATMENT OPTIONS: EROSION

This section discusses adaptation options identified to respond to erosion hazards.

6.1 All Management Units – Present Day

As per the inundation adaptation options, It is recommended to implement adaptation options in the present day that will facilitate flexible adaptation in the future:

- Prevention of further development / limiting existing use rights
  - Introduce 'Special Control Area - Coastal Hazard: Erosion'. Depending on the nature of development proposed, approval may be time limited or require structures to be removed by a specified date or when a specified trigger is reached.
  - Require notification on Title for all land located seaward of the 100-year hazard line for coastal erosion. This should be made a condition of any approval for development or subdivision/amalgamation of land. The LGAs should also negotiate with landholders whose land is not subject to an application for planning approval to place such a notification on the title with their consent.
  - Introduce a local planning policy outlining the LGAs' requirements for building construction, land fill, and other relevant matters within the Special Control Area, noting requirements will be slightly different for erosion and inundation.
- Any new assets should avoid the hazard zone.
- Coastal monitoring to regularly document changes to the shoreline and understand system; enables better prediction of management trigger timeframe
- Commence investigations to determine options for appropriate longer-term relocation of affected properties / assets.

6.2 All Management Units – Future Timeframes

The modelling has provided an indicative timeframe as to when adaptation will be required. However, it is recommended to employ the use of triggers for adaptation, including for relocation or managed retreat purposes. These are as per those of WAPC (2019).

- **Trigger 1**: Where the most landward part of the Horizontal Shoreline Datum (HSD) is within 40 metres of the most seaward point of a development / structure / foreshore reserve area.
  - The recreational and dune area is considered the asset in this case, as per the values and vulnerability assessment.
- **Trigger 2**: Where a public road is no longer available or able to provide legal access to the property
- **Trigger 3**: When water, sewage or electricity to the lot is no longer available as they have been removed/decommissioned by the relevant authority due to coastal hazards.

As per the inundation discussion, the management measures discussed above apply in the addition to those discussed below in Section 7.

7 MULTI-CRITERIA ANALYSIS

Successful risk management and adaptation planning requires identification and diligent assessment of suitable options to ensure selection of the best strategy. The chosen option should mitigate risk to an acceptable level whilst maximising the values important to the stakeholders.

7.1 Assessment Criteria

For this CHRMAP the key assessment criteria are:

- Effectiveness
  - Ability for the option to mitigate the coastal hazard risk
- Environmental Impact
  - Impact on existing native vegetation / dunes / coastal processes
  - Includes consideration of:
    - Any construction / clearing impacts
    - Impact of maintenance on the environment
- Social Impact
  - This considers stakeholder and community impacts from previous CHRMAP chapters
  - Potential impacts on Aboriginal and European heritage sites and values are considered in this criterion.
- Aesthetic Impact
  - The visual appeal of the option
  - Consideration of option aesthetics tying into the wider town / Management Unit vision
- Cost
  - Upfront capital costs
  - Ongoing maintenance costs
  - Economic affects – such as loss of businesses, income, value
- Future Adaptability
  - Whether the option is easily adaptable in future, such as for updated sea level rise actuals or predictions
  - If the option limits the feasibility of selecting other options in future

Initial assessment of options against the criteria was undertaken by Water Technology as coastal experts. The qualitative criteria (environmental, social and aesthetic) will then be reviewed and modified following review and confirmation by the Steering Group and the Coastal Community Advisory Group. **All ratings are somewhat subjective; however, all ratings will be discussed with the Steering Group to ensure the ratings are reflective of stakeholder knowledge. Community engagement will allow for additional feedback from the community and further review of the scores attributed. The ratings will then be updated to reflect these engagement activities.**

Information provided to date by stakeholders was included in the assessment of each value as required. Options are assessed using the multi-criteria assessment (MCA) matrix shown in Table 7-1 which indicates the rating given to each criterion for a given option and provides the recommendation for pursuing the option.

In most cases it shall be necessary to implement more than one option, and the options selected through the MCA may vary between management units and with implementation timeframes. The results of the MCA for each Management Unit are summarised in the sections below.

Succeeding the MCA will be a cost-benefit analysis (CBA) of options carried forward from the MCA, to be present in the next chapter report for the project. Separate to the score applied in the MCA for option costs, the CBA will allocate an estimated cost to all significant values and detractions of a given option, both at present and over the option's intended design life. This work will be presented as the net present value (NPV) of an option, allowing direct comparison to aid selection of a final strategy.

7.2 Assessment Framework

To perform the MCA, each identified option was assessed against each of the criteria shown below in Table 7-1 for each of the Management Units. The assessment criteria run across the top row whilst the ratings are shown below; each have a possible score from -2 to 2. This methodology is similar to other MCAs undertaken in Western Australia under the same CHRMAP Guidelines (for example: Cardno, 2017 and Water Technology, 2019).

Ratings were assessed by a professional coastal engineer with experience in risk management, adaptation options and their implementation. In this case initial capital and ongoing maintenance costs have been assessed under a single category. The possibility for potential losses is also considered in the cost category. For example, if an option is likely to lead to a drop in land value, that is considered to be a cost to the community, and therefore a lower score. Economic factors have been assessed in more detail within the CBA.

Following preparation of the draft MCA the results were reviewed by the Steering Committee. A Coastal Community Advisory Group (CCAG) was formed comprising community members from across the study area. Members attended a workshop to further review and calibrate the MCA scoring – with particular focus on the categories of Environmental, Social and Aesthetic Impact. This workshop is discussed further in the latest Engagement Outcomes Report (refer Appendix A). Several component category scores changed during this review process, but only one option in three MUs changed recommendations:

- MU1 – PR2 Groynes – changed from 'Recommended' to 'Suitability Unclear', so will still be retained in CBA process.
- MU3 – PR2 Groynes – changed from 'Recommended' to Suitability Unclear, so will still be retained in CBA process.
- MU8 – PR5 Offshore Breakwater – changed from 'Suitability Unclear' to 'Not Recommended', so will be excluded from CBA process.

7.3 Multi-Criteria Analysis Summary

The MCA Analysis for each management unit is provided in Appendix B with each adaptation option assessed. Table 7-2 summarises the evaluated status of each option for each management unit. Options receiving a positive score are recommended for further consideration.

Table 7-1 Multi-criteria assessment framework

Rating; Score	Effectiveness	Environmental Impact	Social Impact	Aesthetic Impact	Cost (Capital & Ongoing)	Future Adaptability	Final Recommendation
Positive; +2	Expected to be very effective	Significant positive impact; return to more natural coastline	Significant positive social impact; encourages community development	Positive aesthetics, improves existing coastline and place recognition	Low costs. Higher capital costs accepted if other criteria met. Very low economic loss.	Very adaptable, not likely to leave legacy issues	Further Investigation Recommended; Score > 0
Positive; +1	Expected to be effective	Positive impact; return to more natural coastline	Positive social impact; encourages community development	Positive aesthetics, retains the existing coastline and place recognition	Reasonable costs. Higher capital costs accepted if other criteria met. Low economic loss.	Adaptable, not likely to leave legacy issues	Further Investigation Recommended; Score > 0
Neutral; 0	May or may not be effective, possibly unable to predict	No (or unclear) environmental impact	No discernible social impact; indeterminate net impact	Neutral aesthetic	Moderate costs	May leave legacy issues	Suitability unclear; Score = 0
Negative; -1	Likely to be ineffective in the short or long term	Potential significant negative impacts, including losing beaches altogether	Negative social impact. May discourage new or existing people from the area	Coastline / foreshore appearance negatively altered	High initial or ongoing costs, especially if low likelihood of success. High economic loss.	Likely to create legacy issues	Not recommended; Score < 0
Negative; -2	Very likely to be ineffective in the short or long term	Significant negative impacts, including losing beaches altogether	Significant negative social impact. May discourage new or existing people from the area	Coastline / foreshore appearance degraded	Very high initial or ongoing costs, especially if low likelihood of success. Very high economic loss.	Will create legacy issues	Not recommended; Score < 0

Table 7-2 Multi-Criteria Analysis summary by MU. Green indicates recommended for further investigation; orange is unclear. Refer Appendix B for full MCA results

Option	MU1	MU2	MU3	MU4	MU5	MU6	MU7	MU8	MU9	MU10	MU11
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	11	11	11	11	11	11	11	11	11	11	11
Leaving assets unprotected (PMR1)	2	2	2	2	2	2	2	2	2	2	2
Demolition / removal / relocation of asset from inside hazard area (PMR2)	7	7	7	7	7	7	7	7	7	7	7
Prevention of further development / prohibit expansion of existing use rights (PMR3)	5	6	6	10	6	6	N/A	6	6	9	6
Voluntary acquisition (PMR4)	4	4	5	N/A	5	5	N/A	5	5	7	5
Design assets to withstand impacts (AC1)	9	10	N/A	10	9	10	12	9	9	9	9
Beach nourishment or replenishment (PR1)	3	-4	3	-7	3	4	4	2	3	3	3
Groynes (PR2)	0	-6	0	-11	1	3	3	0	0	-1	-1
Seawalls (PR3)	-6	-10	-6	-12	-2	0	0	0	0	-1	-1
Artificial reef (PR4)	-3	-6	-4	-10	-3	-4	-4	-5	-4	N/A	N/A
Offshore breakwater (PR5)	-5	-7	-6	-12	0	-3	-4	-1	0	N/A	N/A
Levy / Weir / Storm Surge Barrier (PR6)	4	6	N/A	N/A	4	3	N/A	1	1	1	1
Monitoring (NR1)	7	7	7	7	7	7	7	7	7	7	7
Protection Structure Audit (NR2)	N/A	N/A	N/A	N/A	6	6	6	6	6	N/A	N/A
Notification on title (NR3)	7	7	7	7	7	7	7	6	6	6	6
Emergency evacuation plans (NR4)	6	6	N/A	N/A	6	6	N/A	7	6	7	7
Do nothing (DN1)	-10	-8	-8	-8	-8	-8	-8	-8	-11	-8	-8

8 SUMMARY & NEXT STEPS

This report presents the risk evaluation and multi-criteria analysis for the Capel to Leschenault CHRMAP. The MCA results are presented in full in Appendix B; a summary is presented in Section 7.3.

The next report will present the cost benefit analysis and benefit distribution analysis of the positively scored adaptation options. Their adaptation pathways, including identifying triggers, will also be presented.

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APPENDIX A
ENGAGEMENT OUTCOMES REPORT

APPENDIX B
MULTI-CRITERIA ANALYSIS

Table B-1 Multi-Criteria Analysis – MU1 – Peppermint Grove Beach

Option (Option Code)	Effectiveness	Environment Impact	Social Impact	Aesthetic Impact	Cost	Future Adaptability	Score	Comment
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	2	2	1	2	2	2	11	This option applies to undeveloped land. In this MU most undeveloped land is already zoned as foreshore reserve. Any developable land in MU should be subject to this option. Community will benefit by appropriate foreshore reserve width and access throughout the planning timeframe.
Leaving assets unprotected (PMR1)	0	-1	1	0	1	1	2	Suitable for low-value public assets such as foreshore amenities.
Demolition / removal / relocation of asset from inside hazard area (PMR2)	1	2	2	1	-1	2	7	Suitable for low to medium value public assets such as car park and ablutions block. Potentially costly if triggers met before asset due for replacement.
Prevention of further development / prohibit expansion of existing use rights (PMR3)	1	1	-1	0	2	2	5	Allows for continued use of the land whilst viable, without creating legacy issues. May be unpopular with landholders.
Voluntary acquisition (PMR4)	2	1	0	1	-2	2	4	For private property. Effective but costly option. Ensures foreshore reserve retained. May be unpopular with landholders, depending on implementation strategy.
Design assets to withstand impacts (AC1)	2	2	2	0	1	2	9	For inundation hazard. Early design considerations mean implementation can occur as assets are routinely upgraded / renewed.
Beach nourishment or replenishment (PR1)	0	0	1	1	-1	2	3	Potentially very expensive if no nearby suitable and sustainable sand source available. Could create legacy issues for future.
Groynes (PR2)	1	-1	1	0	-1	0	0	A groyne field may assist to stabilise the shoreline. Groynes can lead to downdrift erosion issues if not designed and constructed appropriately. Would require sand nourishment as part of works, which can help provide a sandy beach.
Seawalls (PR3)	1	-2	-1	-1	-2	-1	-6	Expensive option. Likely to lead to reduction or loss of usable sandy beach.
Artificial reef (PR4)	0	1	0	0	-2	-2	-3	Difficult to design submerged structures to work effectively, and costly to build and maintain.
Offshore breakwater (PR5)	1	0	-1	-1	-2	-2	-5	Costly to build and maintain but can be designed to work effectively and provide usable sandy beach. Social concerns about ocean views likely.
Levy / Weir / Storm Surge Barrier (PR6)	1	1	1	1	-1	1	4	Some form of inundation protection on the banks / mouth of the Capel River to minimise inundation on the low-lying land behind the town. This would be costly but potentially effective. Impacts would need to be investigated thoroughly.
Monitoring (NR1)	2	2	1	0	0	2	7	Low-cost action which causes no problems. Resulting data is required for most management approaches.
Protection Structure Audit (NR2)							N/A	No existing protections structures in this MU.
Notification on title (NR3)	1	2	1	0	2	2	8	For private property. Effective low-cost option. May be unpopular with affected landholders, but appreciated by potential purchasers, depending on implementation strategy.
Emergency evacuation plans (NR4)	1	0	1	0	2	2	6	For inundation hazard. Doesn't directly address vulnerabilities of assets but low cost to plan for keeping people safe. Important for single-road access to town.
Do nothing (DN1)	-2	-2	-2	-1	-1	-2	-10	Not an effective adaptation option and may not be popular with the community.

Table B-2 Multi-Criteria Analysis – MU2 – Capel Coast

Option (Option Code)	Effectiveness	Environment Impact	Social Impact	Aesthetic Impact	Cost	Future Adaptability	Score	Comment
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	2	2	1	2	2	2	11	This option applies to undeveloped land, which there are large areas of in this MU. Community will benefit by appropriate foreshore reserve width and access throughout the planning timeframe.
Leaving assets unprotected (PMR1)	0	-1	1	0	1	1	2	Suitable for low-value public assets such as foreshore recreational amenities.
Demolition / removal / relocation of asset from inside hazard area (PMR2)	1	2	2	1	-1	2	7	Suitable for low-value public assets such as foreshore recreational amenities. Potentially costly if triggers met before asset due for replacement.
Prevention of further development / prohibit expansion of existing use rights (PMR3)	1	1	0	0	2	2	6	Allows for continued use of the land whilst viable, without creating legacy issues. May be unpopular with landholders.
Voluntary acquisition (PMR4)	2	1	0	1	-2	2	4	For private property. Effective but costly option. Ensures foreshore reserve retained. May be unpopular with landholders, depending on implementation strategy. Will cost much less than protection given the sparse development in this MU.
Design assets to withstand impacts (AC1)	2	2	1	1	2	2	10	For inundation hazard. Early design considerations mean implementation can occur as assets are routinely upgraded / renewed.
Beach nourishment or replenishment (PR1)	-2	0	0	0	-2	0	-4	Potentially very expensive if no nearby suitable and sustainable sand source available. Could create legacy issues for future. Not feasible over large section of coastline.
Groynes (PR2)	-1	-2	1	-1	-2	-1	-6	Not feasible over large section of coastline. Groynes can be effective at stabilising shorelines but can also lead to downdrift erosion issues if not designed and constructed appropriately.
Seawalls (PR3)	-1	-2	-1	-2	-2	-2	-10	Expensive option, not realistic due to the length of MU, and number of impacted assets (and hence low funding potential).
Artificial reef (PR4)	-2	0	0	0	-2	-2	-6	Difficult to design submerged structures to work effectively, and costly to build and maintain.
Offshore breakwater (PR5)	-1	0	-1	-1	-2	-2	-7	Expensive option, not realistic due to the length of MU, and number of impacted assets (and hence low funding potential). Costly to build and maintain. Social concerns about ocean views likely.
Levy / Weir / Storm Surge Barrier (PR6)	1	2	1	2	-1	1	6	Some form of inundation protection on the banks / mouth of the Capel River to minimise inundation on the low-lying land. This would be costly but potentially effective. Impacts would need to be investigated thoroughly.
Monitoring (NR1)	2	2	1	0	0	2	7	Low-cost action which causes no problems. Resulting data is required for most management approaches.
Protection Structure Audit (NR2)							N/A	No existing protection structures in this MU.
Notification on title (NR3)	1	2	1	0	2	2	8	For private property. Effective low-cost option. May be unpopular with affected landholders, but appreciated by potential purchasers, depending on implementation strategy.
Emergency evacuation plans (NR4)	1	0	1	0	2	2	6	For inundation hazard. Doesn't directly address vulnerabilities of assets but low cost to plan for keeping people safe.
Do nothing (DN1)	-2	-1	-1	-1	-1	-2	-8	Not an effective adaptation option and may not be popular with the community.

Table B-3 Multi-Criteria Analysis – MU3 - Dalyellup

Option (Option Code)	Effectiveness	Environment Impact	Social Impact	Aesthetic Impact	Cost	Future Adaptability	Score	Comment
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	2	2	1	2	2	2	11	This option applies to undeveloped land. In this MU most undeveloped land is already zoned as foreshore reserve. Any developable land in MU should be subject to this option. Community will benefit by appropriate foreshore reserve width and access throughout the planning timeframe.
Leaving assets unprotected (PMR1)	0	-1	1	0	1	1	2	Suitable for low-value public assets such as foreshore recreational amenities.
Demolition / removal / relocation of asset from inside hazard area (PMR2)	1	2	2	1	-1	2	7	Suitable for low-value public assets such as foreshore recreational amenities. Potentially costly if triggers met before asset due for replacement.
Prevention of further development / prohibit expansion of existing use rights (PMR3)	1	1	0	0	2	2	6	Allows for continued use of the land whilst viable, without creating legacy issues. May be unpopular with landholders.
Voluntary acquisition (PMR4)	2	1	0	2	-2	2	5	For private property. Effective but costly option. Ensures foreshore reserve retained. May be unpopular with landholders, depending on implementation strategy and timeframes.
Design assets to withstand impacts (AC1)							N/A	Only suitable for inundation hazard. In this MU only environmental assets are projected to be affected, so not applicable.
Beach nourishment or replenishment (PR1)	0	0	1	1	-1	2	3	Potentially very expensive if no nearby suitable and sustainable sand source available. Could create legacy issues for future.
Groynes (PR2)	1	-1	1	0	-1	0	0	A groyne field may assist to stabilise the shoreline. Groynes can lead to downdrift erosion issues if not designed and constructed appropriately. Would require sand nourishment as part of works, which can help provide a sandy beach.
Seawalls (PR3)	1	-2	-1	-1	-2	-1	-6	Expensive option. Likely to lead to reduction or loss of usable sandy beach.
Artificial reef (PR4)	0	0	0	0	-2	-2	-4	Difficult to design submerged structures to work effectively, and costly to build and maintain.
Offshore breakwater (PR5)	1	-1	-1	-1	-2	-2	-6	Costly to build and maintain but can be designed to work effectively and provide usable sandy beach. Social concerns about ocean views likely.
Levy / Weir / Storm Surge Barrier (PR6)							N/A	Inundation is not a high risk in this management unit
Monitoring (NR1)	2	2	1	0	0	2	7	Low-cost action which causes no problems. Resulting data is required for most management approaches.
Protection Structure Audit (NR2)							N/A	No existing protection structures in this MU.
Notification on title (NR3)	1	2	1	0	2	2	8	For private property. Effective low-cost option. May be unpopular with affected landholders, but appreciated by potential purchasers, depending on implementation strategy.
Emergency evacuation plans (NR4)							N/A	Suitable for inundation hazard that may affect people but given the few affected assets in this MU and their environmental nature this is not applicable.
Do nothing (DN1)	-2	-1	-1	-1	-1	-2	-8	Not an effective adaptation option and may not be popular with the community.

Table B-4 Multi-Criteria Analysis – MU4 – Bunbury S

Option (Option Code)	Effectiveness	Environment Impact	Social Impact	Aesthetic Impact	Cost	Future Adaptability	Score	Comment
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	2	2	1	2	2	2	11	This option applies to undeveloped land. which there are large areas of in this MU. Community will benefit by appropriate foreshore reserve width and access throughout the planning timeframe.
Leaving assets unprotected (PMR1)	0	-1	1	0	1	1	2	Suitable for low-value public assets such as foreshore recreational amenities.
Demolition / removal / relocation of asset from inside hazard area (PMR2)	1	2	2	1	-1	2	7	Suitable for low-value public assets such as foreshore recreational amenities. Potentially costly if triggers met before asset due for replacement.
Prevention of further development / prohibit expansion of existing use rights (PMR3)	2	2	1	1	2	2	10	Allows for continued use of the land whilst viable, without creating legacy issues. May be unpopular with landholders. Nature of environmental reserve can be maintained effectively with this approach.
Voluntary acquisition (PMR4)							N/A	For private property – none in hazard zone in this MU.
Design assets to withstand impacts (AC1)	2	2	2	0	2	2	10	For inundation hazard which is projected to affect very few assets in this MU. Early design considerations mean implementation can occur as assets are routinely upgraded / renewed.
Beach nourishment or replenishment (PR1)	-2	-1	-1	-1	-2	0	-7	Potentially very expensive if no nearby suitable and sustainable sand source available. Could create legacy issues for future. Not feasible over large section of coastline. Does not complement environmental focus of this MU.
Groynes (PR2)	-2	-2	-2	-2	-2	-1	-11	Not feasible over large section of coastline. Groynes can be effective at stabilising shorelines but can also lead to downdrift erosion issues if not designed and constructed appropriately. Does not complement environmental focus of this MU.
Seawalls (PR3)	-2	-2	-2	-2	-2	-2	-12	Expensive option, not realistic due to the length of MU, and nature of impacted assets. Does not complement environmental focus of this MU.
Artificial reef (PR4)	-2	-2	-2	0	-2	-2	-10	Difficult to design submerged structures to work effectively, and costly to build and maintain. Expensive option, not realistic due to the length of MU, and nature of impacted assets. Does not complement environmental focus of this MU.
Offshore breakwater (PR5)	-2	-2	--2	-2	-2	-2	-12	Expensive option, not realistic due to the length of MU, and number of impacted assets (and hence low funding potential). Costly to build and maintain. Social concerns about ocean views likely. Does not complement environmental focus of this MU.
Levy / Weir / Storm Surge Barrier (PR6)							N/A	Inundation is not a high risk in this management unit
Monitoring (NR1)	2	2	1	0	0	2	7	Low-cost action which causes no problems. Resulting data is required for most management approaches.
Protection Structure Audit (NR2)							N/A	No existing protection structures in this MU.
Notification on title (NR3)	1	2	1	0	2	2	8	For private property. Effective low-cost option. May be unpopular with affected landholders, but appreciated by potential purchasers, depending on implementation strategy.
Emergency evacuation plans (NR4)							N/A	Suitable for inundation hazard that may affect people but given the few affected assets in this MU and their nature this is not applicable.
Do nothing (DN1)	-2	-1	-1	-1	-1	-2	-8	Not an effective adaptation option and may not be popular with the community.

Table B-5 Multi-Criteria Analysis – MU5 - Bunbury

Option (Option Code)	Effectiveness	Environment Impact	Social Impact	Aesthetic Impact	Cost	Future Adaptability	Score	Comment
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	2	2	1	2	2	2	11	This option applies to undeveloped land. In this MU most undeveloped land is already zoned as foreshore reserve. Any developable land in MU should be subject to this option. Community will benefit by appropriate foreshore reserve width and access throughout the planning timeframe.
Leaving assets unprotected (PMR1)	0	-1	1	0	1	1	2	Suitable for low-value public assets such as foreshore recreational amenities.
Demolition / removal / relocation of asset from inside hazard area (PMR2)	1	2	2	1	-1	2	7	Suitable for low-value public assets such as foreshore recreational amenities. Potentially costly if triggers met before asset due for replacement.
Prevention of further development / prohibit expansion of existing use rights (PMR3)	1	1	0	0	2	2	6	Allows for continued use of the land whilst viable, without creating legacy issues. May be unpopular with landholders.
Voluntary acquisition (PMR4)	2	1	0	2	-2	2	5	For private property. Effective but costly option. Ensures foreshore reserve retained. May be unpopular with landholders, depending on implementation strategy and timeframes. Likely to cost less than protection.
Design assets to withstand impacts (AC1)	2	2	1	0	1	2	8	For inundation hazard. Early design considerations mean implementation can occur as assets are routinely upgraded / renewed / redeveloped.
Beach nourishment or replenishment (PR1)	0	0	1	1	-1	2	3	Potentially very expensive if no nearby suitable and sustainable sand source available. Could create legacy issues for future.
Groynes (PR2)	1	0	1	0	-1	0	1	A groyne field may assist to stabilise the shoreline. Groynes can lead to downdrift erosion issues if not designed and constructed appropriately. Would require sand nourishment as part of works, which can help provide a sandy beach. Already in use in this MU.
Seawalls (PR3)	2	-1	-1	-1	-1	-1	-3	Expensive option. Likely to lead to reduction or loss of usable sandy beach. Already in use in this MU. Likely more acceptable because familiar and this MU more developed than others.
Artificial reef (PR4)	0	0	1	0	-2	-2	-3	Difficult to design submerged structures to work effectively, and costly to build and maintain.
Offshore breakwater (PR5)	2	0	1	-1	-1	-1	0	Costly to build and maintain but can be designed to work effectively and provide usable sandy beach. Social concerns about ocean views likely. Concerns and some costs could be offset by designing shore-attached structures.
Levy / Weir / Storm Surge Barrier (PR6)	2	0	2	0	-1	1	4	The storm surge barrier is effective at reducing inundation, but the present design is predicted to be breached by the present day 500-year ARI event, and more frequent future events. Upgrades would be effective at reducing the inundation impact.
Monitoring (NR1)	2	2	1	0	0	2	7	Low-cost action which causes no problems. Resulting data is required for most management approaches. Also a source of data for identifying triggers for other management options.
Protection Structure Audit (NR2)	2	0	0	0	2	2	6	An audit should be undertaken of all existing coastal protection structures.
Notification on title (NR3)	1	2	1	0	2	2	8	For private property. Effective low-cost option. May be unpopular with affected landholders, but appreciated by potential purchasers, depending on implementation strategy.
Emergency evacuation plans (NR4)	1	0	1	0	2	2	6	For inundation hazard. Doesn't directly address vulnerabilities of assets but low cost to plan for keeping people safe. Important for considering inundation of access roads to parts of MU.
Do nothing (DN1)	-2	-1	-1	-1	-1	-2	-8	Not an effective adaptation option and may not be popular with the community.

Table B-6 Multi-Criteria Analysis – MU6 – Bunbury Port

Option (Option Code)	Effectiveness	Environment Impact	Social Impact	Aesthetic Impact	Cost	Future Adaptability	Score	Comment
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	2	2	1	2	2	2	11	This option applies to undeveloped land. In this MU most undeveloped land is already zoned as reserve. Any developable land in MU should be subject to this option. Community will benefit by appropriate foreshore reserve width and access throughout the planning timeframe.
Leaving assets unprotected (PMR1)	0	-1	1	0	1	1	2	Suitable for low-value public assets such as foreshore recreational amenities.
Demolition / removal / relocation of asset from inside hazard area (PMR2)	1	2	2	1	-1	2	7	Suitable for low-value public assets such as foreshore recreational amenities. Potentially costly if triggers met before asset due for replacement.
Prevention of further development / prohibit expansion of existing use rights (PMR3)	1	1	0	0	2	2	6	Allows for continued use of the land whilst viable, without creating legacy issues. May be unpopular with landholders.
Voluntary acquisition (PMR4)	2	1	0	2	-2	2	5	For private property. Effective but costly option. Ensures foreshore reserve retained. May be unpopular with landholders, depending on implementation strategy and timeframes. Likely to cost less than protection.
Design assets to withstand impacts (AC1)	2	2	1	1	2	2	10	For inundation hazard. Early design considerations mean implementation can occur as assets are routinely upgraded / renewed / redeveloped.
Beach nourishment or replenishment (PR1)	1	0	1	1	-1	2	4	Potentially very expensive if no nearby suitable and sustainable sand source available. Could create legacy issues for future. Small ocean frontage and structure-controlled pocket beaches make it a potentially effective option.
Groynes (PR2)	1	1	1	1	-1	0	3	A groyne field may assist to stabilise the shoreline. Groynes can lead to downdrift erosion issues if not designed and constructed appropriately. Could require sand nourishment as part of works, which can help provide a sandy beach. Existing structures increase acceptability.
Seawalls (PR3)	1	0	0	0	-2	0	0	Expensive option. Likely to lead to reduction or loss of usable sandy beach. May be acceptable at this industrialised MU, especially because there are existing seawalls.
Artificial reef (PR4)	0	0	0	0	-2	-2	-4	Difficult to design submerged structures to work effectively, and costly to build and maintain.
Offshore breakwater (PR5)	1	0	0	0	-2	-2	-3	Costly to build and maintain but can be designed to work effectively and provide usable sandy beach.
Levy / Weir / Storm Surge Barrier (PR6)	2	0	2	0	-2	1	3	A storm surge barrier at the Cut may be effective at reducing inundation, combined with additional protection along Preston River. This would be costly; impacts would need to be investigated.
Monitoring (NR1)	2	2	1	0	0	2	7	Low-cost action which causes no problems. Resulting data is required for most management approaches.
Protection Structure Audit (NR2)	2	0	0	0	2	2	6	An audit should be undertaken of all existing coastal protection structures.
Notification on title (NR3)	1	2	1	0	2	2	8	For private property. Effective low-cost option. May be unpopular with affected landholders, but appreciated by potential purchasers, depending on implementation strategy.
Emergency evacuation plans (NR4)	1	0	1	0	2	2	6	For inundation hazard. Doesn't directly address vulnerabilities of assets but low cost to plan for keeping people safe. Important for considering inundation of main access roads.
Do nothing (DN1)	-2	-1	-1	-1	-1	-2	-8	Not an effective adaptation option and may not be popular with the community.

Table B-7 Multi-Criteria Analysis – MU7 – The Cut

Option (Option Code)	Effectiveness	Environment Impact	Social Impact	Aesthetic Impact	Cost	Future Adaptability	Score	Comment
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	2	2	1	2	2	2	11	This option applies to undeveloped land. In this MU most undeveloped land is already zoned as reserve. Any developable land in MU should be subject to this option. Community will benefit by appropriate foreshore reserve width and access throughout the planning timeframe.
Leaving assets unprotected (PMR1)	0	-1	1	0	1	1	2	Suitable for low-value public assets such as foreshore recreational amenities.
Demolition / removal / relocation of asset from inside hazard area (PMR2)	1	2	2	1	-1	2	7	Suitable for low-value public assets such as foreshore recreational amenities. Potentially costly if triggers met before asset due for replacement.
Prevention of further development / prohibit expansion of existing use rights (PMR3)							N/A	No developed land parcels.
Voluntary acquisition (PMR4)							N/A	No developed land parcels.
Design assets to withstand impacts (AC1)	2	2	2	2	2	2	12	For inundation hazard which is projected to affect very few assets in this MU. Early design considerations mean implementation can occur as assets are routinely upgraded / renewed.
Beach nourishment or replenishment (PR1)	1	0	1	1	-1	2	4	Potentially very expensive if no nearby suitable and sustainable sand source available. Could create legacy issues for future. Small ocean frontage and structure-controlled pocket beaches make it a potentially effective option.
Groynes (PR2)	1	1	1	1	-1	0	3	A groyne field may assist to stabilise the shoreline. Groynes can lead to downdrift erosion issues if not designed and constructed appropriately. Could require sand nourishment as part of works, which can help provide a sandy beach. Existing structures increase acceptability.
Seawalls (PR3)	2	0	0	0	-1	-1	0	Expensive option. Likely to lead to reduction or loss of usable sandy beach. MU already has seawall for much of coastline.
Artificial reef (PR4)	0	0	0	0	-2	-2	-4	Difficult to design submerged structures to work effectively, and costly to build and maintain.
Offshore breakwater (PR5)	0	0	0	0	-2	-2	-4	Costly to build and maintain. Location means unlikely to very effective.
Levy / Weir / Storm Surge Barrier (PR6)							N/A	A storm surge barrier at the Cut may be effective at reducing inundation elsewhere, however not necessarily required in this MU.
Monitoring (NR1)	2	2	1	0	0	2	7	Low-cost action which causes no problems. Resulting data is required for most management approaches.
Protection Structure Audit (NR2)	2	0	0	0	2	2	6	An audit should be undertaken of all existing coastal protection structures.
Notification on title (NR3)	1	2	1	0	2	2	8	For private property. Effective low-cost option. May be unpopular with affected landholders, but appreciated by potential purchasers, depending on implementation strategy.
Emergency evacuation plans (NR4)							N/A	Suitable for inundation hazard that may affect people but given the few affected assets in this MU and their environmental nature this is not applicable.
Do nothing (DN1)	-2	-1	-1	-1	-1	-2	-8	Not an effective adaptation option and may not be popular with the community.

Table B-8 Multi-Criteria Analysis – MU8 – Bunbury E

Option (Option Code)	Effectiveness	Environment Impact	Social Impact	Aesthetic Impact	Cost	Future Adaptability	Score	Comment
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	2	2	1	2	2	2	11	This option applies to undeveloped land. In this MU most undeveloped land is already zoned as foreshore reserve. Any developable land in MU should be subject to this option. Community will benefit by appropriate foreshore reserve width and access throughout the planning timeframe.
Leaving assets unprotected (PMR1)	0	-1	1	0	1	1	2	Suitable for low-value public assets such as foreshore recreational amenities.
Demolition / removal / relocation of asset from inside hazard area (PMR2)	1	2	2	1	-1	2	7	Suitable for low-value public assets such as foreshore recreational amenities. Potentially costly if triggers met before asset due for replacement.
Prevention of further development / prohibit expansion of existing use rights (PMR3)	1	1	0	0	2	2	6	Allows for continued use of the land whilst viable, without creating legacy issues. May be unpopular with landholders.
Voluntary acquisition (PMR4)	2	1	0	2	-2	2	5	For private property. Effective but costly option. Ensures foreshore reserve retained. May be unpopular with landholders, depending on implementation strategy and timeframes. Likely to cost less than protection.
Design assets to withstand impacts (AC1)	2	2	1	0	2	2	9	For inundation hazard. Early design considerations mean implementation can occur as assets are routinely upgraded / renewed / redeveloped.
Beach nourishment or replenishment (PR1)	0	-1	1	1	-1	2	2	Potentially very expensive if no nearby suitable and sustainable sand source available. Could create legacy issues for future.
Groynes (PR2)	0	0	1	0	-1	0	0	A groyne field may assist to stabilise the shoreline. Groynes can lead to downdrift erosion issues if not designed and constructed appropriately. Would require sand nourishment as part of works, which can help provide a sandy beach.
Seawalls (PR3)	2	2	-2	0	-1	-1	0	Expensive option. Likely to lead to reduction or loss of usable sandy beach. Likely more acceptable because nature of MU means they can be smaller structures.
Artificial reef (PR4)	-2	0	1	0	-2	-2	-5	Difficult to design submerged structures to work effectively, and costly to build and maintain.
Offshore breakwater (PR5)	1	0	1	-1	-1	-1	-1	Costly to build and maintain but could potentially be designed to work effectively and provide usable sandy beach. Social concerns about ocean views likely. Concerns and some costs could be offset by designing shore-attached structures.
Levy / Weir / Storm Surge Barrier (PR6)	2	0	2	-1	-2	0	1	A storm surge barrier at the Cut may be effective at reducing inundation, potentially combined with additional protection along Preston River. This would be costly; impacts would need to be investigated. Future adaptability scored neutral because it creates reliance on protection but can be modified for increasing SLR if required.
Monitoring (NR1)	2	2	1	0	0	2	7	Low-cost action which causes no problems. Resulting data is required for most management approaches.
Protection Structure Audit (NR2)	2	0	0	0	2	2	6	An audit should be undertaken of all existing coastal protection structures.
Notification on title (NR3)	1	2	2	0	2	2	9	For private property. Effective low-cost option. May be unpopular with affected landholders, but appreciated by potential purchasers, depending on implementation strategy.
Emergency evacuation plans (NR4)	1	0	2	0	2	2	7	For inundation hazard. Doesn't directly address vulnerabilities of assets but low cost to plan for keeping people safe. Important for considering inundation of access roads to parts of MU.
Do nothing (DN1)	-2	-1	-1	-1	-1	-2	-8	Not an effective adaptation option and may not be popular with the community.

Table B-9 Multi-Criteria Analysis – MU9 – Leschenault Estuary

Option (Option Code)	Effectiveness	Environment Impact	Social Impact	Aesthetic Impact	Cost	Future Adaptability	Score	Comment
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	2	2	1	2	2	2	11	Community will benefit by appropriate foreshore reserve width and access throughout the planning timeframe. This option applies to undeveloped land, which there are large areas of in this MU. Community will benefit by appropriate foreshore reserve width and access throughout the planning timeframe.
Leaving assets unprotected (PMR1)	0	-1	1	0	1	1	2	Suitable for low-value public assets such as foreshore recreational amenities.
Demolition / removal / relocation of asset from inside hazard area (PMR2)	1	2	2	1	-1	2	7	Suitable for low-value public assets such as foreshore recreational amenities. Potentially costly if triggers met before asset due for replacement.
Prevention of further development / prohibit expansion of existing use rights (PMR3)	1	1	0	0	2	2	6	Allows for continued use of the land whilst viable, without creating legacy issues. May be unpopular with landholders.
Voluntary acquisition (PMR4)	2	1	0	2	-2	2	5	For private property. Effective but costly option. Ensures foreshore reserve retained. May be unpopular with landholders, depending on implementation strategy and timeframes. Likely to cost less than protection.
Design assets to withstand impacts (AC1)	2	2	1	0	2	2	9	For inundation hazard. Early design considerations mean implementation can occur as assets are routinely upgraded / renewed / redeveloped.
Beach nourishment or replenishment (PR1)	0	0	1	1	-1	2	3	Potentially expensive if no nearby suitable and sustainable sand source available. Could create legacy issues for future.
Groynes (PR2)	0	0	1	0	-1	0	0	A groyne field may assist to stabilise the shoreline. Groynes can lead to downdrift erosion issues if not designed and constructed appropriately. Would require sand nourishment as part of works, which can help provide a sandy beach.
Seawalls (PR3)	2	0	0	0	-1	-1	0	Expensive option. Likely to lead to reduction or loss of usable sandy beach / socially amenable shoreline. Likely more acceptable because nature of MU means they can be smaller structures.
Artificial reef (PR4)	-1	0	1	0	-2	-2	-4	Difficult to design submerged structures to work effectively, and costly to build and maintain.
Offshore breakwater (PR5)	1	0	1	0	-1	-1	0	Costly to build and maintain but could potentially be designed to work effectively and provide usable sandy beach. Could be social concerns about estuary views. Concerns and some costs could be offset by designing shore-attached structures.
Levy / Weir / Storm Surge Barrier (PR6)	2	0	2	-1	-2	0	1	A storm surge barrier at the Cut may be effective at reducing inundation. This would be costly; impacts would need to be investigated. Future adaptability scored neutral because it creates reliance on protection but can be modified for increasing SLR if required.
Monitoring (NR1)	2	2	1	0	0	2	7	Low-cost action which causes no problems. Resulting data is required for most management approaches.
Protection Structure Audit (NR2)	2	0	0	0	2	2	6	An audit should be undertaken of any existing coastal protection structures. Water Technology are not aware of any in this MU.
Notification on title (NR3)	1	2	2	0	2	2	9	For private property. Effective low-cost option. May be unpopular with affected landholders, but appreciated by potential purchasers, depending on implementation strategy.
Emergency evacuation plans (NR4)	1	0	1	0	2	2	6	For inundation hazard. Doesn't directly address vulnerabilities of assets but low cost to plan for keeping people safe. Important for considering inundation of main access roads.
Do nothing (DN1)	-2	-2	-2	-2	-1	-2	-11	Not an effective adaptation option and may not be popular with the community.

Table B-10 Multi-Criteria Analysis – MU10 – Collie River S

Option (Option Code)	Effectiveness	Environment Impact	Social Impact	Aesthetic Impact	Cost	Future Adaptability	Score	Comment
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	2	2	1	2	2	2	11	This option applies to undeveloped land. In this MU most undeveloped land is already zoned as foreshore reserve. Any developable land in MU should be subject to this option. Community will benefit by appropriate foreshore reserve width and access throughout the planning timeframe.
Leaving assets unprotected (PMR1)	0	-1	1	0	1	1	2	Suitable for low-value public assets such as foreshore recreational amenities.
Demolition / removal / relocation of asset from inside hazard area (PMR2)	1	2	2	1	-1	2	7	Suitable for low-value public assets such as foreshore recreational amenities. Potentially costly if triggers met before asset due for replacement.
Prevention of further development / prohibit expansion of existing use rights (PMR3)	1	2	1	1	2	2	9	Allows for continued use of the land whilst viable, without creating legacy issues. May be unpopular with landholders.
Voluntary acquisition (PMR4)	2	2	1	2	-2	2	7	For private property. Effective but costly option. Ensures foreshore reserve retained. May be unpopular with landholders, depending on implementation strategy and timeframes. Likely to cost less than protection.
Design assets to withstand impacts (AC1)	2	2	1	0	2	2	9	For inundation hazard. Early design considerations mean implementation can occur as assets are routinely upgraded / renewed / redeveloped.
Beach nourishment or replenishment (PR1)	0	0	1	1	-1	2	3	Potentially very expensive if no nearby suitable and sustainable sand source available. Could create legacy issues for future.
Groynes (PR2)	-1	0	1	0	-1	0	-1	A groyne field is not an effective erosion mitigation option for this MU...
Seawalls (PR3)	1	0	0	0	-1	-1	-1	Expensive option. Likely more acceptable because nature of MU means they can be smaller structures, however erosion risk based on application of policy so not necessarily required / appropriate.
Artificial reef (PR4)							N/A	Not appropriate in this riverine environment
Offshore breakwater (PR5)							N/A	Not appropriate in this riverine environment
Levy / Weir / Storm Surge Barrier (PR6)	2	0	2	-1	-2	0	1	A storm surge barrier at the Cut may be effective at reducing inundation. This would be costly; impacts would need to be investigated. Future adaptability scored neutral because it creates reliance on protection but can be modified for increasing SLR if required.
Monitoring (NR1)	2	2	1	0	0	2	7	Low-cost action which causes no problems. Resulting data is required for most management approaches.
Protection Structure Audit (NR2)							N/A	No existing protection structures in this MU.
Notification on title (NR3)	1	2	2	0	2	2	9	For private property. Effective low-cost option. May be unpopular with affected landholders, but appreciated by potential purchasers, depending on implementation strategy.
Emergency evacuation plans (NR4)	1	0	2	0	2	2	7	For inundation hazard. Doesn't directly address vulnerabilities of assets but low cost to plan for keeping people safe. Important for considering inundation of access roads to parts of MU.
Do nothing (DN1)	-2	-1	-1	-1	-1	-2	-8	Not an effective adaptation option and may not be popular with the community.

Table B-11 Multi-Criteria Analysis – MU11 – Collie River N

Option (Option Code)	Effectiveness	Environment Impact	Social Impact	Aesthetic Impact	Cost	Future Adaptability	Score	Comment
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	2	2	1	2	2	2	11	This option applies to undeveloped land. In this MU most undeveloped land is already zoned as foreshore reserve. Any developable land in MU should be subject to this option. Community will benefit by appropriate foreshore reserve width and access throughout the planning timeframe.
Leaving assets unprotected (PMR1)	0	-1	1	0	1	1	2	Suitable for low-value public assets such as foreshore recreational amenities.
Demolition / removal / relocation of asset from inside hazard area (PMR2)	1	2	2	1	-1	2	7	Suitable for low-value public assets such as foreshore recreational amenities. Potentially costly if triggers met before asset due for replacement.
Prevention of further development / prohibit expansion of existing use rights (PMR3)	1	1	0	0	2	2	6	Allows for continued use of the land whilst viable, without creating legacy issues. May be unpopular with landholders.
Voluntary acquisition (PMR4)	2	1	0	2	-2	2	5	For private property. Effective but costly option. Ensures foreshore reserve retained. May be unpopular with landholders, depending on implementation strategy and timeframes. Likely to cost less than protection.
Design assets to withstand impacts (AC1)	2	2	1	0	2	2	9	For inundation hazard. Early design considerations mean implementation can occur as assets are routinely upgraded / renewed / redeveloped.
Beach nourishment or replenishment (PR1)	0	0	1	1	-1	2	3	Potentially very expensive if no nearby suitable and sustainable sand source available. Could create legacy issues for future.
Groynes (PR2)	-1	0	1	0	-1	0	-1	A groyne field is not an effective erosion mitigation option for this MU. .
Seawalls (PR3)	1	0	0	0	-1	-1	-1	Expensive option. Likely more acceptable because nature of MU means they can be smaller structures, however erosion risk based on application of policy so not necessarily required / appropriate.
Artificial reef (PR4)							N/A	Not appropriate in this riverine environment
Offshore breakwater (PR5)							N/A	Not appropriate in this riverine environment
Levy / Weir / Storm Surge Barrier (PR6)	2	0	2	-1	-2	0	1	A storm surge barrier at the Cut may be effective at reducing inundation. This would be costly; impacts would need to be investigated. Future adaptability scored neutral because it creates reliance on protection but can be modified for increasing SLR if required.
Monitoring (NR1)	2	2	1	0	0	2	7	Low-cost action which causes no problems. Resulting data is required for most management approaches.
Protection Structure Audit (NR2)							N/A	No existing protection structures in this MU.
Notification on title (NR3)	1	2	2	0	2	2	9	For private property. Effective low-cost option. May be unpopular with affected landholders, but appreciated by potential purchasers, depending on implementation strategy.
Emergency evacuation plans (NR4)	1	0	2	0	2	2	7	For inundation hazard. Doesn't directly address vulnerabilities of assets but low cost to plan for keeping people safe. Important for considering inundation of access roads to parts of MU.
Do nothing (DN1)	-2	-1	-1	-1	-1	-2	-8	Not an effective adaptation option and may not be popular with the community.

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Capel to Leschenault CHRMAP

Chapter Report: Risk Treatment

Peron Naturaliste Partnership

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1 INTRODUCTION

It is internationally recognised that the mean sea level has been rising globally since the nineteenth century and is predicted to rise at an increasing rate in the future (IPCC 2021). Rising sea levels and intensifying storm activity will increase the risk of coastal inundation (temporary coastal flooding), storm erosion and long-term shoreline recession. State governments across Australia have introduced obligations that require local governments to consider and plan for these hazards. In Western Australia (WA), the governing policy is the Western Australian Planning Commission's (WAPC) State Planning Policy No. 2.6: State Coastal Planning Policy (WAPC, 2013, herein referred to as "SPP2.6"). SPP2.6 recommends that management authorities develop a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for land use or development potentially vulnerable to coastal hazards. Specific guidelines have been developed to assist in this process (WAPC, 2019).

SPP2.6 requires adequate risk management planning is undertaken where existing or proposed development is in an area at risk of being affected by coastal hazards over the 100-years planning timeframe. SPP2.6 and the CHRMAP Guidelines provide the risk assessment framework to be applied to identify risks that are intolerable to the community, and other stakeholders such as local governments, indigenous and cultural interests, and private enterprise. Risk management measures are then developed according to the adaptation hierarchy outlined in SPP2.6.

The Peron Naturaliste Partnership (PNP) comprises membership of nine local government authorities. The PNP's Coastal Adaptation Pathways Project identified the coastal areas of Capel, Leschenault and Greater Bunbury as being particularly exposed to coastal hazards and climate change, which triggered the need for this CHRMAP. Therefore, the present study aims to investigate the nature and severity of coastal hazards that are likely to affect these regions from Capel to Leschenault over future planning horizons. Refer Figure 1-2 for locality, study area extent and management units.

This CHRMAP project aims to increase knowledge and understanding of coastal hazard risks and identify risk management and adaptation measures for implementation. The outcomes will be used to inform local and state government policies, strategies and plans, including (but not limited to), planning strategies, community strategic plans, drainage strategies, asset management plans, emergency management plans, and foreshore management plans. The project will adhere to the WAPC (2019) guidelines with scope and deliverables to be consistent with the objectives identified by these guidelines and SPP2.6. In addition, the project will identify the strategic direction for coastal adaptation scenarios from the present-day to 2120 (100 yrs. management time frame) and identify an implementation plan to achieve this direction. Overall, this CHRMAP will develop a flexible adaptation pathway for the region and serve as a key reference for management, planning and policy-making for the short-term (0-15 years), medium-term (15-30 years), and long-term (100 years).

Delivery of this project will occur over 9 stages (as summarised Figure 1-1), each of which represents a key hold point. The staged approached is developed according to the PNP's scope and is in line with the CHRMAP Guidelines (WAPC, 2019).

This report presents the Stage G Risk Treatment Chapter Report, which assesses treatment options using Cost Benefit Analysis (CBA). The red bubble displayed in Figure 1-1 outlines Stage G in the context of the CHRMAP.

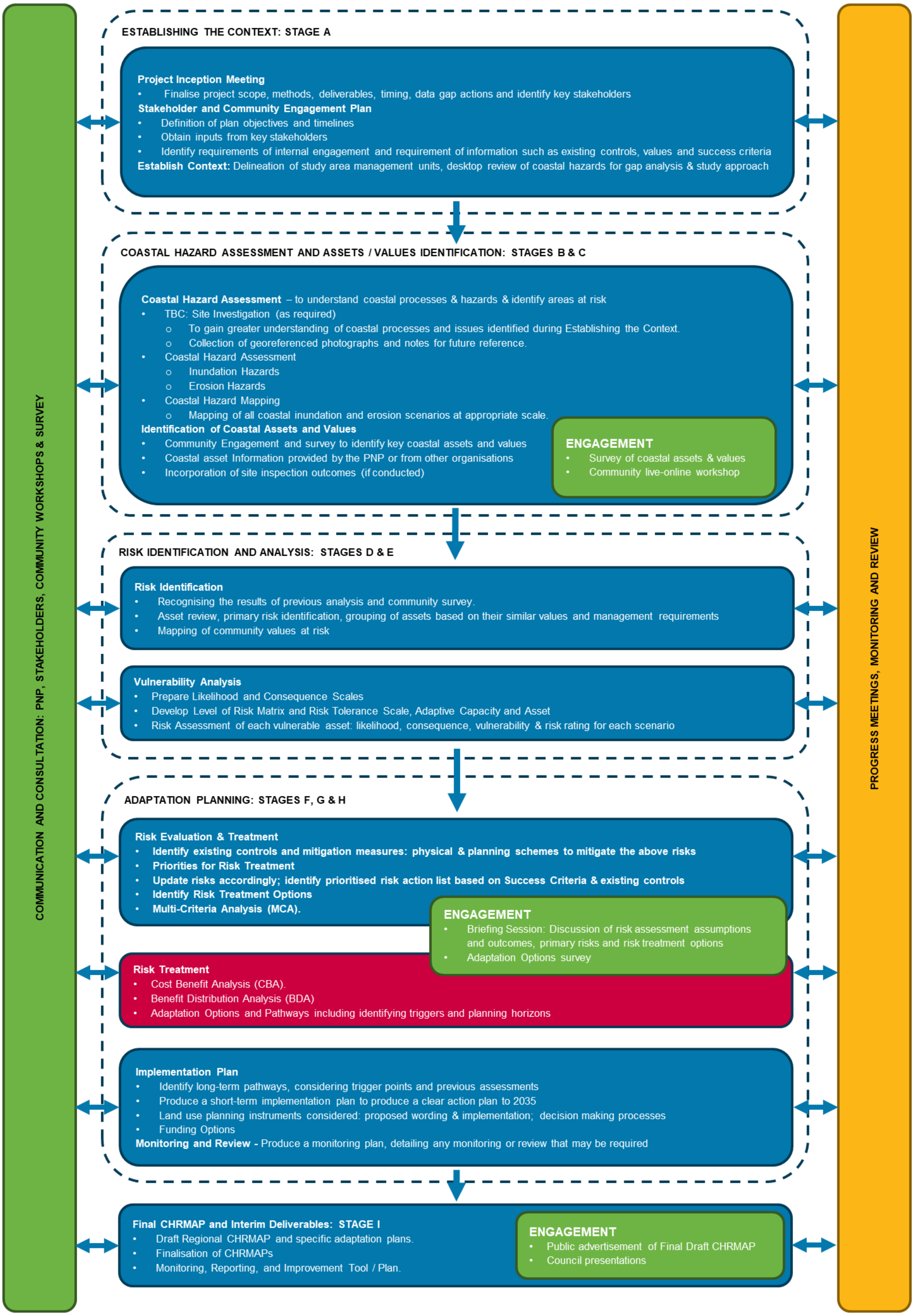

Figure 1-1 Methodology

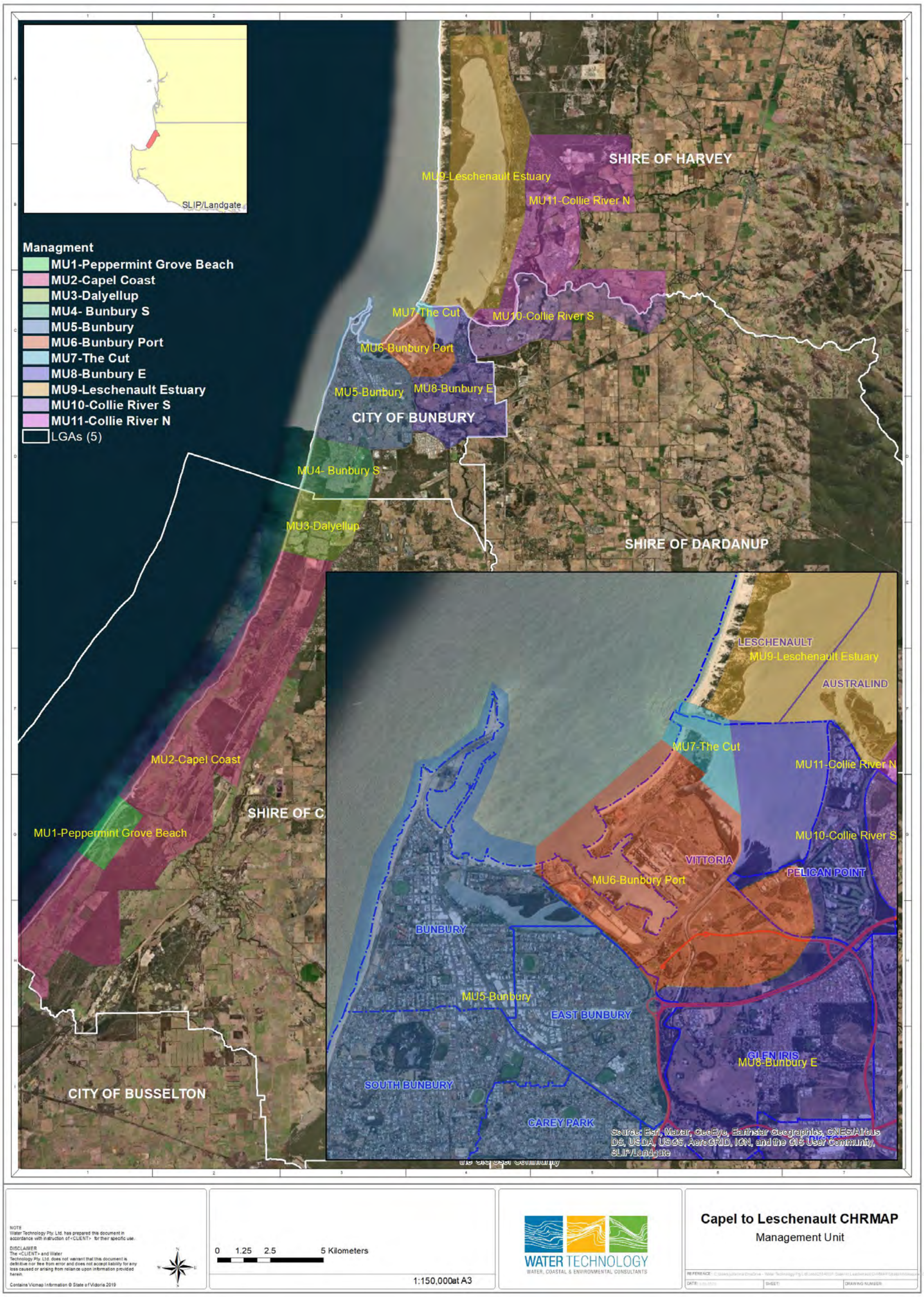

Figure 1-2 Study Area and Management Units (MU)

2 COST BENEFIT ANALYSIS

2.1 Approach

The Cost-Benefit Analysis (CBA) aims to examine the selection of coastal adaptation options through economic analysis. In the previous Chapter Report (Water Technology, 2022), potential coastal adaptation options were assessed against a range of criteria, including cost. This CBA includes coastal adaptation options requiring significant financial investment and scoring positively in the MCA. A rigorous assessment of costs and benefits for each coastal adaptation option will assist with preferential selection and potentially uncover any poor financial assumptions included in the MCA.

While the CBA process assists in contrasting options available "*at the time of the analysis*" and "*for a set of specific assumptions*", it is not the Panacea for decision-making. For instance, changing scientific, environmental and macro-economic considerations can upset cost estimates in the future. Some of the CBA assumptions may not hold true for the long duration often considered in CBA analysis for major infrastructure (CoVID pandemic, technological advances, etc.).

The CBA analysis allows selection of coastal adaptation options which are economically defendable. The CBA has only addressed valuing the loss of assets, managed retreat and physical protection options. Indirect costs that another user might consider to be a loss are not considered in this CBA. For example, costs associated with Special Control Area (SCA) title notifications, emergency planning, and development restrictions were not included in our analysis. Also options selected have been designed to provide similar level of beach and foreshore amenities to the present-day situation. This may not be practical. Possibly, there may be further decisions about coastal amenities management (such as policies, planning decisions, legal proceedings, etc.), guided by community values, which may alter this assumption. In this CBA all coastal adaptation options are designed to provide beach and foreshore amenities into the future.

The cost-benefit of each coastal adaptation option is presented in net present value (NPV) terms. NPV is a standard economic analysis to compare options with time-variable costs and benefits. It allows for the adjustment of all future economic considerations to present-day dollars for a more direct comparison. This relates to the time-value of money, as planned expenses in the future are, in a sense, cheaper than equivalent costs today. This is because the money required for a future expense could be spent elsewhere today to provide value over time (i.e., it can be invested now to generate a return). An expense that occurred today could not be invested elsewhere. In this case, all our cashflows are costs, so options with a lower net present cost are considered better investments from a financial standpoint.

The real discount rate chosen for this project was 4% with sensitivity analyses at 7% and 2%. This decision was based on similar assessments (DPMC, 2016; Transport for NSW, 2022; Baird, 2020; APH, 2018; Abelson and Dalton, 2018), the very long timeframe of analysis, and concerns about valuing future spending so low, which is at odds with resilient coastal planning principles.

The discount rate converts all future costs back to today's dollar value for comparison (in the NPV). For example, a project that costs $10 million today would have an NPV of $10 million. However, a project costing $1 million per year for 10 years would discount to an NPV of roughly $7.5 million discounted at 7%. Similarly, a project with only a single outlay of $10 million in 10 years' time would have an NPV of roughly $5.4 million discounted at 7%. This example shows the importance of when a cost is realised.

The CBA has been performed over a 100-year period, to match the project planning timeframe and meet the requirements of the CHRMAP. It should be noted that the uncertainty around the CBA estimates and assumptions made grows with time. Cost estimates beyond 2040 should be viewed as indicative trends only. Long-term coastal adaptation pathways should be monitored and updated regularly.

2.2 Options Suitable for Cost-Benefit Analysis

The CBA has only addressed options, including practical and economic actions across the planning timeframe. The economic base case used for comparison is calculated by valuing the loss of assets and values in an assumed scenario of inaction rather than "Business As Usual" (BAU). Total inaction is unrealistic in practical terms as emergency management works and obligations of other legislation would require LGAs and State Departments to act when projected coastal erosion and inundation occur. The scenario of economic inaction is also therefore different to the "Do-Nothing" adaptation option which would assume that no actions or management are undertaken by anyone over the planning timeframe, and that hazards and resultant asset loss/damage occurs exactly as the hazard analysis suggests. The adaptation options considered suitable for CBA are summarised in Table 2-1 – managed retreat and physical protection options (e.g., nourishment, groynes, seawalls, artificial reefs, offshore breakwaters, levy/weir/storm-surge-barrier).

Table 2-1 Risk treatment options from WAPC (2019) suitable for CBA. Note PR4 is greyed out as it did not progress through MCA for any MUs.

Option Category	Option Name	Option Code
Planned / Managed Retreat	Voluntary acquisition	PMR4
Protect	Beach nourishment or replenishment	PR1
	Groyne	PR2
	Seawall	PR3
	Artificial reef	PR4
	Offshore breakwater	PR5
	Levy / Weir / Storm Surge Barrier	PR6

2.3 Other Options

The remaining adaptation options from WAPC (2019) are not considered suitable for CBA and have been costed using traditional budgeting techniques for MUs where they received a positive MCA score. Table 2-2 and Table 2-3 provide cost estimates and notes on any scoping details or assumptions.

Table 2-2 Budget cost summary for options not suitable for CBA analysis – MU1 to MU5.

Option	MU1	MU2	MU3	MU4	MU5
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	▪ $100,000 ▪ Item cost for investigations and management plans	▪ $150,000 ▪ Item cost for investigations and management plans	▪ $150,000 ▪ Item cost for investigations and management plans	▪ $150,000 ▪ Item cost for investigations and management plans	▪ $150,000 ▪ Item cost for investigations and management plans
Leaving assets unprotected (PMR1)	▪ $415,000 ▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ (Plus 3% annual maintenance of $12,450)	▪ $244,000 ▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ (Plus 3% annual maintenance of $7,320)	▪ $501,000 ▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ (Plus 3% annual maintenance of $15,030)	▪ $59,000 ▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ (Plus 3% annual maintenance of $1,770)	▪ $2,011,000 ▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ (Plus 3% annual maintenance of $60,330)
Demolition / removal / relocation of asset from inside hazard area (PMR2)	▪ $993,000 ▪ To 2035 for public built assets ▪ Allows for removal of building at Wave Walk ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ (Plus 1% annual maintenance of $9,930)	▪ $537,000 ▪ To 2035 for public built assets ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ (Plus 1% annual maintenance of $5,370)	▪ $1,102,000 ▪ To 2035 for public built assets ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ (Plus 1% annual maintenance of $11,020)	▪ $129,000 ▪ To 2035 for public built assets ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ (Plus 1% annual maintenance of $1,290)	▪ $4,506,000 ▪ To 2035 for public built assets ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ (Plus 1% annual maintenance of $45,060)
Prevention of further development / prohibit expansion of existing use rights (PMR3)	▪ $100,000 ▪ Item cost for investigations and management plans ▪ (Plus 1% annual maintenance of $1,000)	▪ $100,000 ▪ Item cost for investigations and management plans ▪ (Plus 1% annual maintenance of $1,000)	▪ $100,000 ▪ Item cost for investigations and management plans ▪ (Plus 1% annual maintenance of $1,000)	▪ $50,000 ▪ Item cost for investigations and management plans ▪ (Plus 1% annual maintenance of $1,000)	▪ $100,000 ▪ Item cost for investigations and management plans ▪ (Plus 1% annual maintenance of $1,000)
Design assets to withstand impacts (AC1)	▪ $200,000 ▪ Item cost for investigations and management plans – primarily any case-by-case work needed for public assets ▪ (Plus 1% annual maintenance of $2,000)	▪ $200,000 ▪ Item cost for investigations and management plans – primarily any case-by-case work needed for public assets ▪ (Plus 1% annual maintenance of $2,000)	Not applicable	▪ $150,000 ▪ Item cost for investigations and management plans – primarily any case-by-case work needed for public assets ▪ (Plus 1% annual maintenance of $1,500)	▪ $500,000 ▪ Item cost for investigations and management plans – primarily any case-by-case work needed for public assets ▪ (Plus 1% annual maintenance of $5,000)
Monitoring (NR1)	▪ $20,000 ▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ (Plus 10% annual maintenance of $2,000)	▪ $20,000 ▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ (Plus 10% annual maintenance of $2,000)	▪ $20,000 ▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ (Plus 10% annual maintenance of $2,000)	▪ $20,000 ▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ (Plus 10% annual maintenance of $2,000)	▪ $30,000 ▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ (Plus 10% annual maintenance of $3,000)
Protection Structure Audit (NR2)	Not applicable	Not applicable	Not applicable	Not applicable	▪ $75,000 ▪ Item cost to inspect condition, influence on sediment transport and inundation and remaining design life on all coastal management structures ▪ (Plus 2% annual maintenance of $1,500)

Option	MU1	MU2	MU3	MU4	MU5
Notification on title (NR3)	▪ $250,000 ▪ Item cost for investigations and implementation plans ▪ (Plus 1% annual maintenance of $2,500)	▪ $250,000 ▪ Item cost for investigations and implementation plans ▪ (Plus 1% annual maintenance of $2,500)	▪ $250,000 ▪ Item cost for investigations and implementation plans ▪ (Plus 1% annual maintenance of $2,500)	▪ $50,000 ▪ Item cost for investigations and implementation plans ▪ (Plus 1% annual maintenance of $500)	▪ $250,000 ▪ Item cost for investigations and implementation plans ▪ (Plus 1% annual maintenance of $2,500)
Emergency evacuation plans (NR4)	▪ $250,000 ▪ Item cost for investigations and evacuation plans ▪ (Plus 1% annual maintenance of $2,500)	▪ $250,000 ▪ Item cost for investigations and evacuation plans ▪ (Plus 1% annual maintenance of $2,500)	Not applicable	Not applicable	▪ $250,000 ▪ Item cost for investigations and evacuation plans ▪ (Plus 1% annual maintenance of $2,500)

Table 2-3 Budget cost summary for options not suitable for CBA analysis – MU6 to MU11

Option	MU6	MU7	MU8	MU9	MU10	MU11
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	▪ $50,000 ▪ Item cost for investigations and management plans	▪ $50,000 ▪ Item cost for investigations and management plans	▪ $100,000 ▪ Item cost for investigations and management plans	▪ $150,000 ▪ Item cost for investigations and management plans	▪ $150,000 ▪ Item cost for investigations and management plans	▪ $150,000 ▪ Item cost for investigations and management plans
Leaving assets unprotected (PMR1)	▪ $360,000 ▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ (Plus 3% annual maintenance of $10,800)	▪ $88,000 ▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ (Plus 3% annual maintenance of $2,640)	▪ $111,000 ▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ (Plus 3% annual maintenance of $3,330)	▪ $351,000 ▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ (Plus 3% annual maintenance of $10,530)	▪ $44,000 ▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ (Plus 3% annual maintenance of $1,320)	▪ $44,000 ▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ (Plus 3% annual maintenance of $1,320)
Demolition / removal / relocation of asset from inside hazard area (PMR2)	▪ $791,000 ▪ To 2035 for public built assets ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ (Plus 1% annual maintenance of $7,910)	▪ $194,000 ▪ To 2035 for public built assets ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ (Plus 1% annual maintenance of $1,940)	▪ $244,000 ▪ To 2035 for public built assets ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ (Plus 1% annual maintenance of $2,440)	▪ $853,000 ▪ To 2035 for public built assets ▪ Allows for removal of building – Leschenault Discovery Centre on Old Coast Road ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ (Plus 1% annual maintenance of $8,530)	▪ $97,000 ▪ To 2035 for public built assets ▪ Maintenance assumes ongoing allowance for reserve along riverbank ▪ (Plus 1% annual maintenance of $970)	▪ $97,000 ▪ To 2035 for public built assets ▪ Maintenance assumes ongoing allowance for reserve along riverbank ▪ (Plus 1% annual maintenance of $970)
Prevention of further development / prohibit expansion of existing use rights (PMR3)	▪ $30,000 ▪ Item cost for investigations and management plans ▪ (Plus 1% annual maintenance of $300)	Not applicable	▪ $100,000 ▪ Item cost for investigations and management plans ▪ (Plus 1% annual maintenance of $1,000)	▪ $150,000 ▪ Item cost for investigations and management plans ▪ (Plus 1% annual maintenance of $1,500)	▪ $250,000 ▪ Item cost for investigations and management plans ▪ (Plus 1% annual maintenance of $2,500)	▪ $100,000 ▪ Item cost for investigations and management plans ▪ (Plus 1% annual maintenance of $1,000)

Option	MU6	MU7	MU8	MU9	MU10	MU11
Design assets to withstand impacts (AC1)	▪ $100,000 ▪ Item cost for investigations and management plans – primarily any case-by-case work needed for public assets ▪ (Plus 1% annual maintenance of $1,000)	▪ $50,000 ▪ Item cost for investigations and management plans – primarily any case-by-case work needed for public assets ▪ (Plus 1% annual maintenance of $500)	▪ $500,000 ▪ Item cost for investigations and management plans – primarily any case-by-case work needed for public assets ▪ (Plus 1% annual maintenance of $5,000)	▪ $500,000 ▪ Item cost for investigations and management plans – primarily any case-by-case work needed for public assets ▪ (Plus 1% annual maintenance of $5,000)	▪ $150,000 ▪ Item cost for investigations and management plans – primarily any case-by-case work needed for public assets ▪ (Plus 1% annual maintenance of $1,500)	▪ $150,000 ▪ Item cost for investigations and management plans – primarily any case-by-case work needed for public assets ▪ (Plus 1% annual maintenance of $1,500)
Monitoring (NR1)	▪ $10,000 ▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ (Plus 10% annual maintenance of $1,000)	▪ $20,000 ▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ (Plus 10% annual maintenance of $2,000)	▪ $30,000 ▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ (Plus 10% annual maintenance of $3,000)	▪ $30,000 ▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ (Plus 10% annual maintenance of $3,000)	▪ $20,000 ▪ Riverbank survey for storm behaviour and to track HSD and inundation levels ▪ (Plus 10% annual maintenance of $2,000)	▪ $10,000 ▪ Riverbank survey for storm behaviour and to track HSD and inundation levels ▪ (Plus 10% annual maintenance of $1,000)
Protection Structure Audit (NR2)	▪ $50,000 ▪ Item cost to inspect condition, influence on sediment transport and inundation and remaining design life on all coastal management structures ▪ Includes Port breakwaters ▪ (Plus 2% annual maintenance of $1,000)	▪ $50,000 ▪ Item cost to inspect condition, influence on sediment transport and inundation and remaining design life on all coastal management structures ▪ Includes structures at The Cut ▪ (Plus 2% annual maintenance of $1,000)	▪ $50,000 ▪ Item cost to inspect condition, influence on sediment transport and inundation and remaining design life on all coastal management structures ▪ Includes walls along Collie River ▪ (Plus 2% annual maintenance of $1,000)	▪ $50,000 ▪ Item cost to inspect condition, influence on sediment transport and inundation and remaining design life on all coastal management structures ▪ (Plus 2% annual maintenance of $1,000)	Not applicable	Not applicable
Notification on title (NR3)	▪ $50,000 ▪ Item cost for investigations and implementation plans ▪ (Plus 1% annual maintenance of $500)	▪ $50,000 ▪ Item cost for investigations and implementation plans ▪ (Plus 1% annual maintenance of $500)	▪ $250,000 ▪ Item cost for investigations and implementation plans ▪ (Plus 1% annual maintenance of $2,500)	▪ $250,000 ▪ Item cost for investigations and implementation plans ▪ (Plus 1% annual maintenance of $2,500)	▪ $250,000 ▪ Item cost for investigations and implementation plans ▪ (Plus 1% annual maintenance of $2,500)	▪ $100,000 ▪ Item cost for investigations and implementation plans ▪ (Plus 1% annual maintenance of $1,000)
Emergency evacuation plans (NR4)	▪ $100,000 ▪ Item cost for investigations and evacuation plans ▪ (Plus 1% annual maintenance of $1,000)	Not applicable	▪ $250,000 ▪ Item cost for investigations and evacuation plans ▪ (Plus 1% annual maintenance of $2,500)	▪ $250,000 ▪ Item cost for investigations and evacuation plans ▪ (Plus 1% annual maintenance of $2,500)	▪ $250,000 ▪ Item cost for investigations and evacuation plans ▪ (Plus 1% annual maintenance of $2,500)	▪ $100,000 ▪ Item cost for investigations and evacuation plans ▪ (Plus 1% annual maintenance of $1,000)

2.4 Cost Benefit Analysis Methodology

The steps taken to complete the CBA are:

1. Re-analysis of GIS vulnerability datasets to extract asset category data by area. This was undertaken where previous counts of assets were not considered to provide enough detail for economic analysis
2. Finalise quantities of assets at risk for all nine categories for both erosion and inundation hazards for each Management Unit (MU) at each timeframe
3. Determine an appropriate unit value for each category for both loss to erosion or damage by inundation
4. Valuing the loss of existing assets and values – this assumes the scenario of complete inaction over the next 100 years
5. Scoping and designing the adaptation options
6. Pricing the adaptation options
7. Reducing all costs to NPV
8. Conducting sensitivity analysis on NPV discount rate used in analysis
9. Presenting summary of the inaction scenario and adaptation options in NPV for both erosion and inundation
10. Recommendation of options to proceed to for further consideration.

2.5 Valuing the Loss of Existing Assets and Values

The size and complexity of the study area has best suited the use of a rapid ‘unit cost method’ for estimating erosion and / or coastal inundation damage costs to properties and assets. This method primarily assumes a single cost for each land parcel in each category. Where parcel sizes and shapes vary too greatly, a value has been assigned per area or lineal length. The total damage costs for each category are estimated by using the count of each property or asset type, which might be expected to be affected for each hazard type at each timeframe.

This simplified method does not consider the proportion of a property or asset that is affected, the presence or location of buildings within a property, or the inundation depth at the building. However, given the large size of the study area, the accuracy of the erosion and inundation modelling, and the lack of suitable building data with surveyed floor levels, we consider the method suitable for estimating damage costs for the purposes of a cost benefit analysis.

2.5.1 Updated Assets and Values at Risk

Review of the asset category counts produced from GIS in the vulnerability analysis showed that three categories were not considered to provide enough detail for economic analysis, as follows:

- Roads
- Developed Foreshore
- Undeveloped Foreshore

These categories were re-analysed in GIS to extract quantities in spatial units for each category for each timeframe and hazard in each MU. The foreshore quantities were extracted as areas and given their nature, the roads were extracted as lengths, assuming a 15m width. The other six categories have used asset counts from the vulnerability analysis. Final quantities are presented in 4Appendix A.

2.5.2 Unit costs

Different unit costs have been used for erosion, which would be assumed to result in a total loss of the asset, compared to inundation, which would be assumed to result in non-permanent or repairable damage. Unit cost values for different asset categories are listed in

Table 2-4 and Table 2-5. For the three private categories (Commercial, Residential, Farming / Agricultural / Rural) approximation of current market value has been used. Although the exact timeframe and speed at which this value would be lost is unclear, at the time of writing market value is applicable and at some point in the future, it would be reduced to zero under an economic scenario of complete inaction over the next 100 years. For public categories with built infrastructure, construction cost information from Cardno (2018) after Rawlinsons (2016) has been considered and factored. This is in line with current uncertainties in construction costs due to Covid19, and to ensure public infrastructure, situated on land which is frequently not subject to land acquisition costs is adequately valued.

Inundation estimates are generally adapted from the DECC (2007) residential flood damage curves, and DNRE (2000), applying work by CRES (1992) for commercial flood damage curves, road repair costs and rural flood damage costs. All costs have been factored to present-day using the relevant changes in CPI.

All public asset categories are not considered to appreciate in value in real terms. There is an argument that private asset categories, however, are a special case as these asset classes historically appreciate at a higher rate than inflation (RBA, 2015). For this analysis, we have assumed that residential real estate does not appreciate. In addition, construction costs and all other costs are assumed to increase at the expected inflation rate; therefore, no adjustment is required in the analysis.

The economic benefits of the beach (both use and non-use values) are not included as no meaningful inputs were available. This means the cost of the do-nothing base case may be a little higher than presented. However, this has been partially offset by using higher rates for the loss of foreshore areas.

2.5.3 Value of Existing Vulnerable Assets and Values

The base-case economic scenario of assuming complete inaction over the next 100-years was costed for each MU for each timeframe by multiplying the quantity of assets identified as vulnerable by the unit rate for that timeframe. The resultant amounts for each timeframe were then converted to one summary NPV.

Table 2-4 Erosion costs for each asset category

Asset Category	Erosion Cost ($AUD)	Notes
Commercial	$375,000 / each	A review of sales in the study area was undertaken (Real Commercial, 2022) to establish an estimate. Also equivalent to five times the inundation damage amount. This method represents a market value. For economic analysis this may be considered on overestimate because the zoning value of the land is typically not included in pure economic analysis.
Residential	$500,000 / each	Market value, based on review of median house prices in study area (On The House, 2022). For CBA this may be considered on overestimate because the zoning value of the land is typically not included in pure economic analysis.
Farming / Agricultural / Rural	$90,000 / each	Average size of parcels for this category, from GIS, is 7.5ha. A rate of $12,000/ha has been used to determine an average parcel rate (Rural Bank, 2021).
Roads	$3.0M / km	Assumes two lanes of 3.5m and 1.5m, shoulders with $300/m^2 rate from DIRDC (2018) and Cardno (2018).
Developed Foreshore Reserve	$3.125M / hectare	This category has been valued highly because of the method used for private residential property and to represent the non-use values of this space evident through previous community and stakeholder consultation. Allowed 125% of Undeveloped Foreshore category due to presence of built infrastructure.
Undeveloped Foreshore Reserve	$2.5M / hectare	As a qualitative category, but integral to the purpose of the CHRMAP, this has been valued cognisant of the more easily valued developed/quantitative categories to ensure it is adequately represented in the CBA. This category has been valued highly because of the method used for private residential property and to represent the non-use values of this space evident through previous engagement. Available information, based on studies considering people's Willingness to Pay for access and use of wetlands (Brander et al 2006) were interpolated for foreshore as direct data was not found to be available.
Public and Community Utilities	$375,000 / each	Allocated same rate as Commercial to ensure government infrastructure accounted for adequately.
Environmental	$250,000 / each	A qualitative category, that has frequently been identified by the community as one of the most important during previous CHRMAP stages, this has been valued cognisant of the more easily valued developed/quantitative categories to adequately represent it in the CBA. Many environmental assets cannot be practically relocated. Assumed 50% of Residential category.
Heritage	$2.0M / each	As a qualitative category, but integral to the community fabric of the study area, this has been valued cognisant of the more easily valued developed/quantitative categories to ensure it is adequately represented in the CBA. It may not be practical for many assets in this category to be relocated. Assumed 400% of Residential category.

Table 2-5 Inundation costs for each asset category

Asset Category	Inundation Cost ($AUD)	Notes
Commercial	$75,000 / each	DNRE, 2000 DECC, 2007 CRES, 1992
Residential	$100,000 / each	
Farming / Agricultural / Rural	$3,750 / each	
Roads	$50, 000 / linear km	
Developed Foreshore Reserve	$6,000 / hectare	Estimate of replacement cost of damaged infrastructure.
Undeveloped Foreshore Reserve	$2,000 / hectare	As a qualitative category, but integral to the purpose of the CHRMAP, this has been valued cognisant of the more easily valued developed/quantitative categories to ensure it is adequately represented in the CBA. Nominal value estimated at 33% of Develop Foreshore Reserve. Acknowledges likely impacts of increased saltwater intrusion – both the distance inland and the increased frequency of events and the subsequent increased expected cost to maintain vegetation.
Public and Community Utilities	$75,000 / each	Assumed equivalent to Commercial category.
Environmental	$25,000 / each	As a qualitative category, that has frequently been identified by the community as one of the most important categories during previous stages of the CHRMAP this has been valued cognisant of the more valuable developed/quantitative categories to ensure it is adequately represented in the CBA. Nominal value estimated at 25% of Residential; some environmental assets will likely have very little impact from coastal inundation while others could be completely destroyed.
Heritage	$400,000 / each	As a qualitative category, but integral to the community fabric of the study area this has been valued cognisant of the more valuable developed/quantitative categories to ensure it is adequately represented in the CBA. It may not be practical for many assets in this category to be relocated. Assumed 400% of Residential category.

2.6 Planned / Managed Retreat – Voluntary Acquisition

The costs for this option have been determined for each MU using the following steps:

1. Calculate the acquisition cost for the three private categories at market values for the timeframe they are considered vulnerable to erosion.

2. Calculate the infrastructure removal and subsequent land improvement cost to return land to undeveloped foreshore reserve for all six categories with built infrastructure (Table 2-6). A factor of 25% has been allowed for preliminaries, project management, design, mobilisation and demobilisation. A contingency of 30% has been included for uncertainties in budget estimating. An annual maintenance cost of 2% has been applied.
3. Include the value of losing the three categories itemised and described below. The three private categories have been priced to be acquired so are not counted again. Roads are not counted as they have been considered service assets – without the need to access other land uses, they are no longer needed, so they are not considered an economic loss. Both foreshore categories are not valued as a loss again because new usable foreshore is what is being created by this option:
    a. Public and Community – These facilities are considered lost to the study area as no cost to replace them elsewhere is included. Valuation is same as the base-case economic scenario.
    b. Environmental – It is assumed assets in this category cannot be practically relocated, and no cost is included to attempt to relocate such assets.
    c. Aboriginal Heritage – It is assumed not practical for many assets in this category to be relocated. And no cost is included to attempt to relocate such assets, which cannot be replaced.
4. The resultant amounts for each timeframe were then converted to one summary NPV.

It is important to note that the process of purchasing developed private property for the purposes of planned / managed retreat is not considered to result in an economic benefit – it is simply transferring the cost from one party to another. For the purposes of this CBA, the methodology is considered appropriate to budget all options and compare their financial implications over time for the coastal land managers (primarily LGA's).

Table 2-6 Valuation considerations for voluntary acquisition option

Category	Acquisition Cost	Infrastructure Removal and Land Improvement Cost
Commercial	Same as base case valuation	20% of 2020 base-case
Residential	Same as base case valuation	20% of 2020 base-case
Farming / Agricultural / Rural	Same as base case valuation	5% of 2020 base-case
Roads	Zero – government owned	20% of 2020 base-case
Developed Foreshore Reserve	Zero – government owned	5% of 2020 base-case
Public and Community Utilities	Zero – government owned	5% of 2020 base-case

2.7 Protection Options

2.7.1 Beach Nourishment – PR1

The costs for this option have been determined for each MU using the following steps:

1. Calculate a sand nourishment volume, based on the length of coast requiring protection and a height and width estimate. Example values used on the open coast are 2.0m high and 30m wide. A 10-year useful life has been assumed – after which the nourishment would be repeated.

2. Estimate a sand volume that could be delivered each day – considering location, access.
3. Estimate the number of mobile plant required to place the sand.
4. Calculate the initial nourishment cost.
5. A factor of 25% has been allowed for preliminaries, project management, design, mobilisation and demobilisation. A contingency of 30% has been included for uncertainties in budget estimating. An annual volume increase in cost of 1% has been applied.
6. The resultant amounts for each timeframe were then converted to one summary NPV.

This concept cost estimate requires the use of several assumptions, as follows:

- Assume there is a suitable sand source in the sub-region that can supply adequate quality, particle size and volume of sand over the project timeframe.
- Assume a cost of \$27/m^3 to supply and transport sand to work site.
- Assume an average day rate of \$1,500 per piece of mobile plant

2.7.2 Rock Structure Options – PR2 to PR5

The costs for this option have been determined for each MU using the following steps:

1. Scope and design the structural option using information from the existing CHRMAP chapter reports and taking indicative design waves and water levels from the numerical model used to estimate the coastal hazards.
2. Estimate an appropriate crest level, toe depth, structure length, structure slope
3. Calculate quantity of materials required – rock, sand, geofabric
4. Use assumed costs to calculate initial costs of material purchase and installation.
5. A factor of 25% has been allowed for preliminaries, project management, design, mobilisation and demobilisation. A contingency of 30% has been included for uncertainties in budget estimating.
6. An annual maintenance cost of 2% has been applied.
7. The resultant amounts for each timeframe were then converted to one summary NPV.

This concept cost estimate requires the use of several assumptions, as follows:

- Assume required armour sizes are available in sub-region and quarry production rates are suitable to supply adequate volume of required sizes
- Assume initial costs of rock armour of \$75/tonne and core of \$55/tonne and Geofabric of \$30/m^2
- Complex features have been approximated by modifying characteristics of cross-sections
- Groynes are assumed to be two-sided revetments
- High level assumptions regarding the structure shape and construction style.

2.7.3 Inundation Protection – Levy/Barrier

The costs for this option have been determined for each applicable MU using the following steps:

1. Scope and design the structural option using information from the existing CHRMAP chapter reports and desktop review of proposed option location.
2. For levy options, a similar methodology as sand nourishment was used, with added conservative modifications:

a. Increased estimates for the number of pieces of mobile plant required

b. Decreased estimates on the volume of material able to be delivered and placed daily

c. A contingency of 50% has been included for increased uncertainties in budget estimating

d. An annual maintenance cost of 2.5% has been applied

3. For bespoke options such as construction of culvert with storm-flap one-way drains, similar principles as for other options were used:

   a. Estimate initial costs based on purchase and supply to site

   b. Estimate number of pieces of mobile plant required

   c. Estimate number of days' work

   d. Determine an initial cost estimate

   e. A factor of 25% has been allowed for preliminaries, project management, design, mobilisation and demobilisation

   f. Apply a contingency for uncertainties in budget estimating, typically between 30% and 50%

   g. Apply an annual maintenance cost

4. The resultant amounts for each timeframe were then converted to one summary NPV.

2.7.4 Inundation Protection – New Storm Surge Barrier at The Cut

An option identified in previous stages of the CHRMAP was a large-scale engineering option to construct a new storm surge barrier at The Cut to prevent coastal inundation to MUs 8, 9, 10 and 11, and the estuary-facing components of MU6 and MU7.

The economic base-case analysis of this option was undertaken using the following steps:

- Apply total do nothing NPV values for inundation for MUs 6,8,9,10,11. Note that inundation in MU7 is negligible on the estuary side and MU6 was factored down by 50% as an estimate for the estuary side
- Summed numbers to give a combined total do nothing inundation value for NPV discount rates
- Estimated cost of new storm surge barrier at The Cut (see below for assumptions and details)
- Estimated cost of additional levy works in the MUs which may be required
- Converted option construction and costs to NPV, assuming construction in 2035

A desktop review of existing storm surge barriers to mitigate coastal flooding risk was undertaken, with Table 2-7 summarising the information and references. Characteristics of these structures were compared, including:

- Location – country, coast, estuary, river
- Operational Span – the width of waterway that can be closed to water flow
- Operational Height – the vertical distance from the bottom of waterway channel to the design water surface level
- Construction cost
- Other features and notes

Due to different construction years, locations, jurisdictions and design features, the comparison of costs is difficult but Mooyaart et al (2014) analysed this in more detail and concluded there is an average indicative cost of 2.2M Euro per metre of operational span in 2014, with a standard deviation of 56%. Assuming average inflation of 3% from 2014 to 2022 and converting to Australian dollars at an exchange rate of 1.48 AUD to 1.0 Euro at the time of writing produces cost estimates of approximately $4.1M/metre of operational span. The current depth of the channel at the Cut is less than 3m below low tide, so an operational height for concept design of a barrier is likely to be less than 10m, and therefore significantly cheaper than the initial estimated cost rate. A rate of $2.0M/metre of operational span has been used. Selection of an appropriate operational span would depend on further detailed analysis of freshwater and saltwater interactions at Leschenault Estuary as well as other factors such as maritime navigation and re-analysis of climate change projections. The current channel at The Cut varies between approximately 130m and 230m. An operational span of 80m has been assumed for a concept surge barrier. The following assumptions have been applied:

1. A factor of 25% has been allowed for preliminaries, project management, design, mobilisation and demobilisation
2. Contingency for uncertainties in budget estimating, typically between 30% and 50%
3. An annual maintenance cost
4. Resultant amounts for each timeframe were then converted to one summary NPV.

Table 2-7 Desktop comparison of large-scale storm surge barriers

Structure	Operational Span	Operational Height	Cost	Notes
Thames Barrier London, UK	520m	20m	Equivalent of ~1.6B UK Pounds in 2016	Completed 1984 (UK Environment Agency, 2022)
Hartel Barrier, Netherlands	150m	14m	98M Euro in 1997	Completed 1997 (Mooyaart et al 2014)
Maeslant Barrier, Netherlands	360m	20m	450M Euro in 1997	Completed 1997 (Mooyaart et al 2014)
Colne Barrier, Wivenhoe UK	130m	8m	15m UK Pounds in 1993	Completed 1993 30m span width for navigation (UK Environment Agency, 1993)

2.8 Cost Benefit Analysis Results

2.8.1 MU1

CBA results for erosion and inundation are presented in Table 2-8 and Table 2-9.

Table 2-8 MU1 CBA results for erosion adaptation options

Net Present Value 2020	Do Nothing	PMR4: Voluntary Acquisition	PR1: Beach Renourishment	PR2: Groynes
Option Notes	Economic base case	Acquisition assumed in same year as hazard line identifies parcels as vulnerable	▪ Assumes beach renourishment of 3,000m ocean coast ▪ Assumes suitable sand source available (grain size, volume, cleanliness. proximity) ▪ 2035 implementation	▪ Assumes 9 rock groynes 100m long, 400m apart ▪ 2035 implementation
7% NPV	$14,520,108	$9,177,898	$6,439,605	$10,448,300
4% NPV	$19,896,564	$13,064,903	$17,754,526	$18,465,578
2% NPV	$36,919,985	$32,808,196	$43,450,046	$30,244,997

Table 2-9 MU1 CBA results for inundation adaptation options

Net Present Value 2020	Do Nothing Economic Base-Case	PR6: Levy / Barrier
Option Notes	Economic base case	▪ To address inundation of Stirling Wetland ▪ Assumes two levies either side of river, each 2km long ▪ 2035 implementation ▪ Less volume per day, as likely to be slower than beach nourishment ▪ Higher contingency (50%) to cover any treatment, revegetation, local drainage challenges
7% NPV	$3,301,716	$2,123,191
4% NPV	$3,392,130	$3,844,497
2% NPV	$3,789,201	$6,476,725

2.8.2 MU2

CBA results for erosion and inundation are presented in Table 2-10 and Table 2-11.

Table 2-10 MU2 CBA results for erosion adaptation options

Net Present Value 2020	Do Nothing Economic Base-Case	PMR4: Voluntary Acquisition
Option Notes	Economic base case	Acquisition assumed in same year as hazard line identifies parcels as vulnerable
7% NPV	$49,128,122	$34,933,026
4% NPV	$57,439,172	$36,646,160
2% NPV	$76,834,706	$40,482,759

Table 2-11 MU2 CBA results for inundation adaptation options

Net Present Value 2020	Do Nothing Economic Base-Case	PR6: Levy / Barrier
Option Notes	Economic base case	To address inundation of Stirling Wetland: ▪ Assumes new culverts with one-way valves installed at Higgins Cut with some associated earthworks ▪ Higher contingency than usual (50%) to cover any treatment, revegetation, local drainage challenges ▪ Assume 2035 installation" To address inundation at Yalgar River Mouth at Stirling Beach, north of Peppermint Grove beach, from flowing to connect with Stirling Wetlands: ▪ Assumes levy at 300m long ▪ Assume 2035 implementation ▪ Less volume per day as likely to be slower than beach nourishment ▪ Higher contingency than usual (50%) to cover any treatment, revegetation, local drainage challenges
7% NPV	$16,641,294	$412,843
4% NPV	$16,778,761	$747,541
2% NPV	$17,184,129	$1,259,363

2.8.3 MU1 and MU2 joint consideration of inundation

As coastal inundation from MU1 flows into MU2 as the major pathway it is important to consider the joint potential impacts and options cost for the inundation vulnerabilities at these MU's. Join CBA results for inundation are presented in Table 2-12.

Table 2-12 MU1 and MU2 CBA results for inundation adaptation options

Net Present Value 2020	Do Nothing Economic Base-Case	PR6: Levy / Barrier
Option Notes	Economic base case	From MU1: ▪ To address the inundation of Stirling Wetland via the Capel River ▪ Assumes two levies either side of the Capel River, each 2km long ▪ 2035 implementation ▪ Less volume per day, as likely to be slower than beach nourishment Higher contingency (50%) to cover any treatment, revegetation, local drainage challenges From MU2: To address the inundation of Stirling Wetland: ▪ Assumes new culverts with one-way valves installed at Higgins Cut with some associated earthworks ▪ Higher contingency than usual (50%) to cover any treatment, revegetation, local drainage challenges ▪ Assume 2035 installation To address coastal inundation at Minninup Drain Outlet at Stirling Beach, north of Peppermint Grove beach, from flowing to connect with Stirling Wetlands: ▪ Assumes levy at 300m long ▪ Assume 2035 implementation ▪ Less volume per day as likely to be slower than beach nourishment ▪ Higher contingency than usual (50%) to cover any treatment, revegetation, and local drainage challenges
7% NPV	$19,943,010	$2,575,178
4% NPV	$20,170,891	$4,652,006
2% NPV	$20,973,330	$7,816,334

2.8.4 MU3

CBA results for erosion Table 2-13. Inundation is not a concern for MU3.

Table 2-13 MU3 CBA results for erosion adaptation options

Net Present Value 2020	Do Nothing Economic Base-Case	PMR4: Voluntary Acquisition	PR1: Beach Renourishment	PR2: Groynes
Option Notes	Economic base case	Acquisition assumed in same year as hazard line identifies parcels as vulnerable	▪ Assumes beach nourishment of 2,800m of ocean coast ▪ Assumes suitable sand source available (grain size, volume, cleanliness. proximity) ▪ 2035 Implementation	▪ Assumes 6 rock groynes 100m long ▪ 2035 Implementation
7% NPV	$7,119,490	$7,275,455	$10,863,824	$11,136,564
4% NPV	$9,314,638	$10,607,575	$29,952,467	$19,681,967
2% NPV	$15,690,942	$21,222,330	$73,301,652	$32,237,336

2.8.5 MU4

There are no CBA options for MU4.

2.8.6 MU5

CBA results for erosion and inundation are presented in Table 2-14 and Table 2-15.

Table 2-14 MU5 CBA results for erosion adaptation options

Net Present Value 2020	Do Nothing Economic Base-Case	PMR4: Voluntary Acquisition	PR1: Renourishment	PR2: Groynes	PR5: Offshore Breakwater
Option Notes	Economic base case	Acquisition assumed in same year as hazard line identifies parcels as vulnerable	▪ Assumes sand nourishment of 5km ocean frontage ▪ Assumes suitable sand source available (grain size, volume, cleanliness. proximity) ▪ 2020 Implementation	▪ Assumes 15 rock groynes 100m long, 400m apart ▪ 13 on ocean coast and 2 in Koombana Bay ▪ 2020 Implementation	▪ Assumes 15 offshore rock breakwaters 100m long, 300m apart ▪ 13 on ocean coast and 2 in Koombana Bay ▪ 2020 Implementation
7% NPV	$148,373,568	$50,155,220	$50,465,640	$72,027,835	$102,014,718
4% NPV	$163,438,159	$72,578,498	$93,273,566	$83,499,242	$123,950,438
2% NPV	$200,128,500	$135,047,435	$182,471,564	$104,337,185	$163,796,922

Table 2-15 MU5 CBA results for inundation adaptation options

Net Present Value 2020	Do Nothing Economic Base-Case	PR6: Levy / Barrier
Option Notes	Economic base case	▪ Replacement of storm surge barrier at the Leschenault Inlet ▪ 2035 Implementation
7% NPV	$156,614,671	$10,765,544
4% NPV	$169,233,704	$17,917,396
2% NPV	$199,492,622	$27,183,146

2.8.7 MU6

CBA results for erosion and inundation are presented in Table 2-16 and Table 2-17.

Table 2-16 MU6 CBA results for erosion adaptation options

Net Present Value 2020	Do Nothing Economic Base-Case	PMR4: Voluntary Acquisition	PR1: Renourishment	PR2: Groynes	PR3: Seawall
Option Notes	Economic base case	Acquisition assumed in same year as hazard line identifies parcels as vulnerable	▪ Assumes sand nourishment of 100m on west side of port and 1,200m on east side of port and 800m of estuary shoreline along Estuary Drive ▪ Assumes suitable sand source available (grain size, volume, cleanliness. proximity) ▪ 2035 implementation	▪ Assumes 5 rock groynes 75m long, 300m apart along ocean coast ▪ 2035 Implementation	▪ Assumes 1,300m seawall on ocean coast ▪ Assumes 800m seawall on estuary coast ▪ 2035 implementation ▪ No sand nourishment included - beach not maintained
7% NPV	$38,008,632	$23,958,369	$2,426,164	$5,006,448	$6,158,522
4% NPV	$40,598,186	$26,987,841	$6,689,136	$8,848,038	$10,884,132
2% NPV	$44,967,160	$32,900,566	$16,370,096	$14,492,310	$17,827,254

Table 2-17 MU6 CBA results for inundation adaptation options

Net Present Value 2020	Do Nothing Economic Base-Case	PR6: Levy / Barrier
Option Notes	Economic base case	▪ Assumes 700m levy to cover ocean frontage (400m east of port and 300m on west). ▪ Does not address inundation risk from estuary frontage - this is assumed to be addressed separately with consideration of a new storm surge barrier at The Cut. ▪ Assume 2020 implementation ▪ Less volume per day as likely to be slower than beach nourishment ▪ Higher contingency (50%) to cover any treatment, revegetation, local drainage challenges
7% NPV	$26,312,888	$1,025,689

Net Present Value 2020	Do Nothing Economic Base-Case	PR6: Levy / Barrier
4% NPV	$26,621,894	$1,219,144
2% NPV	$27,256,539	$1,570,559

2.8.8 MU7

CBA results for erosion are presented in Table 2-18. There are no CBA options for inundation for MU7.

Table 2-18 MU7 CBA results for erosion adaptation options

Net Present Value 2020	Do Nothing Economic Base-Case	PR1: Renourishment	PR2: Groynes	PR3: Seawall
Option Notes	Economic base case	▪ Assumes nourishment of 400m of ocean coast and 320m of estuary shoreline ▪ Assumes suitable sand source available (grain size, volume, cleanliness. proximity) ▪ 2050 Implementation	▪ Assumes 2 rock groynes 75m long on ocean-side beach ▪ 2050 Implementation	▪ Assumes 400m seawall on ocean foreshore ▪ Assumes 320m seawall on estuary foreshore ▪ 2050 Implementation
7% NPV	$20,628,835	$367,453	$741,882	$712,214
4% NPV	$25,970,239	$1,491,432	$1,991,796	$1,912,142
2% NPV	$32,947,529	$4,519,318	$4,251,845	$4,081,810

2.8.9 MU8

CBA results for erosion are presented in Table 2-19. The only CBA option for inundation in MU8 is addressed separately with consideration of a new storm surge barrier at The Cut in Section 2.8.13.

Table 2-19 MU8 CBA results for erosion adaptation options

Net Present Value 2020	Do Nothing Economic Base-Case	PMR4: Voluntary Acquisition	PR1: Renourishment	PR2: Groynes	PR3: Seawall
Option Notes	Economic base case	Acquisition assumed in same year as hazard line identifies parcels as vulnerable	▪ Assumes 2600m shoreline treated along estuary and river shoreline around Pelican Point ▪ Assumes suitable sand source available (grain size, volume, cleanliness. proximity) ▪ 2035 Implementation	▪ Assumes 8 rock groynes, 30m long, 100m apart to cover estuary coast from Venezia Blvd north ▪ Assumes 6 groynes to cover section of river foreshore ▪ 2035 Implementation	▪ Assumes 2,600m seawall to cover shoreline in MU along estuary and river shoreline around Pelican Point ▪ No sand nourishment included; beachfront not maintained ▪ 2035 Implementation
7% NPV	$51,714,280	$39,762,016	$1,147,614	$1,154,403	$2,548,161
4% NPV	$56,866,153	$46,080,688	$3,164,068	$2,040,209	$4,503,438
2% NPV	$69,768,889	$64,537,160	$7,743,315	$3,341,683	$7,376,237

2.8.10 MU9

CBA results for erosion are presented in Table 2-20. The only CBA option for inundation in MU9 is addressed separately with consideration of a new storm surge barrier at The Cut in Section 2.8.13.

Table 2-20 MU9 CBA results for erosion adaptation options

Net Present Value 2020	Do Nothing Economic Base-Case	PMR4: Voluntary Acquisition	PR1: Renourishment	PR2: Groynes	PR3: Seawall	PR5: Offshore Breakwater
Option Notes	Economic base case	Acquisition assumed in same year as hazard line identifies parcels as vulnerable	▪ Assumes only 25% of shoreline treated (6,250m) ▪ Assumes suitable sand source available (grain size, volume, cleanliness. proximity) ▪ 2020 implementation	▪ Assumes 63 rock groynes, 30m long, approximately 100m apart or as required to treat 25% of shoreline in MU ▪ Locations to be determined ▪ 2020 Implementation	▪ Assumes 6,250m seawall to cover 25% shoreline in MU ▪ 2020 Implementation ▪ Does not include sand nourishment - beachfront not maintained	▪ Assumes 63 offshore rock breakwaters 30m long, approximately 100m apart or as required to treat 25% of shoreline in MU ▪ Locations to be determined ▪ 2020 Implementation
7% NPV	$508,634,906	$77,785,411	$7,964,048	$13,373,146	$16,906,669	$16,571,412
4% NPV	$536,210,058	$87,030,699	$14,719,622	$15,503,000	$19,599,285	$20,134,680
2% NPV	$595,430,739	$111,541,986	$28,796,073	$19,371,905	$24,490,452	$26,607,398

2.8.11 MU10

CBA results for erosion are presented in Table 2-21. The only CBA option for inundation in MU10 is addressed separately with consideration of a new storm surge barrier at The Cut in Section 2.8.13.

Table 2-21 MU10 CBA results for erosion adaptation options

Net Present Value 2020	Do Nothing Economic Base-Case	PMR4: Voluntary Acquisition	PR1: Renourishment
Option Notes	Economic base case	Acquisition assumed in same year as hazard line identifies parcels as vulnerable	▪ Nourishment along bank of river for 2,400m ▪ Assumes suitable sand source available (grain size, volume, cleanliness. proximity) ▪ 2035 implementation
7% NPV	$17,992,994	$18,834,065	$353,013
4% NPV	$19,370,105	$21,430,658	$973,287
2% NPV	$21,828,524	$26,534,391	$2,381,892

2.8.12 MU11

CBA results for erosion are presented in Table 2-22.The only CBA option for inundation in MU11 is addressed separately with consideration of a new storm surge barrier at The Cut in Section 2.8.13.

Table 2-22 MU11 CBA results for erosion adaptation options

Net Present Value 2020	Do Nothing Economic Base-Case	PMR4: Voluntary Acquisition	PR1: Renourishment
Option Notes	Economic base case	Acquisition assumed in same year as hazard line identifies parcels as vulnerable	▪ Nourishment along bank of river for 2,400m ▪ Assumes suitable sand source available (grain size, volume, cleanliness. proximity) ▪ 2035 Implementation
7% NPV	$16,048,763	$17,997,344	$353,013
4% NPV	$17,950,371	$23,502,931	$973,287
2% NPV	$22,412,647	$36,366,576	$2,381,892

2.8.13 New Storm Surge Barrier at The Cut

The joint CBA option for inundation in MU8,9,10,11 and part of MU6 is addressed separately with consideration of a new storm surge barrier at The Cut, with results presented in Table 2-23 and Table 2-24

Table 2-23 New storm surge barrier at The Cut – Do Nothing Economic Base-Case results

Net Present Value 2020	MU6 (50% of total to represent estuary frontage inundation only)	MU8	MU9	MU10	MU11	Total
7% NPV	$13,156,444	$61,399,907	$30,580,105	$10,017,388	$6,341,631	$121,495,475
4% NPV	$13,310,947	$62,041,758	$31,510,116	$10,027,676	$6,368,017	$123,258,514
2% NPV	$13,628,269	$64,416,455	$33,535,323	$10,087,732	$6,535,317	$128,203,095

Table 2-24 New storm surge barrier at The Cut - CBA results

Net Present Value 2020	Do Nothing Economic Base-Case	PR6: Levy / Barrier
Option Notes	Economic base case	▪ New storm surge barrier at The Cut ▪ Provide protection from coastal inundation via estuary in MU's 8,9,10,11 and some of 6 ▪ Also assumes levy at 1,000m long to complement new storm surge barrier at The Cut ▪ Higher contingency (50%) to cover any treatment, revegetation, local drainage challenges ▪ 2035 Implementation
7% NPV	$121,495,475	$124,748,614
4% NPV	$123,258,514	$207,700,310
2% NPV	$128,203,095	$315,270,865

It is important to note for this MU's 8, 9, 10 and 11 that the effectiveness of erosion options may also depend on measures to manage inundation as the low-lying foreshore means options to manage erosion could be submerged. Compared to other MU's, the interrelationships of options to manage erosion and inundation should be considered in more detail.

2.9 Cost Benefit Analysis Discussion

2.9.1 Sensitivity Analysis of NPV Discount Rate

As the nature of CHRMAP principles requires robust and early planning for coastal hazards, the selection of a discount rate(s) to be used for NPV analysis is particularly important. The planning timeframe is very long compared to many CBA applications. The competing principles of early coastal planning making for more-resilient communities may not align well with the CBA principle that future spending of money is cheaper. Given the long planning timeframe it could be argued that the 2% sensitivity analysis rate should be used, or given more weight than the higher numbers, particularly if private property inflation continues into the future at historic rates.

2.9.2 Planning Timeframe

It is important to note that this is a concept-level CBA, that has used high-level cost estimates, coupled with the timeframe of projected hazards, and the very long timeframe for such economic analyses, the results should be used cautiously.

2.9.3 Assumptions

This concept-level CBA has necessarily used several high-level assumptions and estimates. As no design information is available until later phases of implementation it is necessary to undertake option scoping and concept design on limited information. Assumptions about price, extent of forecast vulnerabilities and the very long timeframe mean the results are suitable for the relative comparison of options, but preliminary and detailed design phases require further consideration of costs. A summary of key assumptions is provided below:

1. Hazards occur as projected and trigger losses, or decision points on option implementation in accordance with the same projected timeframes,
2. NPV discount rates of 7%, 4% and 2% are suitable for the timeframe and level of detail of cost estimates.
3. Unit costs are representative of the study area.
4. The economic benefits provided by the beach (both use and non-use values) are not included as no meaningful inputs were available to use. This means the cost of the do-nothing base case may be a little higher than presented, but this has been offset by using higher rates for the loss of foreshore areas.
5. It is important to note that the process of purchasing developed private property for the purposes of planned / managed retreat (PMR4 – Voluntary Acquisition) is not considered to result in an economic benefit – it is simply transferring the cost from one party to another. For the purposes of this CBA, the methodology is considered appropriate to budget all options and compare their financial implications over time for the coastal land managers (primarily LGA's).
6. The PMR4 Option – Voluntary Acquisition assumes purchase of private property at a standard market rate. It is unclear how the real estate market will react to erosion from sea level rise as coastal erosion following storm events have a more immediate and significant impact. It is, however, expected that market values may reduce in areas that are actively eroding. This was considered beyond the scope of this project to attempt to model. However, if there is a significant reduction in the purchase price for this option it may represent a significant cost saving that could make this option more competitive in more locations.
7. Options provide similar levels of beach and foreshore amenity as the present-day. Underlying this assumption includes several others around rehabilitation of rezoned land being practical and effective; resources required for coastal engineering will continue to be available as needed (construction rock and nourishment sand for example).
8. Coastal management technologies will not substantially change in the future.
9. Assumed base costs for works (informed by historical information) are representative of future markets, particularly as at the time of writing Covid19 is still having an effect and inflation rates are high, particularly in WA.

2.9.4 Recommended option(s) for further consideration for each MU

The "non-CBA" options will generally form a part of one or more overarching options selected from the CBA list.

The CBA has been used as an additional tool to assist decision-making when assessing adaptation options with which to proceed. However, the reality that only some of the WAPC adaptation options are suitable for CBA, and the uncertainty in effectiveness of those that are not suitable, means that the CBA results need to be used cautiously whilst considering the rest of the information identified during the CHRMAP project.

Several assessed options have negative benefit/cost ratios – they did not perform better than the economic do-nothing base case, for all discount rates. They should not be proceeded unless more detailed investigation can be undertaken to determine the scope and extent of such works. MU3 is the only MU where all options for all discount rates did not perform better than the economic base case.

Review of the CBA results shows that the ranking of options for each MU by current NPV price depends on which discount rate is used. If options stayed in the same ranking for all three discount rates there would be a much stronger argument for selection of a single option with which to proceed.

Options recommended to proceed are presented in Table 2-25 for erosion and Table 2-26 for inundation.

Table 2-25 Recommended CBA options for erosion for each MU

Management Unit	Recommended Option	Secondary Option (s)	Notes
MU1	PMR4	PR2	▪ PMR4 is best value for one discount rate (4%) and second best for the other two. ▪ PR2 is second best value for one discount rate (2%). Although this option has the worst value for the other two rates it has still been recommended over PR1 given concerns on sand source feasibility.
MU2	PMR4	Not applicable	▪ PMR4 is better value than the base case for all discount rates and no other options were recommended for CBA.
MU3	PMR4	PR2	▪ No options performed better than the base case for any discount rate. ▪ PMR4 performed best out of the options. ▪ PR2 performed second best
MU4	Not applicable	Not applicable	▪ There are no CBA options for MU4.
MU5	PR2	PMR4	▪ PR2 is best value for one discount rate (2%). ▪ PMR4 was best value for the other two discount rates (7% and 4%) but not by a significant amount. ▪ PMR4 has a lot more uncertainty around its implementation, given the large size of this MU and the large number of values and built assets that are vulnerable including the Transforming Bunbury Waterfront project. Further investigation could consider more detailed analysis on subsections of this MU. ▪ PR1 may be suitable as an interim option in parts of this MU.
MU6	PR2	PR1	▪ PR2 is best value for one of the discount rates (2%). ▪ PR1 was best value for the other two discount rates (7% and 4 %) and its risks around implementation and longevity are less of a concern within this more-sheltered MU. It may be suitable as an interim option.

Management Unit	Recommended Option	Secondary Option (s)	Notes
MU7	PR1	PR3	▪ PR1 is best value for two discount rates (7$ and 4%). ▪ PR3 is not recommended as it would mean the loss of the beach. Should the objectives of this MU change in the future PR3 may be suitable long-term. ▪ PR1 could later be transitioned to PR3 if required.
MU8	PR2	PR1	▪ PR2 is best value for two discount rates (4% and 2%) and almost equal best for the 7% rate.
MU9	PR2	PR1	▪ PR2 is best value for the 2% discount rate (2%), and very close to PR1 for the 4% discount rate. ▪ Uncertainties around PR1 could pose some risk. ▪ PR5 is a more-expensive option but could be designed with amenity as a focus in this sheltered environment. Could be a tertiary option to consider following further consultation
MU10	PR1	Not applicable	▪ PR1 is best value for all discount rates by a significant amount.
MU11	PR1	Not applicable	▪ PR1 is best value for all discount rates by a significant amount.

Table 2-26 Recommended CBA options for inundation for each MU

Management Unit	Recommended Option (s)	Notes
MU1	PR6	▪ PR6 is better value than the base case for only one discount rate (7%) and no other options were recommended for CBA. ▪ Due to the pathway of the inundation hazard this MU should be considered jointly with MU2.
MU2	PR6	▪ PR6 is better value than the base case for all discount rates and no other options were recommended for CBA. ▪ Due to the pathway of the inundation hazard this MU should be considered jointly with MU2.
MU1 & MU2	PR6	▪ Due to the pathway of the inundation hazard these MU's are considered together. ▪ PR6 is better value than the base case for all discount rates and no other options were recommended for CBA.
MU3	Not applicable	▪ Inundation is not a concern for MU3.
MU4	Not applicable	▪ There are no CBA options for MU4.
MU5	PR6	▪ PR6 is better value than the base case for all discount rates and no other options were recommended for CBA.
MU6 – ocean frontage	PR6	▪ PR6 is better value than the base case for all discount rates and no other options were recommended for CBA.

Management Unit	Recommended Option (s)	Notes
MU6 – estuary frontage	Not applicable	▪ Further investigation is required as the broader PR6 option comprising a new storm surge barrier at The Cut did not perform better than the base case for any discount rate.
MU7	Not applicable	▪ There are no CBA options for MU4.
MU8, 9, 10, 11	Not applicable	▪ Further investigation is required as the broader PR6 option comprising a new storm surge barrier at The Cut did not perform better than the base case for any discount rate. A feasibility analysis is recommended to assess its effectiveness with consideration of freshwater flooding events and further civil and maritime design considerations as to what scale of facility would be required.

2.9.5 Selection of Options for Benefit Distribution Analysis

After completing the CBA and reviewing the results, Water Technology discussed possible coastal adaptation options to proceed to Benefit Distribution Analysis (BDA). The contractual documentation for the CHRMAP project determined that three sites shall be considered in BDA. Following several discussions, considering projected vulnerable assets, nature of hazards, tenure of land projected to be vulnerable, the following three options were selected:

- MU 1 and 2 - PR6 - Levies along the banks of the Capel River to minimise inundation. This option shall also consider inundation protection at Higgins Cut and the mouth of the Yalgar River at Stirling Beach.
- MU 3 - PR2 - Groynes to protect Dalyellup, the old landfill site and wastewater treatment plant to the north from erosion. Although this option has not scored positively in the CBA, its analysis in the BDA will still be valuable and provide further information about the selection of adaptation options.
- MU 5 - PR2 - Groynes to protect Bunbury Back Beach from erosion.

3 SUMMARY & NEXT STEPS

The CBA analysis is contingent on NPV discount rates and unit cost rates assumption. Notwithstanding these assumptions, the process provides a tool to assist decision-makers in drawing comparisons between several coastal adaptation options. The large study area allows the consistent application of the CBA across a large section of the coast.

Sensitivity analyses on the NPV discount rate demonstrate the variability inherent in the methodology at some locations. A review of the CBA results shows that ranking options by NPV depend on which discount rate is used. If options stayed in the same ranking for all three discount rates, there would be a much stronger argument for selecting a single option with which to proceed. The unit cost assumptions would also need to be confirmed by carrying on further design and procurement studies. In particular, the procurement of sand suitable for nourishment works may be questionable in some of the MU and should be the subject of further studies.

One or more options have been recommended to proceed for further investigation and/or implementation for each MU for both erosion and inundation. The recommendations have considered the CBA results holistically as well as being cognisant of the findings of previous stages of the CHRMAP.

Options for BDA have been recommended. The next stage for the project is to complete the detailed BDA investigations for the three locations selected and provide implementation recommendations for each MU.

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APPENDIX A
UPDATED ASSETS AND VALUES AT RISK

Table A-1 Total vulnerable area/count of asset categories to erosion in MU1 for each project timeframe

Category	2020 Quantity	2035 Quantity	2050 Quantity	2120 Quantity
Roads (km)	0	0.1	0.1	2
Residential (parcels)	2	3	3	154
Commercial (parcels)	0	0	0	0
Public and Community (parcels)		1	1	2
Foreshore - Developed (ha)	0	0	0	0
Foreshore - Undeveloped (ha)	1.3	4.5	7.6	19.2
Environmental (item)	28	30	32	39
Agricultural / Rural (parcels)	0	0	0	0
Aboriginal Heritage (item)	0	0	0	0

Table A-2 Total vulnerable area/count of asset categories to inundation in MU1 for each project timeframe

Category	2020 Quantity	2035 Quantity	2050 Quantity	2120 Quantity
Roads (km)	1.6	1.8	1.8	2.6
Residential (parcels)	6	6	6	33
Commercial (parcels)	1	1	1	1
Public and Community (parcels)	3	3	4	5
Foreshore - Developed (ha)	0	0	0	0
Foreshore - Undeveloped (ha)	2.7	2.9	2.9	3.7
Environmental (item)	87	90	91	99
Agricultural / Rural (parcels)	25	25	25	25
Aboriginal Heritage (item)	0	0	0	0

Table A-3 Total vulnerable area/count of asset categories to erosion in MU2 for each project timeframe

Category	2020 Quantity	2035 Quantity	2050 Quantity	2120 Quantity
Roads (km)	0	0	0	0.6
Residential (parcels)	0	0	0	0
Commercial (parcels)	0	0	0	0
Public and Community (parcels)	0	1	3	4
Foreshore - Developed (ha)	0	0	0	0
Foreshore - Undeveloped (ha)	3.5	9.7	15.8	50.7
Environmental (item)	71	79	82	116
Agricultural / Rural (parcels)	20	21	21	55
Aboriginal Heritage (item)	6	6	6	6

Table A-4 Total vulnerable area/count of asset categories to inundation in MU2 for each project timeframe

Category	2020 Quantity	2035 Quantity	2050 Quantity	2120 Quantity
Roads (km)	23	24.1	25.4	36.6
Residential (parcels)	0	0	0	0
Commercial (parcels)	1	1	1	1
Public and Community (parcels)	5	5	5	8
Foreshore - Developed (ha)	0	0	0	0
Foreshore - Undeveloped (ha)	3.3	3.4	3.7	5
Environmental (item)	450	452	465	529
Agricultural / Rural (parcels)	237	239	241	252
Aboriginal Heritage (item)	7	7	7	7

Table A-5 Total vulnerable area/count of asset categories to erosion in MU3 for each project timeframe

Category	2020 Quantity	2035 Quantity	2050 Quantity	2120 Quantity
Roads (km)	0	0	0	0
Residential (parcels)	0	4	4	64
Commercial (parcels)	0	1	1	1
Public and Community (parcels)	0	3	3	3
Foreshore - Developed (ha)	0	0	0.1	0.6
Foreshore - Undeveloped (ha)	0.2	0.8	1.3	3
Environmental (item)	17	20	21	42
Agricultural / Rural (parcels)	0	0	0	0
Aboriginal Heritage (item)	0	0	0	0

Table A-6 Total vulnerable area/count of asset categories to inundation in MU3 for each project timeframe

Category	2020 Quantity	2035 Quantity	2050 Quantity	2120 Quantity
Roads (km)	0	0	0	0
Residential (parcels)	0	0	0	0
Commercial (parcels)	0	0	0	0
Public and Community (parcels)	0	0	0	0
Foreshore - Developed (ha)	0	0	0	0
Foreshore - Undeveloped (ha)	0	0	0	0
Environmental (item)	5	5	5	5
Agricultural / Rural (parcels)	0	0	0	0
Aboriginal Heritage (item)	0	0	0	0

Table A-7 Total vulnerable area/count of asset categories to erosion in MU4 for each project timeframe

Category	2020 Quantity	2035 Quantity	2050 Quantity	2120 Quantity
Roads (km)	0	0	0	0
Residential (parcels)	0	0	0	0
Commercial (parcels)	0	0	0	0
Public and Community (parcels)	0	0	0	2
Foreshore - Developed (ha)	17	21.5	25	43.2
Foreshore - Undeveloped (ha)	13	13	13	13
Environmental (item)	8	9	9	12
Agricultural / Rural (parcels)	0	0	0	0
Aboriginal Heritage (item)	0	0	0	0

Table A-8 Total vulnerable area/count of asset categories to inundation in MU4 for each project timeframe

Category	2020 Quantity	2035 Quantity	2050 Quantity	2120 Quantity
Roads (km)	0	0	0	0
Residential (parcels)	0	0	0	0
Commercial (parcels)	0	0	0	0
Public and Community (parcels)	0	0	0	0
Foreshore - Developed (ha)	11.3	11.3	11.3	11.4
Foreshore - Undeveloped (ha)	13	13	13	13
Environmental (item)	0	0	0	0
Agricultural / Rural (parcels)	0	0	0	0
Aboriginal Heritage (item)	0	0	0	0

Table A-9 Total vulnerable area/count of asset categories to erosion in MU5 for each project timeframe

Category	2020 Quantity	2035 Quantity	2050 Quantity	2120 Quantity
Roads (km)	9.7	13.4	16.9	27.4
Residential (parcels)	0	4	33	267
Commercial (parcels)	3	3	4	8
Public and Community (parcels)	5	5	14	50
Foreshore - Developed (ha)	20	22.7	24.6	26.2
Foreshore - Undeveloped (ha)	9.8	10.5	10.9	13.4
Environmental (item)	60	68	74	141
Agricultural / Rural (parcels)	0	0	0	0
Aboriginal Heritage (item)	0	0	0	1

Table A-10 Total vulnerable area/count of asset categories to inundation in MU5 for each project timeframe

Category	2020 Quantity	2035 Quantity	2050 Quantity	2120 Quantity
Roads (km)	31.2	34.5	38.7	90.9
Residential (parcels)	1180	1319	1614	2521
Commercial (parcels)	121	124	142	896
Public and Community (parcels)	163	166	187	236
Foreshore - Developed (ha)	25.3	28.3	29.4	33.8
Foreshore - Undeveloped (ha)	16.7	16.9	17.1	18.3
Environmental (item)	69	301	303	410
Agricultural / Rural (parcels)	0	0	0	0
Aboriginal Heritage (item)	5	5	5	5

Table A-11 Total vulnerable area/count of asset categories to erosion in MU6 for each project timeframe

Category	2020 Quantity	2035 Quantity	2050 Quantity	2120 Quantity
Roads (km)	0.2	0.2	0.2	0.3
Residential (parcels)	0	0	0	0
Commercial (parcels)	9	13	13	18
Public and Community (parcels)	2	2	2	2
Foreshore - Developed (ha)	0	0	0	0
Foreshore - Undeveloped (ha)	7	9	10.6	12.5
Environmental (item)	49	56	56	90
Agricultural / Rural (parcels)	0	0	0	2
Aboriginal Heritage (item)	0	0	0	0

Table A-12 Total vulnerable area/count of asset categories to inundation in MU6 for each project timeframe

Category	2020 Quantity	2035 Quantity	2050 Quantity	2120 Quantity
Roads (km)	6.8	6.9	6.9	8.6
Residential (parcels)	0	0	0	0
Commercial (parcels)	297	297	317	337
Public and Community (parcels)	6	6	6	6
Foreshore - Developed (ha)	0	0	0	0
Foreshore - Undeveloped (ha)	9.8	10.4	10.9	12.6
Environmental (item)	120	120	120	147
Agricultural / Rural (parcels)	7	7	7	7
Aboriginal Heritage (item)	0	0	0	0

Table A-13 Total vulnerable area/count of asset categories to erosion in MU7 for each project timeframe

Category	2020 Quantity	2035 Quantity	2050 Quantity	2120 Quantity
Roads (km)	0	0	0	0
Residential (parcels)	0	0	0	0
Commercial (parcels)	0	0	0	0
Public and Community (parcels)	0	0	0	0
Foreshore - Developed (ha)	0	0	0	0
Foreshore - Undeveloped (ha)	1.8	2.6	3.3	8.8
Environmental (item)	28	118	118	129
Agricultural / Rural (parcels)	0	0	0	0
Aboriginal Heritage (item)	0	0	0	0

Table A-14 Total vulnerable area/count of asset categories to inundation in MU7 for each project timeframe

Category	2020 Quantity	2035 Quantity	2050 Quantity	2120 Quantity
Roads (km)	0	0	0	0
Residential (parcels)	0	0	0	0
Commercial (parcels)	0	0	0	0
Public and Community (parcels)	0	0	0	0
Foreshore - Developed (ha)	0	0	0	0
Foreshore - Undeveloped (ha)	4.7	4.8	5	6.3
Environmental (item)	126	126	126	127
Agricultural / Rural (parcels)	0	0	0	0
Aboriginal Heritage (item)	0	0	0	0

Table A-15 Total vulnerable area/count of asset categories to erosion in MU8 for each project timeframe

Category	2020 Quantity	2035 Quantity	2050 Quantity	2120 Quantity
Roads (km)	0.2	0.2	0.3	1.7
Residential (parcels)	3	3	11	92
Commercial (parcels)	0	2	2	2
Public and Community (parcels)	16	17	17	22
Foreshore - Developed (ha)	2.5	3.9	5.4	10.7
Foreshore - Undeveloped (ha)	2.4	3.2	3.6	4.1
Environmental (item)	76	80	82	104
Agricultural / Rural (parcels)	0	0	0	0
Aboriginal Heritage (item)	3	3	4	4

Table A-16 Total vulnerable area/count of asset categories to inundation in MU8 for each project timeframe

Category	2020 Quantity	2035 Quantity	2050 Quantity	2120 Quantity
Roads (km)	13.5	13.7	13.9	20.7
Residential (parcels)	433	439	451	598
Commercial (parcels)	16	16	16	21
Public and Community (parcels)	66	66	66	73
Foreshore - Developed (ha)	19.8	19.8	20	20.7
Foreshore - Undeveloped (ha)	4	4	4	4
Environmental (item)	220	220	220	231
Agricultural / Rural (parcels)	13	13	13	13
Aboriginal Heritage (item)	13	13	13	14

Table A-17 Total vulnerable area/count of asset categories to erosion in MU9 for each project timeframe

Category	2020 Quantity	2035 Quantity	2050 Quantity	2120 Quantity
Roads (km)	0.7	1.5	2.5	9.3
Residential (parcels)	0	1	15	86
Commercial (parcels)	0	0	0	5
Public and Community (parcels)	0	0	6	27
Foreshore - Developed (ha)	0	0	0	0
Foreshore - Undeveloped (ha)	162.5	182.6	201.7	279.6
Environmental (item)	266	285	296	359
Agricultural / Rural (parcels)	1	4	8	33
Aboriginal Heritage (item)	2	2	2	2

Table A-18 Total vulnerable area/count of asset categories to inundation in MU9 for each project timeframe

Category	2020 Quantity	2035 Quantity	2050 Quantity	2120 Quantity
Roads (km)	18	18.8	19.3	22.3
Residential (parcels)	142	154	174	245
Commercial (parcels)	5	5	5	9
Public and Community (parcels)	27	31	32	41
Foreshore - Developed (ha)	0	0	0	0
Foreshore - Undeveloped (ha)	254.3	258.5	261.2	322.7
Environmental (item)	422	434	439	488
Agricultural / Rural (parcels)	66	66	66	72
Aboriginal Heritage (item)	2	2	2	2

Table A-19 Total vulnerable area/count of asset categories to erosion in MU10 for each project timeframe

Category	2020 Quantity	2035 Quantity	2050 Quantity	2120 Quantity
Roads (km)	0	0	0.1	0.9
Residential (parcels)	0	0	6	14
Commercial (parcels)	0	0	0	0
Public and Community (parcels)	6	7	7	8
Foreshore - Developed (ha)	0	0	0	0
Foreshore - Undeveloped (ha)	0	0	0	0
Environmental (item)	57	66	69	75
Agricultural / Rural (parcels)	0	0	0	0
Aboriginal Heritage (item)	0	0	0	0

Table A-20 Total vulnerable area/count of asset categories to inundation in MU10 for each project timeframe

Category	2020 Quantity	2035 Quantity	2050 Quantity	2120 Quantity
Roads (km)	0.3	0.4	0.4	0.4
Residential (parcels)	53	53	53	56
Commercial (parcels)	3	3	3	3
Public and Community (parcels)	19	19	19	21
Foreshore - Developed (ha)	0	0	0	0
Foreshore - Undeveloped (ha)	0	0	0	0
Environmental (item)	90	90	90	92
Agricultural / Rural (parcels)	0	0	0	0
Aboriginal Heritage (item)	2	2	2	2

Table A-21 Total vulnerable area/count of asset categories to erosion in MU11 for each project timeframe

Category	2020 Quantity	2035 Quantity	2050 Quantity	2120 Quantity
Roads (km)	0.3	0.4	0.4	0.9
Residential (parcels)	1	1	17	49
Commercial (parcels)	0	0	0	0
Public and Community (parcels)	3	3	3	6
Foreshore - Developed (ha)	0	0	0	0
Foreshore - Undeveloped (ha)	0	0	0	0
Environmental (item)	49	50	50	57
Agricultural / Rural (parcels)	0	0	0	0
Aboriginal Heritage (item)	0	0	0	0

Table A-22 Total vulnerable area/count of asset categories to inundation in MU11 for each project timeframe

Category	2020 Quantity	2035 Quantity	2050 Quantity	2120 Quantity
Roads (km)	2.8	2.8	2.8	3.1
Residential (parcels)	38	38	38	52
Commercial (parcels)	0	0	0	0
Public and Community (parcels)	8	8	8	8
Foreshore - Developed (ha)	0	0	0	0
Foreshore - Undeveloped (ha)	0	0	0	0
Environmental (item)	72	72	72	72
Agricultural / Rural (parcels)	0	0	0	0
Aboriginal Heritage (item)	0	0	0	0

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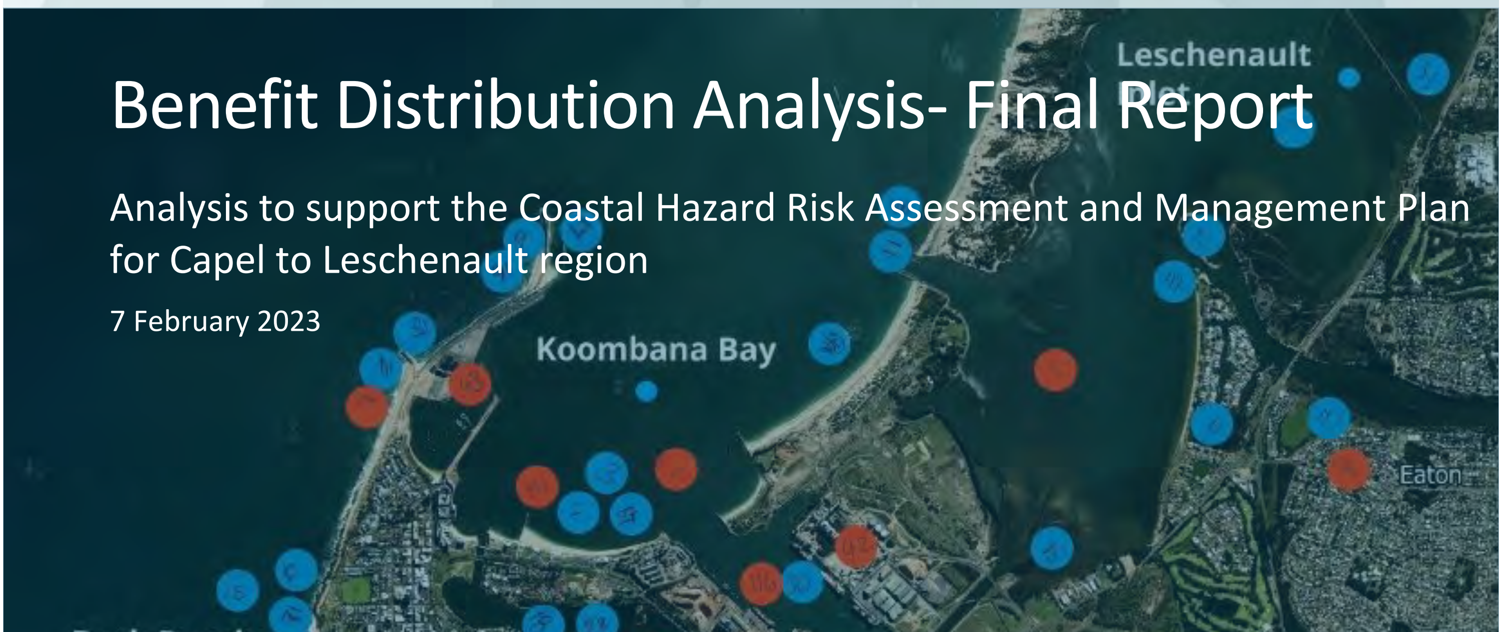

Benefit Distribution Analysis- Final Report

Analysis to support the Coastal Hazard Risk Assessment and Management Plan for Capel to Leschenault region

7 February 2023

A Marsden Jacob Report

Prepared for Peron Naturaliste Partnership
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Acronyms and abbreviations

BDA	Benefit Distribution Analysis
CBA	Cost-Benefit Analysis
CHRMAP	Coastal Risk Management and Adaptation Plan
MU	Management Unit
PNP	Peron Naturaliste Partnership
SPP	State Planning Policy
TEV	Total Economic Value

1. Introduction

1.1 Background

To combat rising sea levels, state governments across Australia have introduced obligations that require local governments to consider and plan for these hazards. In Western Australia, the governing policy is the State Planning Policy No. 2.6 (SPP 2.6)[1].

SPP 2.6 requires adequate risk management planning is undertaken where existing or proposed development is in an area at risk of being affected by coastal hazards over the 100-years planning timeframe. SPP 2.6 and the Coastal Risk Management and Adaptation Plan (CHRMAP) Guidelines[2] provide the risk assessment framework to be applied to identify risks that are intolerable to the community, and other stakeholders such as local governments, indigenous and cultural interests, and private enterprise. Risk management measures are then developed according to the adaptation hierarchy outlined in SPP 2.6.

1.1.1 Coastal Risk Management and Adaptation Plan (CHRMAP)

WA guidelines for CHRMAP set out an 8-stage process for developing CHRMAPs. The stages are as follows:

1. Establish the context
2. Risk identification
3. Vulnerability analysis
4. Risk evaluation
5. **Risk treatment**
6. **Implementation plan**
7. Monitor and review
8. Final CHRMAP

A Cost-Benefit Analysis (CBA) fits within Stage 5 (Risk treatment). A Benefit Distribution Analysis (BDA) fits within Stage 6 (implementation plan). The outputs of these two stages are:

- A CBA that identifies the preferred risk management measures; and
- A BDA that forms the basis for the funding proposal for the identified risk management measures.

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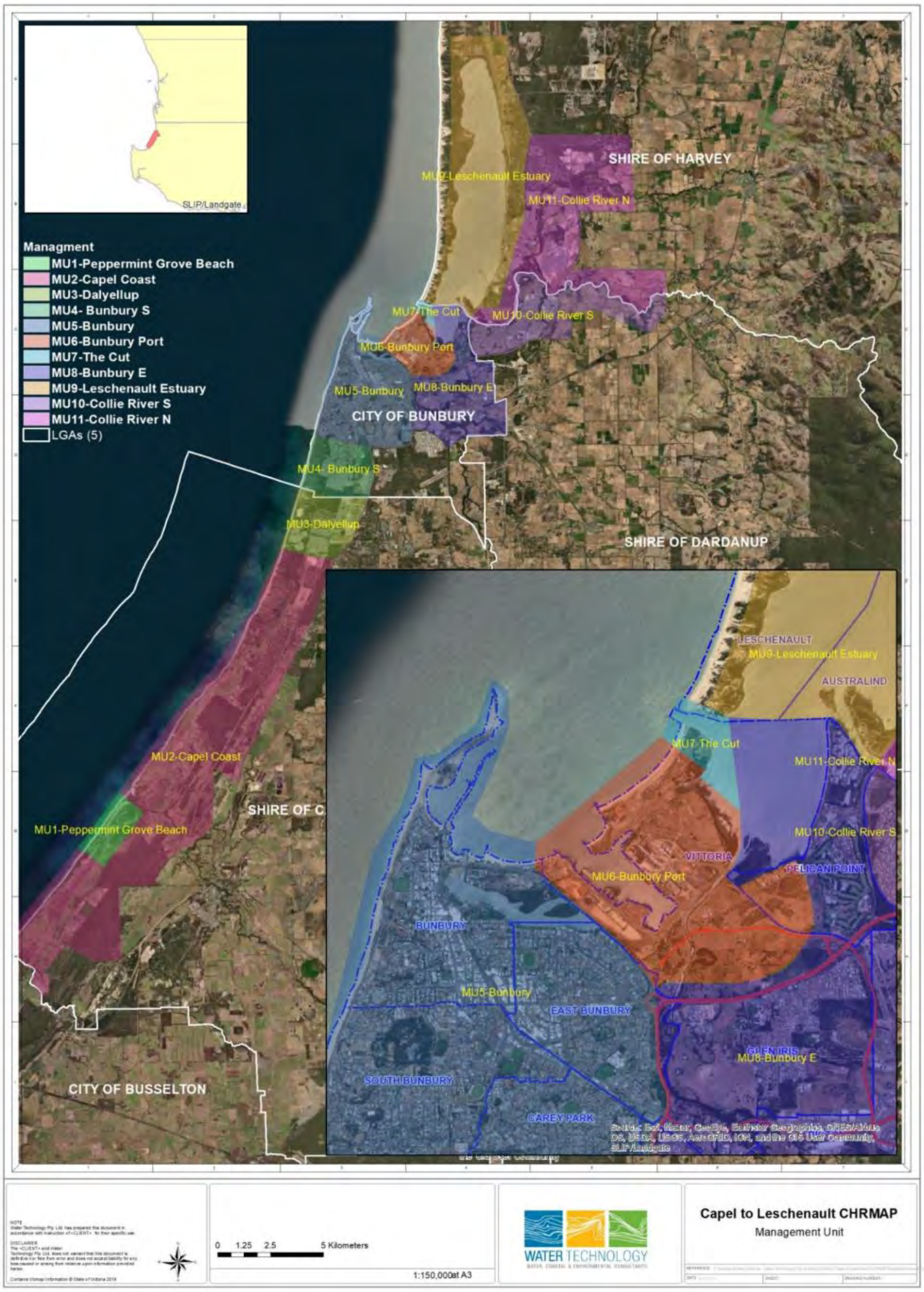
1 State Coastal Planning Policy Guidelines www.wa.gov.au/system/files/2021-06/GD-state-coastal-planning-policy-guidelines-Published-Version-Feb-2021.pdf

2 https://www.wa.gov.au/government/document-collections/coastal-hazard-risk-management-and-adaptation-planning-guidelines

1.1.2 Study area

The Peron Naturaliste Partnership (PNP) comprises membership of nine local government authorities. The PNP's Coastal Adaptation Pathways Project identified the coastal areas of Capel, Leschenault and Greater Bunbury as being particularly exposed to coastal hazards and climate change, which triggered the need for this CHRMAP. The aim of the present study is therefore to investigate the nature and severity of coastal hazards which are likely to affect these regions from Capel to Leschenault over future planning horizons. Figure 1 illustrates the locality, study area extent and management units (MUs).

Figure 1: Study area and the identified Management Units (MU)



1.2 Cost Benefit Analysis (CBA)

As part of the CBA, Water Technology undertook the following steps:

- Identifying the full range of risk treatment options;
- Using Multi-Criteria analysis to identify a short list of the most important areas and highest-ranking treatment options; and
- Using the CBA to identify preferred treatment options for addressing short, medium, and long-term risk and whether the preferred treatment will deliver a net benefit.

The CBA considered each option against a base case scenario. Usually the base-case scenario will be a 'Do nothing' scenario. Under each of these options, the full range of quantifiable costs and benefits were identified and collated. The full list of identified options and assets deemed to be at risk are detailed in the following section.

1.2.1 Scope of analysis

The full list of options that were considered as part of the CBA are listed in Table 1.

Table 1: Full list of options considered in the CBA

Option Category	Option Name	Option Code
Planned / Managed Retreat	Voluntary acquisition	PMR4
Protect	Beach nourishment or replenishment	PR1
	Groyne	PR2
	Seawall	PR3
	Artificial reef	PR4
	Offshore breakwater	PR5
	Levy / Weir / Storm Surge Barrier	PR6

The CBA identified the following asset types as being under threat:

- Roads
- Residential properties
- Commercial properties
- Public and Community
- Foreshore - Developed
- Foreshore - Undeveloped
- Environmental

- Agricultural / Rural
- Aboriginal Heritage

1.3 Benefit Distribution Analysis (BDA)

A BDA is undertaken to allocate the derived benefits from the options identified to the relevant stakeholder. The relevant stakeholders are all those who are expected to benefit from the protection of the identified area. Key beneficiaries are likely to include:

- Private land holders
- Utility providers (such as State government departments)
- Industry and businesses that either operate or directly linked to the area under threat
- Local community (Direct users of the area under threat)
- Broader community (Indirect users)

It is important to identify the beneficiaries and accurately evaluate their individual share of benefits. This paves the way for the next step in the BDA which is identifying funding options and a funding model. CHRMAP follows a “beneficiary pay principle” and thus, requires the accurate allocation of the proportion of benefits to the beneficiaries.

1.3.1 Scope of analysis

Following completion of the CBA and review of the results, Water Technology discussed possible options to proceed to Benefit Distribution Analysis (BDA). The Cost Benefit Analysis report recommended that the BDA is conducted for the following Management Units (MU):

- MU 1 and 2 – Peppermint Grove beach and Capel coast
- MU 3 – Dalyellup
- MU 5 – Bunbury

Within these areas, the treatment options to be assess for the BDA were:

- Levy / Weir / Storm Surge Barrier (PR 6) for Peppermint Grove beach and Capel coast (MU 1 and 2)
- Groynes (PR 2) for Dalyellup (MU 3) and Bunbury (MU 5)

It should be noted that while the Management Unit areas may be subject to both inundation and erosion risks, the treatment options only address one or other of the risks (either inundation or erosion).

Levy / weir / storm surge barriers reduce the risk of inundation while groynes reduce the risk of erosion.

1.4 Uncertainties/constraints with analysis

This report sets out Marsden Jacob's analysis of the distribution of the benefits – as identified by Water Technology in the Cost Benefit Analysis. As discussed in detail in section 2.5, the cost benefit analysis was undertaken at a high level due to large number of management units and possible interventions considered. Given the uncertainties in the exact timing and scale of the benefits, the analysis should not be relied upon for final decision making at this point. Instead, the analysis sets out the Benefit Distribution Analysis process and the approach can be updated once revised risk and intervention costs and benefits are produced.

2. Framework and Approach

2.1 Cost sharing principles such as 'beneficiary pays'

Cost allocation is typically generally done on a User pays / Impactor pays / Beneficiary pays approach for environmental projects with high infrastructure cost. Coastal adaption principles and Stage 6 of the CHRMAP process set out that risk management plans be implemented using a 'beneficiary pays' approach. In this way the funding arrangements reflect the benefit derived from coastal management actions, minimise subsidies, and avoid additional burden on taxpayers and ratepayers.

Under a beneficiary pays approach, the cost of works is recovered from identified beneficiaries. Beneficiaries generally include those who directly and indirectly benefit from the proposed works. A direct beneficiary of the proposed works can be someone whose land/property is situated in the identified threatened area. An indirect beneficiary can be someone who derives value from knowing that the coastal line is preserved. Indirect beneficiaries are usually from the wider community.

Key beneficiaries are likely to include:

- State Government (Utilities such as roads, Water, Electricity)
- Business and industry (Cafés etc)
- Private land holders (Private property that is saved)
- Local community (local users of beaches, parks, estuaries etc. - provided proposed treatment enhances rather detracts from the value of these assets)
- Broader community (wider users of green assets including non-uses such as altruism)

Benefits and the beneficiaries can be identified by considering the community values of the assets that are being protected. Often, the list of beneficiaries does not include beneficiaries of second and further round effects. These beneficiaries are those, for example, who benefit from the protection of a café or improved productivity from lands that are preserved. Inability to identify these beneficiaries becomes an issue when there is a mix of direct and indirect beneficiaries.

Using a beneficiary pays approach, a funding model can then be developed to determine how the infrastructure is paid for. The BDA will point towards how funding should be organised i.e., what proportion of the cost of works should be paid for by each beneficiary. The funding model will initially begin with funding assessment. Marsden Jacob's approach to funding assessment is based on experience as well as processes used in other jurisdictions, and is as follows:

- Step 1 – Current status of council resources for coastal management actions.
- Step 2 – Are there any potential opportunities to align actions and leverage funding from neighbouring local, state or Commonwealth programs?
- Steps 3 – Are there any relevant grant programs that could provide funding?

- Step 4 – Potential for voluntary contributions from interested parties.
- Step 5 – Considering the previous steps, what mechanisms could be used to equitable secure contributions?

The equity of funding arrangements needs to be considered and documented. The mechanisms used to enable funding arrangements will be most acceptable where they are efficient, transparent to the community and relatively easy to understand.

To assist apportioning the costs (capital and recurrent costs) of constructing coastal protection works based on the beneficiary pays principle, a benefit distribution analysis should be completed and accompany an application to construct the works. A benefit distribution analysis assesses the distribution of benefits between stakeholders from implementing risk treatment options such as coastal protection works.

2.2 Total economic valuation (TEV) framework

In order to identify the full range of benefits and beneficiaries that will arise from climate interventions, it is firstly important to ensure the full range of uses and values are identified. This is particularly important for public assets – which may have multiple values and uses.

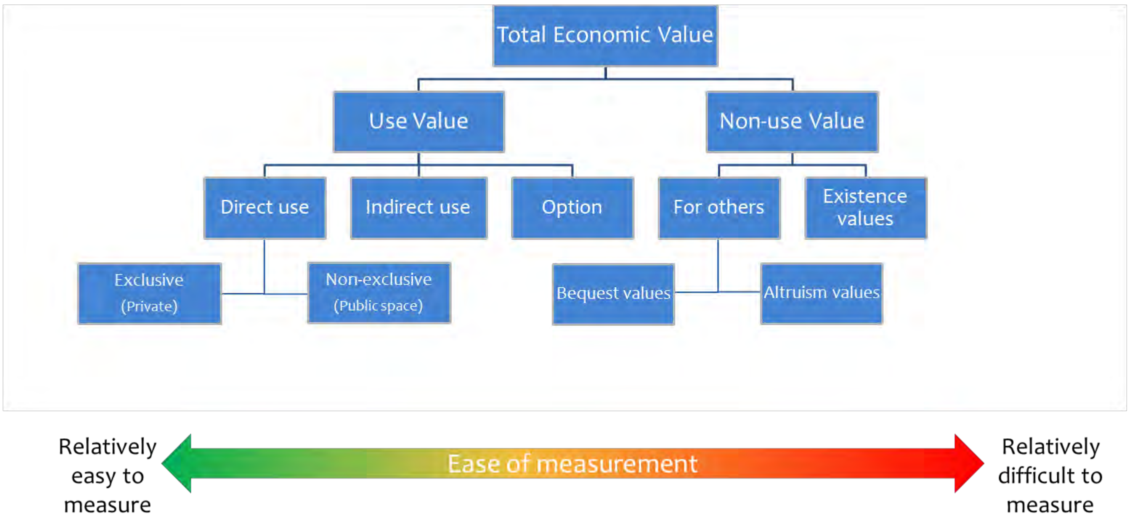
The concept of total economic value (TEV) is a well-established and useful framework for identifying the various values associated with protected areas.[3] This framework is a useful tool for economic valuation, which measures market and non-market values that people hold for the study area and can be applied to value coastal areas and other natural resources such as wetlands, parks etc.

The TEV framework provides a useful classification for the full range of community values. This is shown in Figure 2. The basic premise of the framework is that the total economic value of an area is a function of its use and non-use values. The use values are made up of its direct use values, indirect use values, and option values. Non-use values typically include bequest and existence values.

The framework also helps to avoid double counting of ecosystem functions, intermediate services, and final services.

[3] Economic values of protected areas, IUCN – https://portals.iucn.org/library/efiles/documents/PAG-002.pdf

Figure 2: Total economic value (TEV) framework



Source: Adapted from Phillips (1998)

TEV includes both use values, which measure the value of using assets that are protected, and non-use values, which refer to an individual's willingness to contribute to the cost of protecting public assets (such as beaches and estuaries), even if the individual will not use the areas themselves.

2.2.1 Valuation methods

On the left-hand side of the TEV framework there are values for the exclusive direct use of assets – such as private land. The value the community places on these assets may be impacted from the market price paid for private land. For all the other uses, there is no direct market value for the benefit obtained. These are often referred to as non-market values.

There are various methods for valuing the benefits described in the TEV framework – where there is no direct market. Some of these are described below.

1. **Contingent valuation method** – This uses a direct approach to valuing an environmental good or service in that it asks people through surveys or experiments what they are willing to pay for the good or willing to accept for the loss of the good. This method uses the concepts of willingness to pay (WTP) and willingness to accept (WTA).
2. **Hedonic pricing** – This method uses existing markets (housing or labour) to determine the values of an environmental good. The underlying assumption is that property values or wages reflect a stream of benefits, some of which can be attributed to the environment.
3. **Travel cost method** – This method also uses existing markets by evaluating people's travel in terms of time, expenditure, and entry fees to assess recreational and leisure values of an area.
4. Some of the other methods use include **Change in productivity method**, **Loss (or gain) of earnings methods**, **Opportunity cost approach**, and **Replacement cost approach**.

2.3 Assets identified in the CBA

The CBA collated information gathered through the *Coastal Assets and Community Values Report* as well as the *Risk Treatment Report* and identified the following asset types as being under threat:

- Roads
- Residential properties
- Commercial properties
- Public and Community
- Foreshore - Developed
- Foreshore - Undeveloped
- Environmental
- Agricultural / Rural
- Aboriginal Heritage

Based on the collated information, Water Technology estimated the damage that would arise for each type of asset that were impacted by either erosion or inundation – as set out in Table 2. The estimation of the rates applied by Water Technology are presented in detail in the Cost Benefit Analysis section of the Risk Treatment Chapter Report.

Table 2: Estimated damage arising from each asset type impacted by erosion or inundation

Asset type	Erosion rates $2020 (real)	Inundation rates $2020 (real)
Roads (per km)	$3,000,000	$50,000
Residential (per parcel)	$500,000	$100,000
Commercial (per parcel)	$375,000	$75,000
Public and Community (per parcel)	$375,000	$75,000
Foreshore - Developed (per ha)	$3,125,000	$6,000
Foreshore - Undeveloped (per ha)	$2,500,000	$2,000
Environmental (per item)	$250,000	$25,000
Agricultural / Rural (per parcel)	$90,000	$3,750
Aboriginal Heritage (per item)	$2,000,000	$400,000

Source: Water Technology, 2022

Applying the different types of values identified in the TEV framework, Table 3 sets out the various assets and their value type based on the TEV framework. Additionally, this table also sets out a potential valuation method for each of these assets and their beneficiaries.

Table 3: Asset values, valuation methods and potential beneficiaries

Asset type	Asset owner	TEV Value type	Valuation method	Beneficiaries
Roads	Likely to be a mix of Local Government and State Government	Direct use or opportunity value	Replacement cost	Some benefit to all WA residents Higher benefit to local residents accessing private and public assets. For this BDA we have assumed that the road network is an asset that provides direct or opportunity values to all WA residents
Residential	Private landowners	Direct use value	Market value	Private landowners of the properties that will be protected
Commercial	Private landowners	Direct use value	Market value	Private landowners of the properties that will be protected
Public and Community	Local or state Government	Direct use value	Non-Market	Community - probably a mix of local community and broader community
Foreshore - Developed	Local or state Government	Direct use value	Non-Market	Community - probably a mix of local community and broader community
Foreshore - Undeveloped	Local or state Government	Direct use value or opportunity value	Non-Market	Community - probably a mix of local community and broader community
Environmental	NA	Non-use value (existence value)	Existence	Broader WA community
Agricultural / Rural	Private landowners	Direct use value	Market value	Private landowners of the properties that will be protected
Aboriginal Heritage	NA	Non-use value (existence value)	Existence	Broader WA community

Comparing the different asset types, it can be seen that privately owned assets (such as residential, commercial or agricultural land) are easily apportioned to the private land holder.

It can also be seen that we have allocated foreshore (either developed or undeveloped) as "use values" – and it appears likely that the largest users will be the local community.

In contrast environment and aboriginal heritage assets are categorised as "non-use values" and so the whole WA community are identified as beneficiaries.

When the CBA is revised, it would be appropriate to review the value of the damage to each asset type from erosion and inundation as well as to test these assumptions on the use and value of these assets to both the local community and the broader WA public.

2.4 Approach for the BDA in this report

In this report, our approach to BDA is to focus on three MUs and a single option within these areas. The reasoning behind this is set out in Section 1.3. Following this, it was decided to focus on one option for each of the units. The options considered are:

- PR (Protect) 6 for MU 1 and 2 – Levy / Weir / Storm Surge Barrier – To address inundation only
- PR 2 for MU 3 and 5 – Groynes – To address erosion only

These options were chosen based on the recommendation from Water Technology and their analysis of the costs and benefits associated with each of the option.

The CBA identified that the biggest threats to each of the regions were either coastal erosion or inundation. The benefits were then calculated separately for inundation and erosion. The combined benefits were calculated up to the year 2120 and their present value was calculated using a rate of 4% and sensitivities were tested at rates of 7% and 2%.

The discounted benefits were then divided up proportionally amongst the key beneficiary groups for each of the Management Units. Detailed BDA results are found in Section 4.

2.5 Approach to identifying the funding mechanism

The Water Technology analysis considered four assessment periods of 2020, 2035, 2050, 2120. The analysis identifies assets that are at risk for each of these periods and the assets that would benefit from the proposed interventions.

- Assets identified to be at risk in 2020, essentially require immediate action, whilst assets identified to be at risk in 2035, 2050 or 2120 do not require immediate action.
- For this project identified three broad groups of funding sources:
  - Private property owners (residential, commercial or agricultural)
  - WA State government (representing the broader WA community) and
  - Local community

- We identify the funding required could be collected as either a lump sum, or as an annuity over a number of years. We have assumed that funding through an annuity would be collected over a 15-year period.

Payment form

For each of the stakeholders that are identified as a key beneficiary, we identify the financial contribution that would be required as a singular payment as well as the annuity payment that would be required if the funds were collected over a 15-year period and at 7% discount rate.

15 years is an arbitrary period – but aligns with the duration between the first three assessment periods (2020, 2035, 2050).

If funds started to be collected now, the projects would be largely funded ahead of the 2035 timeframe for implementation. Ahead of 2035, the risks and work required for 2050 could be reviewed, and then annuity payments could be required for 15 years to ensure any activities undertaken at that time were also funded ahead of work commencing.

3. Discussion of cost benefit analysis

For this project the cost benefit analysis was undertaken by Water Tech and Marsden Jacob have been commissioned to undertake the benefit distribution analysis.

The CBA focussed on 11 Management Units and 6 treatment options for each of the Management Units for protection against coastal erosion and/or inundation. The list of options considered are provided in Section 1.2.

To some extent the benefit distribution analysis set out here is limited in its detail by the cost benefit analysis. For this reason, key recommendations of the report are:

- The design and cost estimation of the preferred interventions should be refined to a preliminary or functional design level; and
- A further detailed cost benefit analysis should be undertaken for the preferred option - seeking to expand the range of benefits considered and also refine the estimation of the value of these benefits.
- Once these steps are undertaken the benefit distribution analysis can be revised or updated to reflect the new costs and benefits.

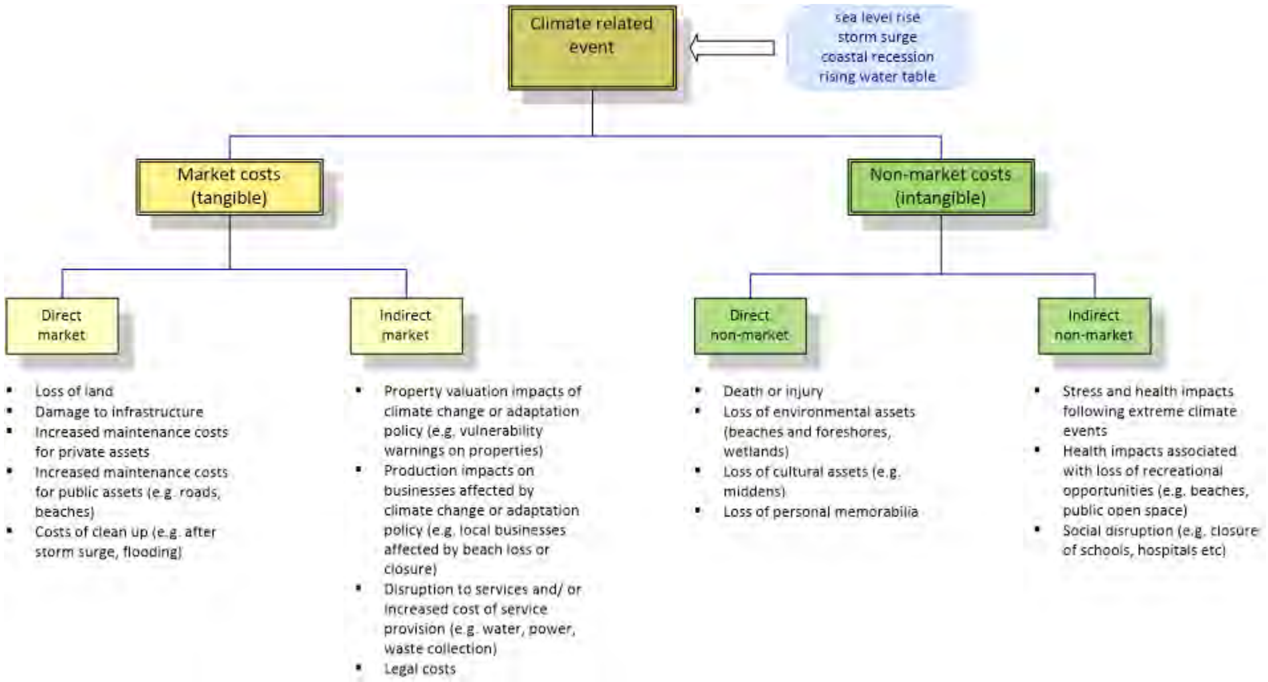
The following sections discuss some of the key aspects that are not included in the current CBA. Each of these elements should be included in the CBA and BDA before final decisions are made on whether to fund any interventions.

3.1 Benefits considered in the CBA

To include the cost benefit analysis within the project timeframe and budget, the analysis focusses on the largest and most easily valued benefits. In this manner, the CBA has similarities to a rapid CBA.[4] This has resulted in the analysis using readily available data which quantifies direct and market use values. However, this CBA does not fully capture or quantify indirect use on non-use values. Traditionally, these values have been difficult to quantify and allocate to a particular group in a CBA. Due to this, care must be taken when interpreting the results of the CBA or the BDA since some costs or benefits may have been missed. Figure 3 shows the TEV framework applied for valuing coastal adaptation. This gives a basic understanding of some non-market values which may not have been identified in the CBA.

4 www.infrastructureaustralia.gov.au/sites/default/files/2021-07/Assessment%20Framework%202021%20Guide%20to%20economic%20appraisal.pdf

Figure 3 TEV framework applied for valuing coastal adaptation.



Source: Marsden Jacob analysis using the TEV framework

In addition to focussing on some key benefit types, the values used for CBA have been based on the estimated values of similar land uses in other locations. This approach is referred to as benefit transfer – but the value of the benefit should be reviewed through primary research undertaken at the specific location.

3.2 Probabilistic approach to identifying hazard lines and impacts

The CBA is based on the current coastal hazard assessment for the base case and appears to be based on the predicted most likely outcome for both inundation and erosion for 2035, 2050 and 2120.

The reality is that both erosion and inundation will occur during specific weather events (such as storms), and these could occur earlier or later than predicted and could be larger or smaller than predicted. For this reason, we consider the current approach used to be suitable to provide indicative values, but a probabilistic approach (which is not required under the SPP2.6 guidelines) would provide an improved understanding of changing risks of erosion and inundation over time.

Ideally the hazard lines and cost benefit analysis would use a probabilistic approach to identify climate change impacts and predicting the damage to the study area. This involves assigning probabilities of impacts to the assets at risk in the study area.

Figure 4 shows the application of a probabilistic approach to individual properties, which Marsden Jacob has previously used for Warilla beach. Each line represents an individual property and the table on left shows the probability of impact under a range of storm impacts for 2016 – benign weather on the left side of the table and extreme storms on the right side of the table.

The table on the right shows the same property under a range of weather events for 2066.

Figure 4: Probabilistic analysis from Warilla beach coastal hazard assessment

2016		Probability of % of land area impacted: 2016											
Piled = 1	0%	10%	10%	10%	10%	10%	10%	10%	10%	10%	5%	4%	0.9%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	0%	0%	0%	0%	0%	0%	4%	23.6%	46%	79%	97%	99%	99%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
100	0%	0%	0%	0%	0%	0%	0%	12%	29%	60%	81%	99%	99%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
100	0%	0%	0%	0%	0%	0%	0%	5%	19%	42%	62%	99%	100%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	0%	0%	0%	0%	0%	0%	0%	0%	8%	28%	43%	86%	100%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	18%	29%	68%	100%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	6%	17%	48%	94%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	6%	34%	75%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	22%	55%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	10%	36%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	13%	35%	62%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	16%	49%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	100%	100%	100%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	19%	51%
1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	19%	45%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	17%	34%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	16%	31%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	15%	28%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	16%	28%
1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%	17%	29%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	5%	18%	29%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	7%	21%	32%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%	9%	22%	34%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	10%	23%	35%
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100	0%	0%	0%	0%	0%	0%	0%	0%	0%	8%	13%	26%	38%
100	0%	0%	0%	0%	0%	0%	0%	0%	1%	10%	15%	29%	41%
100	0%	0%	0%	0%	0%	0%	0%	0%	2%	12%	17%	32%	45%
100	0%	0%	0%	0%	0%	0%	0%	0%	3%	14%	20%	35%	49%
100	0%	0%	0%	0%	0%	0%	0%	0%	5%	16%	22%	39%	54%
1	0%	0%	0%	0%	0%	0%	0%	0%	6%	19%	25%	43%	63%
100	0%	0%	0%	0%	0%	0%	0%	0%	7%	20%	27%	47%	74%
100	0%	0%	0%	0%	0%	0%	0%	0%	8%	24%	32%	55%	92%
100	0%	0%	0%	0%	0%	0%	0%	0%	8%	25%	33%	61%	99%
100	0%	0%	0%	0%	0%	0%	0%	0%	8%	26%	35%	67%	100%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
100	0%	0%	0%	0%	0%	0%	0%	0%	13%	30%	39%	75%	100%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	0%	0%	0%	0%	0%	0%	0%	5%	17%	34%	45%	82%	100%
1	0%	0%	0%	0%	0%	0%	0%	11%	23%	41%	53%	90%	99%
100	0%	0%	0%	0%	0%	0%	4%	16%	28%	45%	60%	97%	99%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
100	0%	0%	0%	0%	0%	2%	9%	21%	33%	52%	68%	99%	99%
100	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
100	0%	0%	0%	0%	2%	6%	14%	25%	37%	58%	74%	99%	99%

2066Piled = 1		Probability of % of land area impacted: 2066											
Piled = 1	0%	10%	10%	10%	10%	10%	10%	10%	10%	10%	5%	4%	0.9%
76	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
1	0%	32%	54%	65%	75%	86%	97%	#####	100%	100%	100%	100%	100%
76	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	13%	44%	95%
1	0%	23%	43%	53%	63%	73%	83%	93%	100%	100%	100%	100%	100%
76	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	28%	77%
1	0%	14%	33%	42%	52%	61%	71%	80%	90%	100%	100%	100%	100%
76	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	12%	58%
1	0%	3%	21%	30%	39%	48%	58%	67%	76%	92%	100%	100%	100%
76	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	41%
1	0%	0%	10%	19%	28%	37%	46%	55%	64%	79%	94%	100%	100%
76	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	26%
1	0%	0%	1%	8%	16%	25%	34%	43%	52%	67%	82%	100%	100%
76	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	12%
1	0%	0%	0%	0%	6%	14%	23%	32%	41%	55%	70%	93%	100%
76	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
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76	0%	0%	0%	6%	13%	20%	27%	34%	41%	53%	64%	83%	100%
1	0%	0%	0%	0%	0%	0%	5%	14%	23%	38%	53%	77%	100%
1	0%	0%	0%	0%	0%	9%	91%	100%	100%	100%	100%	100%	100%
1	0%	0%	0%	0%	0%	0%	8%	17%	26%	40%	54%	77%	100%
1	0%	0%	0%	0%	0%	1%	9%	17%	25%	38%	52%	73%	100%
1	0%	0%	0%	0%	0%	3%	9%	15%	22%	33%	43%	61%	89%
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1	0%	0%	0%	0%	1%	5%	10%	14%	19%	27%	34%	47%	67%
1	0%	0%	0%	0%	2%	7%	11%	15%	19%	26%	34%	45%	64%
1	0%	0%	0%	0%	4%	8%	12%	17%	21%	28%	35%	46%	64%
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1	0%	0%	0%	3%	7%	11%	16%	20%	24%	31%	38%	49%	66%
1	0%	0%	0%	5%	9%	13%	17%	21%	26%	33%	39%	51%	68%
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1	0%	0%	3%	8%	12%	16%	21%	25%	29%	36%	43%	55%	73%
1	0%	0%	5%	9%	13%	17%	21%	26%	30%	37%	44%	55%	74%
1	0%	0%	6%	11%	15%	19%	24%	28%	33%	40%	47%	59%	77%
1	0%	0%	8%	13%	17%	22%	26%	31%	36%	43%	51%	63%	83%
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1	0%	1%	12%	17%	22%	27%	33%	38%	43%	52%	61%	75%	97%
1	0%	2%	14%	19%	25%	31%	37%	42%	48%	58%	67%	82%	100%
1	0%	3%	15%	21%	27%	33%	40%	46%	52%	62%	73%	90%	100%
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76	0%	3%	18%	26%	33%	41%	48%	56%	63%	75%	88%	100%	100%
76	0%	3%	19%	27%	35%	43%	50%	58%	66%	79%	92%	100%	100%
76	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	0%	8%	24%	32%	40%	48%	55%	63%	71%	84%	98%	100%	100%
76	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%
1	0%	13%	29%	37%	45%	53%	60%	68%	76%	90%	100%	100%	100%
1	0%	20%	35%	43%	51%	59%	67%	74%	82%	95%	100%	100%	100%
1	0%	25%	40%	48%	56%	64%	71%	79%	87%	100%	100%	100%	100%
76	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	34%
76	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	24%
1	0%	30%	46%	54%	61%	69%	77%	84%	92%	100%	100%	100%	100%
76	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	15%
1	0%	35%	50%	58%	66%	73%	81%	89%	97%	100%	100%	100%	100%

Source: Adapted from Marsden Jacob (2020)

While we advocate for the use of probabilistic analysis, we note that this approach is not recommended in SPP 2.6 and care must be taken when using this approach. The following points need to be considered when undertaking this:

- Probabilities rely on the knowledge of climate scenarios as well as hydrologic and geological data
- probabilities are not constant over time (with different impacts and different likelihood of occurrences)
- over time properties may be redeveloped with new foundation considerations
- the potential for "edge effects" and other impacts that are difficult to model.

For the reasons outlined above, it is important to place a certain caution when attempting to assign probabilities of potential impacts to assets.

3.3 Beach amenity is a dynamic consideration

The CBA compares each option against the base case – which is considered to be a 'Do Nothing' option – where no action has been taken to protect the coastal assets from erosion or inundation.

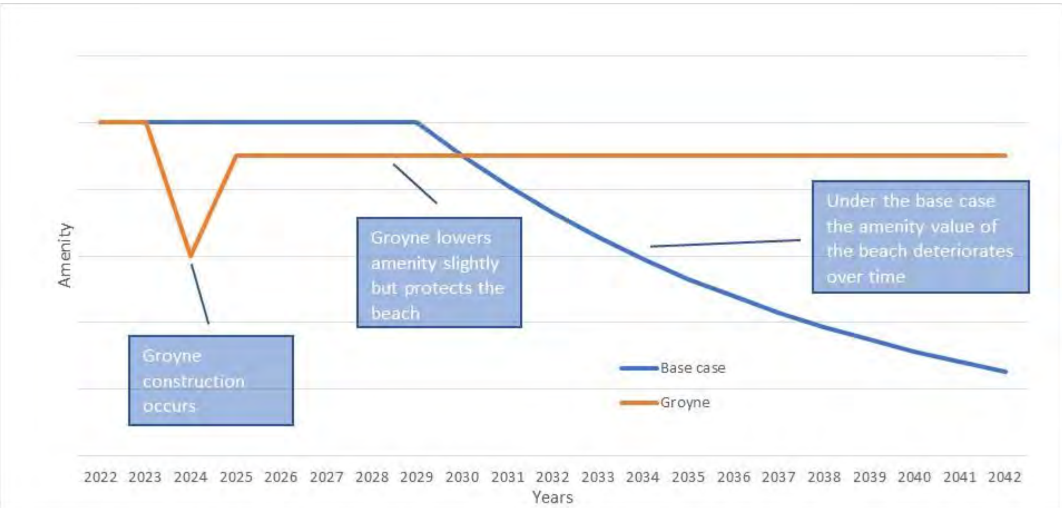
Since the Do Nothing option does not immediately impact the beach amenity (in terms of visual amenity and use of the area), it may be perceived as a more attractive option by the public in the short term. However, in the long term this scenario will inevitably lead to coastal erosion or inundation.

Some actions to protect (such as the installation of groynes) may reduce the amenity of certain coastal assets, such as beaches, below the base case in the short term - but will protect the beach and so improve the amenity, in the longer term.

Because the exact timing of the improvement of the amenity can be hard to pinpoint and quantify, there is a degree of uncertainty as to the occurrence of benefits and their value. However, it is known that protection measures (such as the installation of groynes) may end up providing benefits over a case where there is no action done to protect coastal assets. These points are illustrated graphically in Figure 5, below. It is important to note that amenity is strongly linked to perception. Some beach users may dislike groynes and feel they reduce the beaty of the beach. However, other users may see that the groynes are beneficial, as they will protect the beach in the longer term.

In the figure the amenity of the beach dips when the groyne is constructed (orange line) and the amenity of the beach with groynes may be initially lower than the base case (giving a net cost to the treatment). However, it is expected that the beach would deteriorate under the base case and so the amenity of the beach with a groyne will be greater than it would be under the base case (giving a net benefit to the treatment).

Figure 5: Illustration of the impact of groynes on beach amenity



Source: Marsden Jacob analysis

Currently the CBA assumes there is not any loss of amenity in the short term – but does consider the benefits that are expected to arise in the longer term.

4. Benefit Distribution Analysis

4.1 BDA for Peppermint Grove beach and Capel Coast (MU1 & MU2)

BDA for this MU is only considered for benefits that arise from inundation protection. Residential properties are predicted to be impacted by floods or inundation by 2120 and many unacceptably close by 2050. In 2120, the land depression behind the area will be under constant risk of inundation. The majority of residential properties are not predicted to be affected by inundation. The existing sand dune acts as a natural barrier for coastal inundation. The inundation model assumes ocean water enters the land depression through Capel River and culvert openings, rather than by breaching of the dunes along the open coast.

At Capel Coast, most of the assets at risk of erosion are environmental and undeveloped foreshore. Agricultural / rural lots are predicted to be impacted by both erosion and inundation.[5] The area of inundation extends across the land depression adjacent to Capel River. In the north of the management unit, inundation is minimal. The dominant land use of rural / agricultural and regional open space is reflected in the assets-at-risk totals.

- MU 1 and 2 - PR6 - Levies along the banks of the Capel River to minimise inundation. This option shall also consider inundation protection at Higgins Cut and the mouth of the Minninup Drain outlet near Tatton Place in Stratham .

Key features of this option for Peppermint Grove beach are:

- To address inundation of Stirling Wetland.
  - Assumes two levies either side of river, each 2km long.
  - 2035 implementation.
  - Less volume per day, as likely to be slower than beach nourishment.
  - Higher contingency (50%) to cover any treatment, revegetation, local drainage challenges.

Key feature of this option for Capel Coast are:

- Levies to address inundation of Stirling Wetland.
  - Assumes new culverts with one-way valves installed at Higgins Cut with some associated earthworks.
  - Higher contingency than usual (50%) to cover any treatment, revegetation, local drainage challenges.
  - 2035 implementation.
- To address inundation at the Minninup Drain outlet near Tatton Place in Stratham , north of

5 Water Technology's vulnerability analysis identified 55 agricultural/rural parcels are expected to have an unacceptable vulnerability at 2120

Peppermint Grove beach, from flowing to connect with Stirling Wetlands:

- Assumes levy at 300m long.
- Assume 2035 implementation.
- Less volume per day as likely to be slower than beach nourishment.
- Higher contingency than usual (50%) to cover any treatment, revegetation, local drainage challenges.

As discussed in Section 2.3, the CBA identified nine categories of assets (roads, residential etc) that may be protected by coastal interventions. The value of the damage that would arise from inundation or erosion is also drawn from Table 2, in that section.

Table 4 outlines the assets that are at risk from inundation in the identified Management Units.[6] An important point to note here is that the values are not cumulative. In this instance all the assets identified would be protected under the proposed coastal intervention. The avoided damage represents the benefits of the intervention.

Table 4: Assets at risk from inundation in MU1 and MU2

Assets at risk	2020	2035	2050	2120
Roads (km)	24.6	1.3	1.3	12
Residential (parcels)	6	0	0	27
Commercial (parcels)	2	0	0	0
Public and Community (parcels)	8	0	1	4
Foreshore - Developed (ha)	0	0	0	0
Foreshore - Undeveloped (ha)	6	0.3	0.3	2.1
Environmental (item)	537	5	14	72
Agricultural / Rural (parcels)	262	2	2	11
Aboriginal Heritage (item)	7	0	0	0

Table 5 sets out the value of the avoided damage (i.e., the benefit) of each asset type over the 100-year assessment period.

6 These align with the Hazard Chapter Report describes assets at risk and the associated mapping.

Table 5: Total benefits of the option over the base case combined for MU1 and MU2

Assets	2020	2035	2050	2120	Total
Roads	$1,230,000	$23,559	$8,539	$691	$1,262,789
Residential	$600,000	$0	$0	$3,112	$603,112
Commercial	$150,000	$0	$0	$0	$150,000
Public and Community	$600,000	$0	$9,853	$346	$610,198
Foreshore - Developed	$0	$0	$0	$0	$0
Foreshore - Undeveloped	$12,000	$217	$79	$5	$12,301
Environmental	$13,425,000	$45,306	$45,978	$2,074	$13,518,359
Agricultural / Rural	$982,500	$2,718	$985	$48	$986,251
Aboriginal Heritage	$2,800,000	$0	$0	$0	$2,800,000
Total	**$19,799,500**	**$71,801**	**$65,434**	**$6,276**	**$19,943,010**

Analysis of Table 4 indicates that 99% of the benefit arises from areas that are protected in 2020 – so are already under threat.

The present value cost of interventions is **$2,536,034**. This value is based on the capital expenditure expected to arise in 2035 and the operating and maintenance costs that would occur from 2035 to 2120. It should be noted that while we show this value to the nearest dollar the cost estimates are based on concept design estimate so should be considered to have ± 50% margin.

The allocation of the present value cost of the intervention to each beneficiary is set out in Table 6.

Table 6: BDA for MU1 and MU2

Assets	Percentage of total benefits	Benefits (A$)
Roads	6%	$163,542
Residential	3%	$78,108
Commercial	1%	$19,426
Public and Community	3%	$79,026
Foreshore – Developed	0%	$0
Foreshore – Undeveloped	0%	$1,593
Environmental	68%	$1,750,742
Agricultural / Rural	5%	$127,728
Aboriginal Heritage	14%	$362,624

Source: Marsden Jacob analysis

4.1.1 Private beneficiaries

Private benefits arise for owners of Residential, Commercial and Agricultural / Rural properties. As shown in Table 4, the vast majority of the benefits arise from work done to protect properties that are impacted in 2020.

Also, to note is that there are a high number of agricultural properties are impacted in 2020 compared to later years, and for residential properties there is an extreme delay before further parcels are impacted – as shown in Table 7.

Table 7: Assets benefitting from proposed works (total number of properties for each timeframe) (MUs 1 and 2)

Assets at risk	2020	2035	2050	2120
Residential (parcels)	6	0	0	27
Commercial (parcels)	2	0	0	0
Agricultural / Rural (parcels)	262	2	2	11

Source: Marsden Jacob analysis

Note: Values are not cumulative

For the private properties impacted, the total funds to be collected per property are set out in Table 8.

The table should be interpreted in the following way.

- For the properties under threat in 2020, it is expected that works will commence as soon as possible, with the government allocating funds for the project immediately.
- The beneficiaries of the proposed works will then pay off the annuity for a period of 15 years starting from 2020. It can be seen that the six residential properties that would benefit from the 2020 works would be required to contribute an annual levy of $1,396 for a period of 15 years. In contrast the two commercial properties that would benefit from the 2020 works would be required to contribute an annual levy of $1,047 and rural properties would contribute $52 per year for 15 years. The differing contributions reflect the different benefits that each property is expected to gain from the planned works.
- For properties affected later in the timeframe i.e., 2035, 2050 and 2120, the beneficiaries could be charged the shown annuity from 2020 to a period of 15 years. It can be seen that no residential or commercial properties are expected to benefit from the 2035 or 2050 works but the two rural parcels benefiting from the 2035 works would be required to contribute an annual levy of $19 (for a period of 15 years).
- For works predicted to occur in 2050 or these funds could then be collected now, or the collection of funds could be delayed set aside for works to be done at a larger stage.
- Alternatively, the beneficiaries could be charged these at a later stage. However, the quantity to be charged may then change.

The funding mechanism is explained in detail in Section 2.5. The funds could be collected as a single lump sum, or as an annual payment (we have assumed 15 years).

Table 8: Annual funds to be collected per property that is saved for a period of 15 years

	2020	2035	2050	2120
Residential (parcels)	$1,396	-	-	$2
Commercial (parcels)	$1,047	-	-	-
Agricultural / Rural (parcels)	$52	$19	$7	$1

Source: Marsden Jacob analysis

Note: Annuity is calculated using 7% discount rate and values are rounded.

4.1.2 Local community beneficiaries

As set out in Table 3, the local community are likely to be a significant beneficiary of the following land uses:

- Public and Community land
- Foreshore - Developed
- Foreshore - Undeveloped

While these areas may be used by a mix of local community and the broader community (such as those travelling to or past the area) – the broader community would have a wide range of substitute locations they could use. Therefore, they would be expected to have a relatively low willingness to pay- to protect an area.

If all the funds are to be collected from the local community, then the total budget would be a relatively modest $80,000 as set out in Table 9. If these funds were collected as an annuity (such as from rates) then the annual impact for 15 years would be $8,852 per year for the whole Shire. Given that the Shire of Capel has forecast rates for 2023 of 14.2 million[7] the annual impost of less than $9,000 would require a negligible increase in rates for the local community.

Table 9: Local community assets (MUs 1 and 2)

Assets	Total funds to be collected	Annuity (15 years)
Public and Community	$79,026	$8,677
Foreshore - Undeveloped	$1,593	$175
Total	**$80,619**	**$8,852**

Source: Marsden Jacob analysis

Note: As shown in Table 6, Foreshore – Developed has no benefits attached and therefore is not included in this table and the values are rounded.

[7] https://shireofcapel.sharepoint.com/:b:/s/website/EbF-dXdA6hRIroymace3jGQBYaSWg0WfVeHdNTJSzZBbXw?e=BRLvj6 see Attachment 15.4.1 Financial Report 2208

4.1.3 Broader community beneficiaries

As set out in Section 2.3, some assets are likely to have a significant non-use value arising from existence, altruism or bequest values. These are particularly strong for environmental and heritage items. Similarly, the road network is likely to have a mix of use values (to the local community) and option values (to the broader community).

Based on the benefit distribution, the total contribution from the broader WA community would be $2.277 million dollars – as shown in Table 10. This adds up to 88% of the total funds required for the intervention.

Table 10: Broader community assets (MUs 1 and 2)

Assets	Total funds to be collected	Annuity (15 years)
Roads	$163,542	$17,956
Environmental	$1,750,742	$192,222
Aboriginal Heritage	$362,624	$39,814
Total	**$2,276,908**	**$249,992**

Source: Marsden Jacob analysis

Note: Annuity is calculated using 7% discount rate and values are rounded.

4.2 BDA for Dalyellup (MU3)

The main risk for this area is erosion, with residential and environmental categories the most affected. Inundation, however, is not a high risk. Although this option has not scored positively in the CBA, its analysis in the BDA will still be valuable and provide further information about the selection of adaptation options.

MU3 – PR2 – Groynes to protect Dalyellup, the old landfill site and wastewater treatment plant to the north from erosion.

Key features for this option are as follows:

- Assumes 6 rock groynes 100 m long.
- 2035 implementation.

Table 11 outlines the assets at risk from erosion in the identified MU. It is important to note that the values are not cumulative.

Table 11: Assets at risk from erosion in MU3

Assets at risk	2020	2035	2050	2120
Roads (km)	0	0	0	0
Residential (parcels)	0	4	0	60
Commercial (parcels)	0	1	0	0
Public and Community (parcels)	0	3	0	0
Foreshore - Developed (ha)	0	0	0.1	0.5
Foreshore - Undeveloped (ha)	0.2	0.6	0.5	1.7
Environmental (item)	22	3	1	21
Agricultural / Rural (parcels)	0	0	0	0
Aboriginal Heritage (item)	0	0	0	0

Note: Values are not cumulative

Table 12 sets out the value of the avoided damage (i.e., the benefit) of each asset type over the 100-year assessment period.

Table 12: Total benefits of the option over the base case for MU3

Assets	2020	2035	2050	2120	Total
Roads	$0	$0	$0	$0	$0
Residential	$0	$724,892	$0	$34,574	$759,466
Commercial	$0	$135,917	$0	$0	$135,917
Public and Community	$0	$407,752	$0	$0	$407,752
Foreshore - Developed	$0	$0	$41,052	$1,801	$42,853
Foreshore - Undeveloped	$500,000	$543,669	$164,209	$4,898	$1,212,776
Environmental	$4,250,000	$271,835	$32,842	$6,050	$4,560,727
Agricultural / Rural	$0	$0	$0	$0	$0
Aboriginal Heritage	$0	$0	$0	$0	$0
Total	**$4,750,000**	**$2,084,065**	**$238,103**	**$47,322**	**$7,119,490**

The present value of interventions is **$11,136,564**. This value is based on the capital expenditure expected to arise in 2035 and the operating and maintenance costs that would occur from 2035 to 2120.

As noted in the CBA produced by Water Technology, this option does not deliver a net benefit and so is unlikely to be progressed.

It should be noted that while we show this value to the nearest dollar the cost estimates are based on concept design estimate so should be considered to have ± 50% margin.

The allocation of the present value cost of the intervention to each of the beneficiaries is set out in Table 13.

Table 13: BDA for MU3

Assets	Percentage of total benefits	Benefits (A$)
Roads	0%	$0
Residential	11%	$759,466
Commercial	2%	$135,917
Public and Community	6%	$407,752
Foreshore - Developed	1%	$42,853
Foreshore - Undeveloped	17%	$1,212,776
Environmental	64%	$4,560,727
Agricultural / Rural	0%	$0
Aboriginal Heritage	0%	$0

Source: Marsden Jacob analysis

4.2.1 Private beneficiaries

Private benefits arise for owners of Residential, Commercial and Agricultural / Rural properties. As shown in Table 14, 60 residential parcels are projected to be impacted in the year 2120.

Table 14: Assets at benefitting from proposed action (total number of properties for each timeframe) (MU3)

Assets at risk	2020	2035	2050	2120
Residential (parcels)	0	4	0	60
Commercial (parcels)	0	1	0	0
Agricultural / Rural (parcels)	0	0	0	0

Source: Marsden Jacob analysis

Note: Values are not cumulative

For the private properties impacted, the total funds to be collected per property are set out in Table 15. The funding mechanism is explained in detail in Section 2.5. This could be collected as a single lump sum, or as an annual payment (we have assumed 15 years) – as a special levy attached to Local Government rates.

Table 15: Total funds to be collected per property saved for a period of 15 years

	2020	2035	2050	2120
Residential (parcels)	-	$31,124	-	$99
Commercial (parcels)	-	$23,343	-	-
Agricultural / Rural (parcels)	-	-	-	-

Source: Marsden Jacob analysis

Note: Agricultural parcels are not impacted and hence, are not included in the table. Annuity is calculated using 7% discount rate and values are rounded.

4.2.2 Local community beneficiaries

As set out in Table 3, the local community are likely to be a significant beneficiary of the following land uses:

- Public and Community land
- Foreshore - Developed
- Foreshore - Undeveloped

While these areas may be used by a mix of local community and the broader community (such as those travelling to or past the area) – the broader community would have a wide range of substitute locations they could use. Therefore, they would be expected to have a relatively low willingness to pay- to protect an area.

If all the funds are to be collected from the local community, then the total budget would be around $2.6 million as set out in Table 16. If these funds were collected as an annuity (such as from rates) then the annual impact for 15 years would be $290,124 for the whole Shire. Given that the Shire of Capel has forecast rates for 2023 of 14.2 million[8] the annual impost of around $300,000 would require a considerable increase in rates for the local community.

[8] https://shireofcapel.sharepoint.com/:b:/s/website/EbF-dXdA6hRIroymace3jGQBYaSWg0WfVeHdNTJSzZBbXw?e=BRLvj6 see Attachment 15.4.1 Financial Report 2208

Table 16: Local community assets (MU3)

Assets	Total funds to be collected	Annuity (15 years)
Public and Community	$647,749	$71,119
Foreshore - Undeveloped	$68,076	$7,474
Foreshore – Developed	$1,926,599	$211,530
Total	**$2,642,423**	**$290,124**

Source: Marsden Jacob analysis

Note: Annuity is calculated using a discount rate of 7% and the values are rounded.

4.2.3 Broader community beneficiaries

As set out in Section 2.2, some assets are likely to have a significant non-use value arising from existence, altruism or bequest values. These are particularly strong for environmental and heritage items. Similarly, the road network is likely to have a mix of use values (to the local community) and option values (to the broader community).

Based on the benefit distribution, the total contribution from the broader WA community would be around $7.2 million – as shown in Table 17. This adds up to 64% of the total funds required for the intervention.

Table 17: Broader community assets (MU 3)

Assets	Total funds to be collected	Annuity (15 years)
Environmental	$7,245,106	$795,473.73

Source: Marsden Jacob analysis

Note: As noted in Table 13, Aboriginal heritage and roads have no benefits attached and are not included in the table. Annuity is calculated using 7% discount rate and values are rounded.

4.3 BDA for Bunbury (MU5)

For this Management Unit (which includes Bunbury back beach and Koombana bay), erosion is a significant risk from the present day to both built and natural assets along the western coast of the City of Bunbury. Inundation is a significant risk across much of this MU. The inundation risk is predicted to increase from present day to 2120. By 2120, the 1-year ARI is predicted to inundate a significant residential commercial area. Environmental, public and community assets are also predicted to be significantly impacted by inundation.

MU5 – PR 2 – Groynes to protect Bunbury from coastal erosion.

Key features of this option are as follows:

- Implementation in 2020.
- Assumes 15 rock groynes 100 m long, 400 m apart.

- 13 groynes on ocean coast and 2 in Koombana bay.

Table 18 outlines the assets that are at risk from erosion in the identified MU. It is important to note that the values shown are not cumulative.

Table 18: Assets at risk from erosion in MU5

Assets at risk	2020	2035	2050	2120
Roads (km)	9.7	3.7	3.5	10.5
Residential (parcels)	0	4	29	234
Commercial (parcels)	3	0	1	4
Public and Community (parcels)	5	0	9	36
Foreshore - Developed (ha)	20	2.7	1.9	1.6
Foreshore - Undeveloped (ha)	9.8	0.7	0.4	2.5
Environmental (item)	60	8	6	67
Agricultural / Rural (parcels)	0	0	0	0
Aboriginal Heritage (item)	0	0	0	1

Note: Values are not cumulative.

Table 19 sets out the value of the avoided damage (i.e., the benefit) of each asset type over the 100-year assessment period.

Table 19 Total benefits of the option over the base case for MU5.

Assets	2020	2035	2050	2120	Total
Roads	$29,100,000	$4,023,151	$1,379,355	$36,302	**$34,538,808**
Residential	$0	$724,892	$1,904,823	$134,837	**$2,764,552**
Commercial	$1,125,000	$0	$49,263	$1,729	**$1,175,991**
Public and Community	$1,875,000	$0	$443,364	$15,558	**$2,333,922**
Foreshore - Developed	$62,500,000	$3,058,138	$779,992	$5,762	**$66,343,893**
Foreshore - Undeveloped	$24,500,000	$634,281	$131,367	$7,203	**$25,272,850**
Environmental	$15,000,000	$724,892	$197,051	$19,304	**$15,941,246**
Agricultural / Rural	$0	$0	$0	$0	**$0**
Aboriginal Heritage	$0	$0	$0	$2,305	**$2,305**
Total	**$134,100,000**	**$9,165,354**	**$4,885,215**	**$222,999**	**$148,373,568**

The present value of interventions is **$72,027,835.**

Table 20: BDA for MU5

Assets	Percentage of total benefits	Benefits (A$)
Roads	23%	**$34,538,808**
Residential	2%	**$2,764,552**
Commercial	1%	**$1,175,991**
Public and Community	2%	**$2,333,922**
Foreshore - Developed	45%	**$66,343,893**
Foreshore - Undeveloped	17%	**$25,272,850**
Environmental	11%	**$15,941,246**
Agricultural / Rural	0%	**$0**
Aboriginal Heritage	0%	**$2,305**

4.3.1 Private beneficiaries

Private benefits arise for owners of Residential, Commercial and Agricultural / Rural properties. As shown in Table 21, the number of properties expected to benefit from the groynes is lower than the total number of properties at risk. This is because groynes offer protection from erosion and not inundation. The annual funds to be collected per property saved are set out in Table 22.

Table 21: Assets benefitting from the proposed works (total number of properties for each timeframe) (MU5)

Assets at risk	2020	2035	2050	2120
Residential (parcels)	0	4	29	234
Commercial (parcels)	3	0	1	4

Note: Agricultural parcels are not impacted and hence, are not included in the table. Values are not cumulative

Table 22: Funds to be collected per property saved for a period of 15 years

	2020	2035	2050	2120
Residential (parcels)	-	$9,659	$3,501	$31
Commercial (parcels)	$19,987	-	$2,626	$23

Source: Marsden Jacob analysis

Note: Agricultural parcels are not impacted and hence, are not included in the table. Annuity is calculated using 7% discount rate and values are rounded.

4.3.2 Local community beneficiaries

As set out in Table 3, the local community are likely to be a significant beneficiary of the following land uses:

- Public and Community land
- Foreshore - Developed
- Foreshore - Undeveloped

While these areas may be used by a mix of local community and the broader community (such as those travelling to or past the area) – the broader community would have a wide range of substitute locations they could use. Therefore, they would be expected to have a relatively low willingness to pay – to protect an area.

Table 23: Local community assets (MU5)

Assets	Total funds to be collected	Annuity (15 years)
Public and Community	$1,133,001	$124,397
Foreshore - Undeveloped	$32,206,592	$3,536,111
Foreshore – Developed	$12,268,686	$1,347,036
Total	**$45,608,279**	**$5,007,544**

Source: Marsden Jacob analysis

Note: Annuity is calculated using a discount rate of 7% and the values are rounded.

If all the funds are to be collected from the local community, then the total budget would be around $45.6 million as set out in Table 23. The local community's contribution adds up to 63% of the total funds required for the intervention.

4.3.3 Broader community beneficiaries

As set out in Section 2.2, some assets are likely to have a significant non-use value arising from existence, altruism or bequest values. These are particularly strong for environmental and heritage items. Similarly, the road network is likely to have a mix of use values (to the local community) and option values (to the broader community).

Based on the benefit distribution, the total contribution from the broader WA community would be $24.5 million dollars – as shown in Table 24. This adds up to 35% of the total funds required for the intervention.

Table 24: Broader community assets (MU 5)

Assets	Total funds to be collected	Annuity (15 years)
Roads	$16,766,838	$1,840,909
Environmental	$7,738,666	$849,664
Aboriginal Heritage	$1,119	$123
Total	**$24,506,622**	**$2,690,695**

Source: Marsden Jacob analysis

Note: Annuity is calculated using 7% discount rate and values are rounded.

5. Funding assessment

5.1 Funding models that would support development of the preferred management option(s)

Any suitable option chosen to mitigate the identified risks will not proceed further until satisfactory funding arrangements have been identified. Traditionally BDAs comprise of the following steps for funding assessments:

1. Step 1 – Current status of council resources for coastal management actions.
2. Step 2 – Are there any potential opportunities to align actions and leverage funding from neighbouring local, state or Commonwealth programs?
3. Steps 3 – Are there any relevant grant programs that could provide funding?
4. Step 4 – Potential for voluntary contributions from interested parties.
5. Step 5 – Considering the previous steps, what mechanisms could be used to equitable secure contributions?

There are three funding model options: **Impactor, Beneficiary, and Taxpayer**.

Traditionally, the preferred funding model for the proposed works identified will be a combination of **beneficiary pays and grant funding** from the state and Commonwealth government programs.

The preferred funding model for this project would also be a combination of beneficiary pays and grant funding. The funding sources and options are detailed in the following section.

5.2 Funding options and sources

The following groups are the three potential sources for funding for the identified options.

- Beneficiaries
- Grant funding
- Special rate mechanism

However, to identify the ability and capacity of beneficiaries to pay for the proposed works, a number of key things need to be taken into consideration.

- **Willingness to pay for the costs** - Since costs associated with the works are high, there may be reluctance amongst the beneficiaries to either pay upfront for the costs or bear high ongoing costs for a number of years. Thus, extensive consultation needs to be done to ascertain willingness, capacity and ability to pay.
- **Apportioning the environmental benefits to relevant groups** - There are large environmental benefits associated with the proposed works. Significant care must be taken to ensure these benefits are

apportioned accurately to relevant groups so that they can pay for these benefits.

5.3 Councils' statutory ability to levy fees and charges under relevant state government legislation

As noted in Section 2.5, we identified three broad beneficiary groups that are likely

- Private property owners (residential, commercial or agricultural)
- WA State government (representing the broader WA community) and
- Local community

The following table details on beneficiaries, funding source and possible collection methods.

Table 25: Funding sources and collection methods.

Assets	Funding source	Collection method
Roads	WA Taxpayers	State Government grant
Residential	Property owners	Special levy on relevant properties - collected through rates
Commercial	Property owners	Special levy on relevant properties - collected through rates
Public and Community	Indirect users	Added to all rate payers
Foreshore - Developed	Direst users	Added to all rate payers
Foreshore - Undeveloped	Rate payers	Added to all rate payers
Environmental	WA Taxpayers	State Government grant
Agricultural / Rural	Property owners	Special levy on relevant properties - collected through rates
Aboriginal Heritage	WA Taxpayers	State Government grant

In Western Australia the power for Local Governments to collect rates is set out in the *Local Government Act, 1995*.[9] In particular Division 6 sets out types and conditions for rates and charges. In addition to the basic powers to set and collect rates outlined in section 6.32, relevant sections include:

- 6.33 (Differential general rates),
- 6.36 (Local government to give notice of certain rates) and
- 6.37 (Specified area rates)
- 6.38 (Service charges)

9 www.legislation.wa.gov.au/legislation/statutes.nsf/law_a465.html Se

As noted above, Local Government have the power to collect specified area rates – which could be applied to areas that would benefit from climate adaptation projects.

5.4 Capacity of beneficiaries to pay apportioned costs

5.4.1 Private beneficiaries

As set out above it appears that the funds from private beneficiaries could be collected by the local government through the rates process (such as specified areas rates).

A review of the annuity funding required for each of the management areas (as set out in sections 4.1.1, 4.2.1, and 4.3.1) indicates a wide range of annuity fees are required.

The largest funds required are related to erosion benefits that would arise in 2020 or in 2035.

While these beneficiaries are contributing to projects that would save their property (estimated to be worth $500,000 for residential land), contributing an annuity of $31,000 (for MU3) may not be affordable for some beneficiaries.

5.4.2 Local Government beneficiaries

As set out in sections 2 and 4, it is proposed that local community benefits (which are not private benefits) would be funded through Local Government rates – which would be applied to the whole Local Government Area.[10]

MU 1, 2 and MU 3 are within the Shire of Capel, while MU5 is within the City of Bunbury. Table 26, sets out the funds to be collected for each project on an annuity basis (over 15 years at 7% discount rate), and compares this to the total expected rates for the current year.

The analysis shows that the proposed works for MU 1& 2 as well as MU3 are likely to be able to be added to the rate base – without significant difficulty to the council or rate payers. However, the proposed actions at MU5 (in the City of Bunbury) appear likely to cause some difficulty (to use more than 10% of current rates would not be feasible without a potential increased rate charge) and so may need to consider a longer fund collection period or alternative funding mechanism.

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10 We have assumed that grant funding would be available to support local government benefits.

Table 26: Comparison of required funds to LGA rate base

Management area	LGA	Annuity funds to be collected from local community	Total expected rates for 2022/23	Percentage of annual rates
MU1 & 2	Shire of Capel	$8,691	$14,179,504	0.06%
MU3	Shire of Capel	$285,677	$14,179,504	2.01%
MU5	City of Bunbury	$5,007,544	$42,800,000	11.70%

Source: *Capel Budget https://www.capel.wa.gov.au/about/council/meetings/agenda-minutes/*

Bunbury budget: https://cdn.bunbury.wa.gov.au/wp-content/uploads/2022/08/Budget-and-rates-2022-23.pdf

5.4.3 Broader community beneficiaries

As set out in sections 2 and 4, it is proposed that broader community benefits would be funded by a State Government grant. The quantity of funds sought for these projects appears well within the WA Government's capacity to pay. However, over time the WA Government may wish to create a fund – so that similar projects are compared and those delivering the highest benefits are given priority for funding. This is because many of WA's coastal settlements will have similar erosion/inundation issues over next 100 years. For this reason, State Government funds may need to be focussed on the highest priority areas rather than have each Local Government approach the State and their funding request be considered in isolation.

5.4.4 Further consultation

As set out above a number of the indicative funds required appear to be relatively small compared to the value delivered and the overall cost.

However, the proposed interventions for MU3 do pass significant costs (e.g. $31,000 as shown in section 4.2.1 on to a small number of private beneficiaries. The costs are well below the value of the benefit delivered, but may not be within the capacity of the property owners to pay.

In these instances, further consultation may be necessary to establish a suitable approach to apportioning and collecting these funds.

6. Recommended next steps

6.1 Background – design phases for large projects

Projects of this kind have a high level of uncertainty arising from:

- Difficulty in predicting erosion and inundation climate impacts
- Difficulty in predicting the effectiveness of engineering interventions
- Difficulty in costing engineering interventions given the relatively small level of industry expertise and the unique nature of each location and intervention.

The development of large or uncertain engineering projects are often subject to a "gateway process" – whereby the engineering design and costings are iteratively refined, and the viability of the project is reviewed after each design phase.

Standard engineering design stages are concept design, preliminary design, functional design, and detailed design.

Table 27: Order of magnitude design

Design stage	Cost error margins
Concept design	Indicative
Preliminary design	± 50%
Functional design	± 30%
Detailed design	± 10%

6.2 Benefit distribution analysis

The benefits and the distribution analysis provided here form a starting point toward the development of the coastal protection works in the identified areas in the Capel-Bunbury region. The recommended next steps for the coastal protection of the region are as follows:

- A preliminary design and costing of the proposed works analysed as part of the CBA.
- A detailed CBA and BDA, based on the inputs from the preliminary design as well as analysis of the full range of uses of environmental assets and refined value estimation.
- A feasibility analysis of the proposed design.

6.3 Recommendations

Based on the analysis set out in this report we recommend that:

1. the recommended options are progressed to a further level of design and costing (e.g., move towards Functional design)
2. the benefit values used in the CBA and the allocation of benefits to stakeholder groups should be tested for this location and these assets through specialised surveys of users (such as contingent valuation or choice modelling surveys) and analysis of asset use.
3. the funding approach in the BDA is consulted upon with stakeholders
4. the CBA and BDA should be revised and expanded to reflect updated costings, improved knowledge of risks (e.g., Probabilistic approach to identifying hazard lines and impacts) and the full range of benefits

References

Marsden Jacob Associates, 2020. *Warilla Beach Cost-Benefit Analysis. Assessment of coastal management options for Warilla Beach.* Sydney, Australia.

Phillips, A., 1998. *Economic Values of Protected Areas: Guidelines for Protected Area Managers, Task Force on Economic Benefits of Protected Areas of the WCPA of IUCN in Collaboration with the Economics Service Unit of IUCN*. Gland, Switzerland: IUCN.

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Capel to Leschenault CHRMAP

Chapter Report: Risk Treatment – Benefit Distribution Analysis

Peron Naturaliste Partnership

21 March 2023

Document Status

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APPENDICES

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1 INTRODUCTION

It is internationally recognised that the mean sea level has been rising globally since the nineteenth century and is predicted to rise at an increasing rate in the future (IPCC 2021). Rising sea levels and intensifying storm activity will increase the risk of coastal inundation (temporary coastal flooding), storm erosion and long-term shoreline recession. State governments across Australia have introduced obligations that require local governments to consider and plan for these hazards. In Western Australia (WA), the governing policy is the Western Australian Planning Commission's (WAPC) State Planning Policy No. 2.6: State Coastal Planning Policy (WAPC, 2013, herein referred to as "SPP2.6"). SPP2.6 recommends that management authorities develop a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for land use or development potentially vulnerable to coastal hazards. Specific guidelines have been developed to assist in this process (WAPC, 2019).

SPP2.6 requires adequate risk management planning is undertaken where existing or proposed development is in an area at risk of being affected by coastal hazards over the 100-years planning timeframe. SPP2.6 and the CHRMAP Guidelines provide the risk assessment framework to be applied to identify risks that are intolerable to the community, and other stakeholders such as local governments, indigenous and cultural interests, and private enterprise. Risk management measures are then developed according to the adaptation hierarchy outlined in SPP2.6.

The Peron Naturaliste Partnership (PNP) comprises membership of nine local government authorities. The PNP's Coastal Adaptation Pathways Project identified the coastal areas of Capel, Leschenault and Greater Bunbury as being particularly exposed to coastal hazards and climate change, which triggered the need for this CHRMAP. Therefore, the present study aims to investigate the nature and severity of coastal hazards that are likely to affect these regions from Capel to Leschenault over future planning horizons. Refer Figure 1-2 for locality, study area extent and management units.

This CHRMAP project aims to increase knowledge and understanding of coastal hazard risks and identify risk management and adaptation measures for implementation. The outcomes will be used to inform local and state government policies, strategies and plans, including (but not limited to), planning strategies, community strategic plans, drainage strategies, asset management plans, emergency management plans, and foreshore management plans. The project will adhere to the WAPC (2019) guidelines with scope and deliverables to be consistent with the objectives identified by these guidelines and SPP2.6. In addition, the project will identify the strategic direction for coastal adaptation scenarios from the present-day to 2120 (100 yrs. management time frame) and identify an implementation plan to achieve this direction. Overall, this CHRMAP will develop a flexible adaptation pathway for the region and serve as a key reference for management, planning and policy-making for the short-term (0-15 years), medium-term (15-30 years), and long-term (100 years).

Delivery of this project will occur over 9 stages (as summarised Figure 1-1), each of which represents a key hold point. The staged approached is developed according to the PNP's scope and is in line with the CHRMAP Guidelines (WAPC, 2019).

This report presents the Stage G Risk Treatment – Benefit Distribution Analysis Chapter Report, which assesses the proportion of private and public beneficiaries should protections options be implemented. The red bubble displayed in Figure 1-1 outlines Stage G in the context of the CHRMAP.

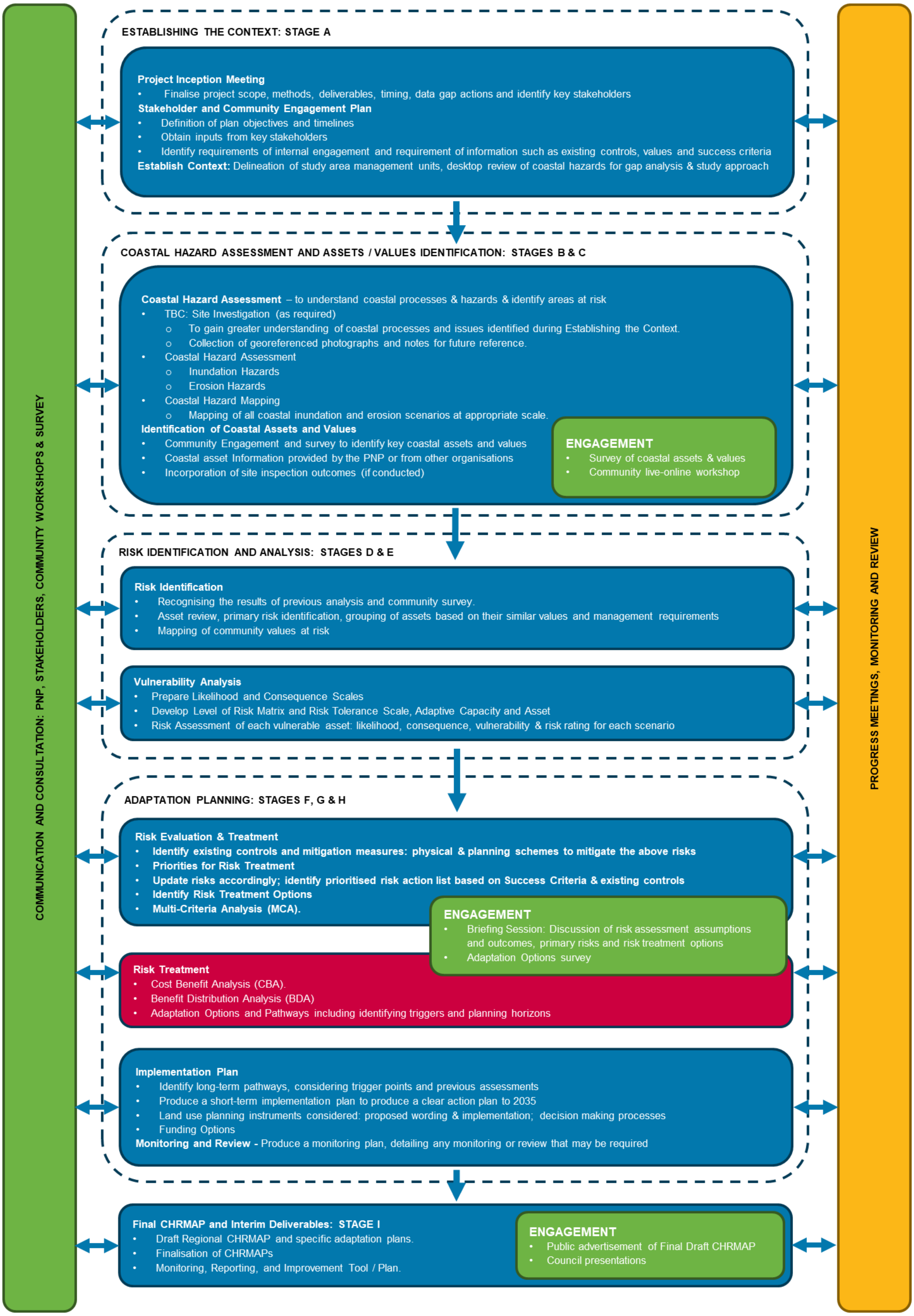

Figure 1-1 Methodology

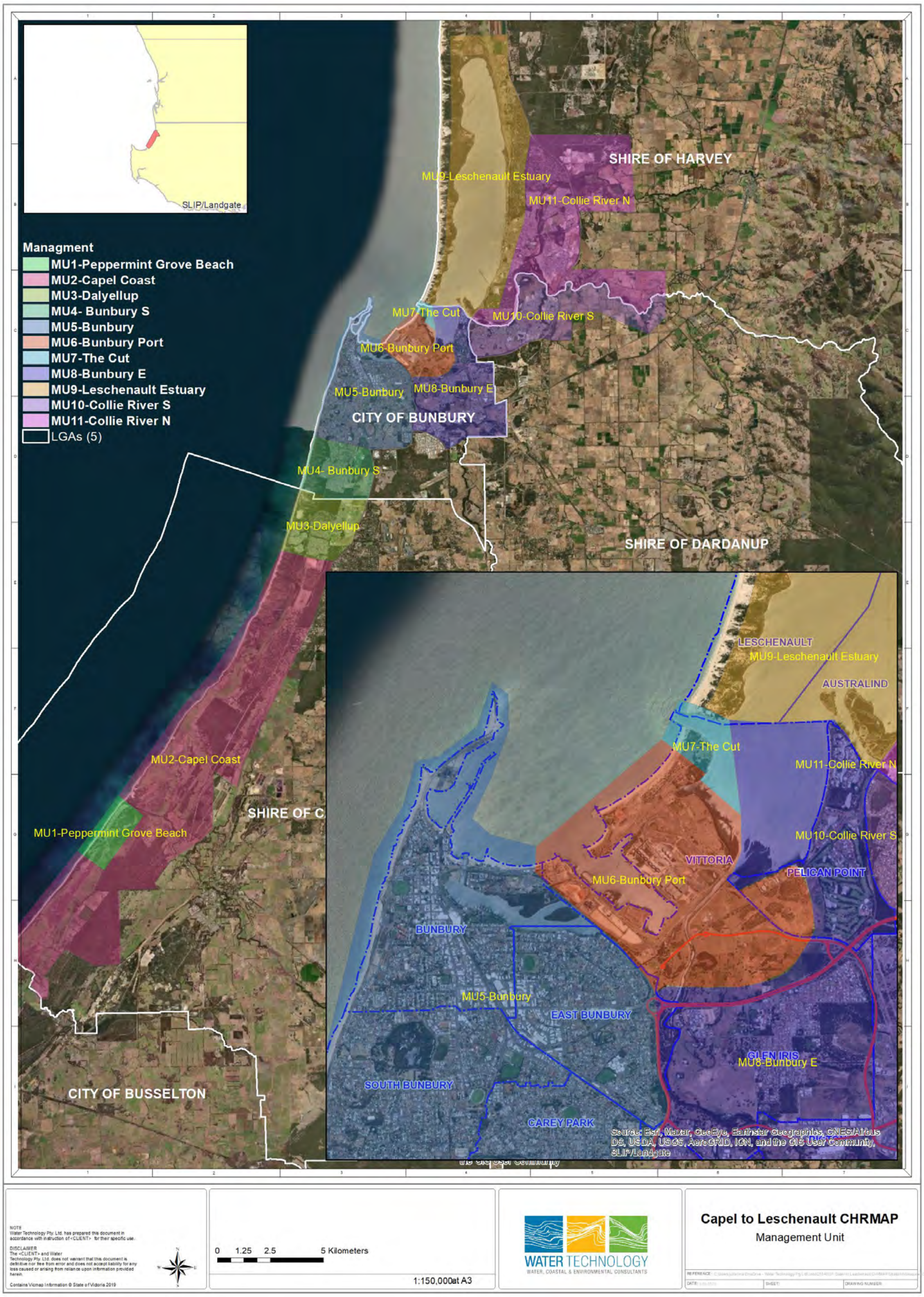

Figure 1-2 Study Area and Management Units (MU)

2 BACKGROUND

During the completion of the CBA and review of the preliminary results, Water Technology discussed possible options to proceed to Benefit Distribution Analysis (BDA), undertaken by sub-consultant Marsden Jacobs and Associates. Following several discussions, considering projected vulnerable assets, nature of hazards, tenure of land projected to be vulnerable, the following three options were selected:

- MU 1 and 2 - PR6 - Levies along the banks of the Capel River to minimise inundation. This option shall also consider inundation protection at Higgins Cut and the and the Minninup Drain outlet near Tatton Place in Stratham.
- MU 3 - PR2 - Groynes to protect Dalyellup, the Dalyellup Residual Waste Disposal Facility and the Bunbury Wastewater Treatment Plant to the north from erosion. Although this option has not scored positively in the CBA, its analysis in the BDA will still be valuable and provide further information about the selection of adaptation options.
- MU 5 - PR2 - Groynes to protect Bunbury Back Beach from erosion.

3 BENEFIT DISTRIBUTION ANALYSIS SUMMARY

Sub-consultant Marsden Jacobs and Associates have produced a stand-alone report on their BDA work – see Appendix A. Their work used the CBA results prepared by Water Technology as their inputs and is summarised below.

3.1 Method

A BDA is undertaken to allocate the derived benefits from the options identified to the relevant stakeholder. The relevant stakeholders are all those who are expected to benefit from the protection of the identified area. Key beneficiaries include:

- Private landholders
- Local community (Direct users of the area under threat)
- Broader community (Indirect users)

It is important to identify the beneficiaries and accurately evaluate their individual share of benefits. This paves the way for the next step in the BDA: identifying funding options and a funding model. CHRMAP follows a "beneficiary pay principle" and, thus, requires the accurate allocation of the proportion of benefits to the beneficiaries.

In order to identify the full range of benefits and beneficiaries that will arise from climate interventions, it is firstly important to ensure the full range of uses and values are identified. The concept of total economic value (TEV, Figure 3-1) is a well-established and useful framework for identifying the various values associated with protected areas. This framework is a useful tool for economic valuation, which measures market and non-market values that people hold for the study area and can be applied to value coastal areas and other natural resources such as wetlands, parks etc.

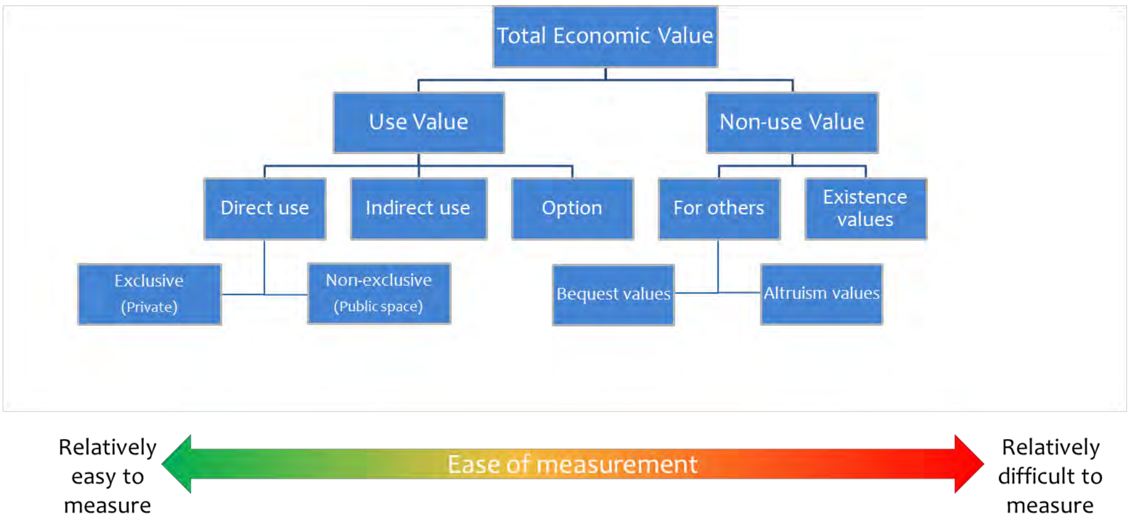

Figure 3-1 Total Economic Value Framework

The TEV framework provides a useful classification for the full range of community values. The basic premise of the framework is that the total economic value of an area is a function of its use and non-use values. The use values are made up of its direct use values, indirect use values, and option values. Non-use values typically include bequest and existence values.

The framework also helps to avoid double counting of ecosystem functions, intermediate services, and final services.

TEV includes both use values, which measure the value of using assets that are protected, and non-use values, which refer to an individual's willingness to contribute to the cost of protecting public assets (such as beaches and estuaries), even if the individual will not use the areas themselves.

On the left-hand side of the TEV framework there are values for the exclusive direct use of assets – such as private land. The value the community places on these assets may be impacted by the market price paid for private land. For all the other uses, there is no direct market value for the benefit obtained. These are often referred to as non-market values.

Applying the different types of values identified in the TEV framework, the 9 asset categories and their value type were assessed based on the TEV framework to determine an appropriate valuation method for each category, and their beneficiaries. The CBA base case results were used to determine the economic impact and apportion it to each asset category for each MU.

3.2 Results

Table 3-1 summarises the percentage of total benefits for each asset category for each MU. Results are highly variable across the different MU's.

Table 3-1 Percentage of total benefits for each asset category at each MU

Asset Category	MU 1 & 2	MU 3	MU 5
Roads	6%	0%	23%
Residential	3%	11%	2%
Commercial	1%	2%	1%
Public and Community	3%	6%	2%
Foreshore – Developed	0%	1%	45%
Foreshore – Undeveloped	0%	17%	17%
Environmental	68%	64%	11%
Agricultural / Rural	5%	0%	0%
Aboriginal Heritage	14%	0%	0%

Table 3-2 to Table 3-10 below summarise the financial contributions required from the custodians of each asset category to implement the preferred treatment options set out in the CBA. Note the Environmental asset category was largely informed by DBCA data. It includes habitat areas potentially suitable for Matters of National Environmental Significance (such as Carnaby's Cockatoo's and Western Ringtail Possums), Threatened and Priority Ecological Communities, and known locations of threatened flora.

For each of the stakeholders identified as a key beneficiary for each asset category, the financial contribution that would be required as a singular payment and the annuity payment that would be required if the funds were collected over a 15-year period and at 7% discount rate. 15 years is an arbitrary period – but it aligns with the duration between the first three assessment periods (2020, 2035, 2050). If funds started to be collected now, the projects would be largely funded ahead of the 2035 timeframe for implementation. Ahead of 2035, the risks and work required for 2050 could be reviewed, and then annuity payments could be required for 15 years to ensure any activities undertaken at that time were also funded ahead of work commencing.

3.2.1 Peppermint Grove Beach and Capel Coast Inundation Risk - MU1 and MU2

Table 3-2 Private asset categories – Annual funds to be collected per property for 15 years for each timeframe for number of properties protected.

Asset Category	2020	2035	2050	2120
Residential	$1,396	-	-	$2
Commercial	$1,047	-	-	-
Agricultural / Rural	$52	$19	$7	$1

Table 3-3 Local community asset categories

Asset Category	Total funds to be collected	Annuity (15 years)
Public and Community	$79,026	$8,677
Foreshore – Undeveloped	$1,593	$175
Total	$80,619	$8,852

Table 3-4 Broader community asset categories

Asset Category	Total funds to be collected	Annuity (15 years)
Roads	$163,542	$17,956
Environmental	$1,750,742	$192,222
Aboriginal Heritage	$362,624	$39,814
Total	$2,276,908	$249,992

3.2.2 Dalyellup Erosion Risk - MU3

Table 3-5 Private asset categories – Annual funds to be collected per property for 15 years for each timeframe for number of properties protected.

Asset Category	2020	2035	2050	2120
Residential	-	$31,124	-	$99
Commercial	-	$23,343	-	-
Agricultural / Rural	-	-	-	-

Table 3-6 Local community asset categories

Asset Category	Total funds to be collected	Annuity (15 years)
Public and Community	$647,749	$71,119
Foreshore – Undeveloped	$68,076	$7,474
Foreshore – Developed	$1,926,599	$211,530
Total	$2,642,423	$290,124

Table 3-7 Broader community asset categories

Asset Category	Total funds to be collected	Annuity (15 years)
Environmental	$7,245,106	$795,473.73

3.2.3 Bunbury Erosion Risk - MU5

Table 3-8 Private asset categories – Annual funds to be collected per property for 15 years for each timeframe for number of properties protected.

Asset Category	2020	2035	2050	2120
Residential	-	$9,659	$3,501	$31
Commercial	$19,987	-	$2,626	$23

Table 3-9 Local community asset categories

Asset Category	Total funds to be collected	Annuity (15 years)
Public and Community	$1,133,001	$124,397
Foreshore – Undeveloped	$32,206,592	$3,536,111
Foreshore – Developed	$12,268,686	$1,347,036
Total	$45,608,279	$5,007,544

Table 3-10 Broader community asset categories

Asset Category	Total funds to be collected	Annuity (15 years)
Roads	$16,766,838	$1,840,909
Environmental	$7,738,666	$849,664
Aboriginal Heritage	$1,119	$123
Total	$24,506,622	$2,690,695

3.3 Discussion

The BDA has found that the allocation of beneficiaries when forecasting coastal management works is a complicated process. The process provides information to assist decision-makers with information about the approximate proportion of beneficiaries between private and public parties. Table 3-11 defines potential funding sources and collection methods for each asset category.

Table 3-11 Potential funding sources and collection methods

Asset Category	Funding Source	Collection Method
Roads	WA Taxpayers	State Government grant
Residential	Property owners	Special levy on relevant properties - collected through rates
Commercial	Property owners	Special levy on relevant properties - collected through rates
Public and Community	Indirect users	Added to all rate payers
Foreshore - Developed	Direct users	Added to all rate payers
Foreshore - Undeveloped	Rate payers	Added to all rate payers
Environmental	WA Taxpayers	State Government grant
Agricultural / Rural	Property owners	Special levy on relevant properties - collected through rates
Aboriginal Heritage	WA Taxpayers	State Government grant

Table 3-12 presents a summary of the annuity funds proposed to be collected from the local community via each relevant LGA, against the total expected rates revenue for 2022/23. Results are markedly different between the Shire of Capel and City of Bunbury.

Table 3-12 Comparison of required funds to LGA rate base

Management Unit	LGA	Annuity funds to be collected from local community	Total expected rates for 2022/23	Percentage of annual rates
MU1 & 2	Shire of Capel	$8,691	$14,179,504	0.06%
MU3	Shire of Capel	$285,677	$14,179,504	2.01%
MU5	City of Bunbury	$5,007,544	$42,800,000	11.70%

As set out above. a number of the indicative funds required appear to be relatively small compared to the value delivered and the overall cost. However, the proposed interventions for MU3 do pass significant costs (e.g. $31,000) onto a small number of private beneficiaries. The costs are well below the value of the benefit delivered but may not be within the capacity of the property owners to pay. In these instances, further consultation may be necessary to establish a suitable approach to apportioning and collecting these funds.

The benefits and the distribution analysis provided here form a starting point toward the development of the coastal protection works in the identified areas in the Capel-Bunbury region. The recommended next steps for the coastal protection of the region are as follows:

- A preliminary design and costing of the proposed works analysed as part of the CBA to determine the performance and cost of the works
- A detailed CBA and BDA, based on the inputs from the preliminary design as well as analysis of the full range of uses of environmental assets and refined value estimation.
- A feasibility analysis of the proposed design.

Based on the analysis MJA recommends that:

1. The recommended options are progressed to a further level of design and costing (e.g., move towards Functional design)
2. The benefit values used in the CBA and the allocation of benefits to stakeholder groups should be tested for this location and these assets through specialised surveys of users (such as contingent valuation or choice modelling surveys) and analysis of asset use.
3. The funding approach in the BDA is consulted upon with stakeholders
4. The CBA and BDA should be revised and expanded to reflect updated costings, improved knowledge of risks (e.g., Probabilistic approach to identifying hazard lines and impacts) and the full range of benefits

4 NEXT STEPS

The next stage for the project is to incorporate the findings of the CBA and BDA into the implementation recommendations for each MU. This work will be presented in the Stage H Implementation Chapter Report.

APPENDIX A
BENEFIT DISTRIBUTION ANALYSIS - DRAFT REPORT (7/2/2023) – MARSDEN JACOBS AND ASSOCIATES

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Appendix G

Capel to Leschenault CHRMAP

Chapter Report: Implementation

Peron Naturaliste Partnership

21 March 2023

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1 INTRODUCTION

The global mean sea level is rising since the nineteenth century and is projected to rise faster in the future (IPCC 2021). Rising sea levels and intensifying storm activity increase the risk of coastal inundation (such as permanent and temporary coastal flooding) and coastal erosion (such as storm beach erosion, long-term shoreline recession, etc.).

To manage these hazards, State governments across Australia have introduced obligations that require local governments to consider and plan for these hazards. Specifically, in Western Australia (WA), the governing policy is the Western Australian Planning Commission's (WAPC) "State Planning Policy No. 2.6: State Coastal Planning Policy" (WAPC, 2013, abbreviated to "SPP2.6"). SPP2.6 recommends that management authorities develop a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for land use or development potentially vulnerable to coastal hazards. Technical Guidelines have been developed to assist in the CHRMAP process (WAPC, 2019).

The SPP2.6 requires risk management planning for existing or proposed development located in an area at risk of coastal hazards over a 100-year planning timeframe. SPP2.6 and the CHRMAP Guidelines provide a risk assessment framework to identify risks that are intolerable to the community and other stakeholders, including local governments, indigenous and cultural interests, and private enterprises. Risk management measures are then proposed and compared, following the SPP2.6 adaptation hierarchy. The CHRMAP aims to increase knowledge and understanding of coastal hazard risks and to identify risk management and adaptation measures for implementation. The outcomes of the CHRMAP can inform local and state government policies, strategies and plans, including (but not limited to), planning strategies, community strategic plans, drainage strategies, asset management plans, emergency management plans, and foreshore management plans. Risk management measures are then developed according to the adaptation hierarchy outlined in SPP2.6.

This project is guided by the CHRMAP Guidelines (WAPC, 2019) with the study scope and deliverables consistent with the objectives identified by these guidelines and the SPP2.6. In addition, the project aims to recommend strategic directions for coastal adaptation scenarios up to 2120 and to propose an implementation plan to achieve coastal adaptation. This CHRMAP project aims to increase knowledge and understanding of coastal hazard risks and identify risk management and adaptation measures for implementation. The commonly adopted coastal risk management hierarchy includes the principles of *Avoid, Retreat, Accommodate,* and *Protect*, as shown in **Error! Reference source not found.**.

> *"Avoiding the placement of sensitive development within areas that are at risk from coastal hazards provides the most resilience to future coastal hazards. Conversely, using protection structures to allow sensitive development within areas that would otherwise be at risk from coastal hazards provides the least resilience to future coastal hazards."*
>
> *WAPC 2019, Coastal hazard risk management and adaptation guidelines – Section 5.1, page 29.*

Avoiding risk exposure and retreating from areas exposed to risk are the preferred course of action in the hierarchy, but either response will be challenging to communicate and complex to implement. This is because there is an historical notion that all land currently developed is suitable for development *ad infinitum*; purchase and improvement of land follows by both the private sector and public agencies (including the development of essential services infrastructure). The fact that this may not hold true over long time periods is unlikely to be factored in to ownership and development of land, and the financial and social constraints of acting can be significant.

Retreat can be further complicated by the absence of suitable land to retreat to, or the cost of developing such land. As such, policy amendments in local planning provisions to enable this is required. To implement this in Capel, Leschenault and Greater Bunbury, a review of state and local planning provisions and recommendations for how these can be updated to further consider and respond to coastal risk is provided.

The outcomes will be used to inform local and state government policies, strategies and plans, including (but not limited to), planning strategies, community strategic plans, drainage strategies, asset management plans, emergency management plans, and foreshore management plans, in accordance with WAPC guidelines.

The project will adhere to the WAPC (2019) guidelines with scope and deliverables to be consistent with the objectives identified by these guidelines and SPP2.6. In addition, the project will identify the strategic direction for coastal adaptation scenarios from the present-day to 2120 (100 years management timeframe) and this implementation plan is the blueprint to achieve this direction. Overall, this CHRMAP will develop a flexible adaptation pathway for the region and serve as a key reference for management, planning and policy-making for the short-term (0-15 years), medium-term (15-30 years), and long-term (100 years).

Delivery of this project will occur over 9 stages (as summarised in Figure 1-2), each of which represents a key hold point. The staged approached is developed according to the PNP's scope and is in line with the CHRMAP Guidelines (WAPC, 2019).

This report presents the Stage H Implementation Chapter Report, which outlines planning and the coastal management actions (i.e. Options) recommended to address erosion and inundation vulnerabilities. The red bubble displayed in Figure 1-2 outlines Stage H in the context of the full CHRMAP methodology.

The specific localities, study area extent and management units used in the study underpinning this implementation report is shown in Figure 1-3.

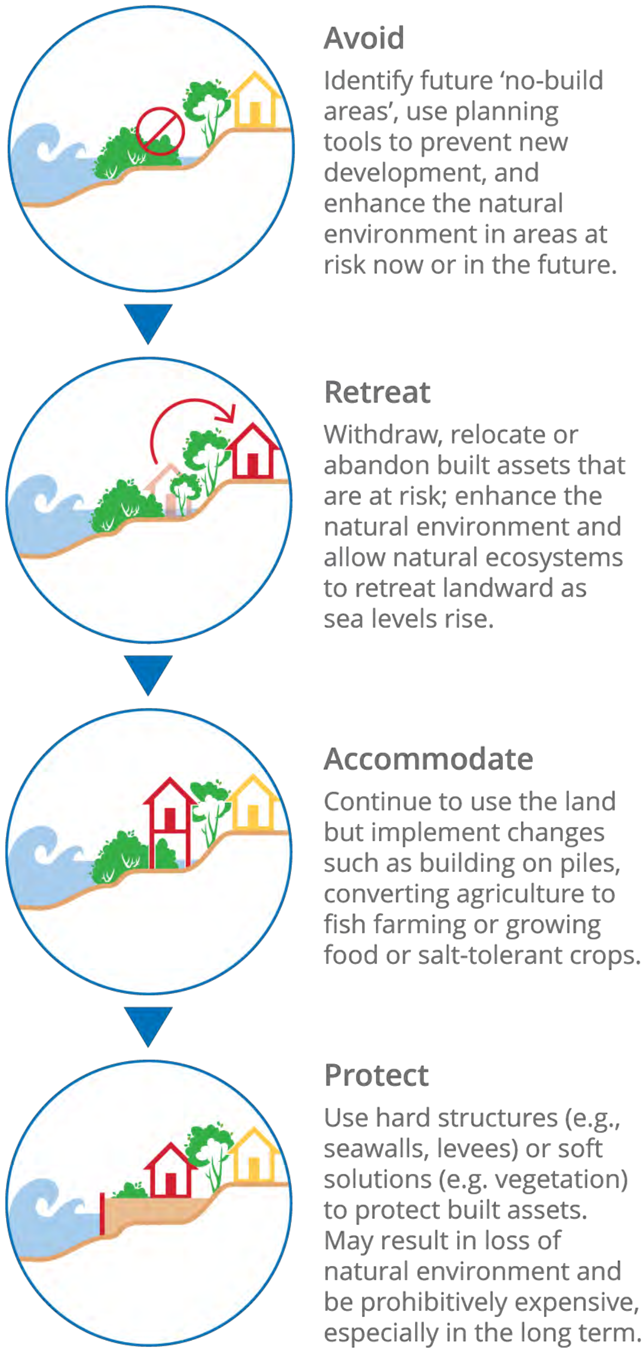

Figure 1-1 Risk management and adaptation hierarchy, as depicted in the WAPC Coastal hazard risk management and adaptation planning guidelines (2019)

COMMUNICATION AND CONSULTATION: PNP, STAKEHOLDERS, COMMUNITY WORKSHOPS & SURVEY

PROGRESS MEETINGS, MONITORING AND REVIEW

ESTABLISHING THE CONTEXT: STAGE A

Project Inception Meeting
- Finalise project scope, methods, deliverables, timing, data gap actions and identify key stakeholders

Stakeholder and Community Engagement Plan
- Definition of plan objectives and timelines
- Obtain inputs from key stakeholders
- Identify requirements of internal engagement and requirement of information such as existing controls, values and success criteria

Establish Context: Delineation of study area management units, desktop review of coastal hazards for gap analysis & study approach

COASTAL HAZARD ASSESSMENT AND ASSETS / VALUES IDENTIFICATION: STAGES B & C

Coastal Hazard Assessment – to understand coastal processes & hazards & identify areas at risk
- TBC: Site Investigation (as required)
  - To gain greater understanding of coastal processes and issues identified during Establishing the Context.
  - Collection of georeferenced photographs and notes for future reference.
- Coastal Hazard Assessment
  - Inundation Hazards
  - Erosion Hazards
- Coastal Hazard Mapping
  - Mapping of all coastal inundation and erosion scenarios at appropriate scale.

Identification of Coastal Assets and Values
- Community Engagement and survey to identify key coastal assets and values
- Coastal asset Information provided by the PNP or from other organisations
- Incorporation of site inspection outcomes (if conducted)

ENGAGEMENT
- Survey of coastal assets & values
- Community live-online workshop

RISK IDENTIFICATION AND ANALYSIS: STAGES D & E

Risk Identification
- Recognising the results of previous analysis and community survey.
- Asset review, primary risk identification, grouping of assets based on their similar values and management requirements
- Mapping of community values at risk

Vulnerability Analysis
- Prepare Likelihood and Consequence Scales
- Develop Level of Risk Matrix and Risk Tolerance Scale, Adaptive Capacity and Asset
- Risk Assessment of each vulnerable asset: likelihood, consequence, vulnerability & risk rating for each scenario

ADAPTATION PLANNING: STAGES F, G & H

Risk Evaluation & Treatment
- **Identify existing controls and mitigation measures: physical & planning schemes to mitigate the above risks**
- **Priorities for Risk Treatment**
- **Update risks accordingly; identify prioritised risk action list based on Success Criteria & existing controls**
- **Identify Risk Treatment Options**
- **Multi-Criteria Analysis (MCA).**

ENGAGEMENT
- Briefing Session: Discussion of risk assessment assumptions and outcomes, primary risks and risk treatment options
- Adaptation Options survey

Risk Treatment
- Cost Benefit Analysis (CBA).
- Benefit Distribution Analysis (BDA)
- Adaptation Options and Pathways including identifying triggers and planning horizons

Implementation Plan
- Identify long-term pathways, considering trigger points and previous assessments
- Produce a short-term implementation plan to produce a clear action plan to 2035
- Land use planning instruments considered: proposed wording & implementation; decision making processes
- Funding Options

Monitoring and Review - Produce a monitoring plan, detailing any monitoring or review that may be required

Final CHRMAP and Interim Deliverables: STAGE I
- Draft Regional CHRMAP and specific adaptation plans.
- Finalisation of CHRMAPs
- Monitoring, Reporting, and Improvement Tool / Plan.

ENGAGEMENT
- Public advertisement of Final Draft CHRMAP
- Council presentations

Figure 1-2 Methodology

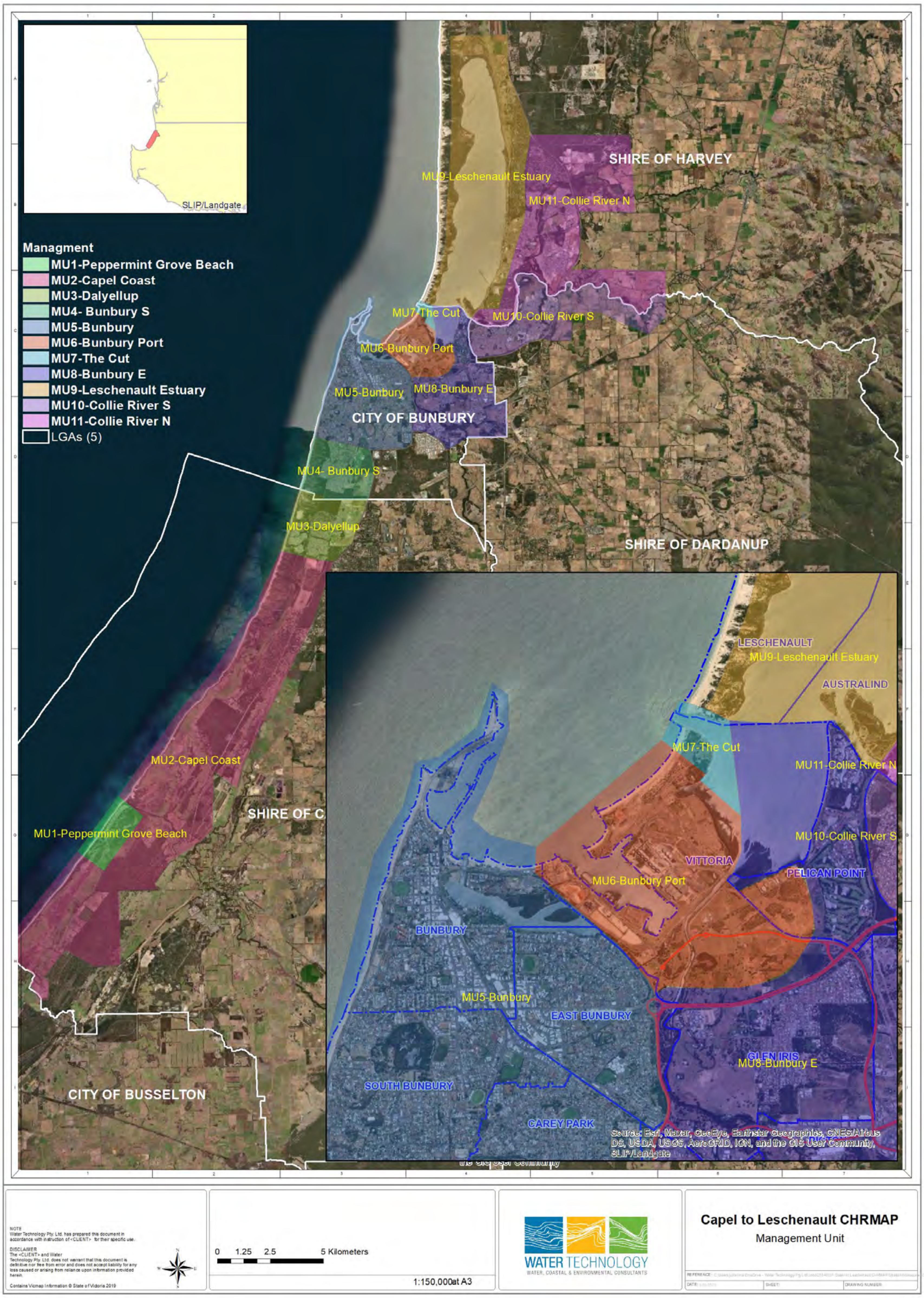

Figure 1-3 Study Area and Management Unit

2 LAND USE PLANNING INSTRUMENTS

Land use planning has an important role to play in increasing the resilience of coastal areas to sea level rise, storm-tide inundation, and erosion, as they govern how coastal areas are developed and managed.

There is a direct relationship between coastal hazard exposure and development. How buildings and assets are designed and located determines their exposure, ultimately impacting risk to people and property.

Therefore, the policy instruments that govern development is an important tool to use in reducing risk exposure. The following sections detail the relevant state and local measures that can be used to increase coastal resilience. In this section, the following land use planning instruments are described:

- Inclusion of coastal hazard exposure to be considered in **structure planning**
- Establishment of **Special Control Area**/s as an overlay to further regulate development in high exposure areas
- Inclusion of coastal hazard information for buyers through **Notifications on Titles** to increase awareness of hazard exposure and risk
- Establishment of a program for **Compulsory Acquisition** of land where coastal hazard risk is deemed intolerable for habitation
- **Reservation of Land** to prevent intensification or inappropriate land use in areas exposed to coastal hazard
- **Other instruments** such as leaseback arrangements and land swaps, which are presently conceptual however may become feasible as further investigation is completed over time.

2.1 General Land Use Planning Instruments

Western Australia has a well-established approach to coastal hazard planning via SPP 2.6 and CHRMAP Guideline, which refer to several planning instruments that can manage coastal hazards, as follows:

2.1.1 Reservation of Land

Land can be reserved for 'Foreshore'. This is particularly the case for public assets, where such a reservation would give rise to improved asset management and planning of the foreshore, including information about when and how to relocate public assets such as public amenities, seating, shelter, playground etc when they reach end of life.

Reservation of land is suitable across the CHRMAP area.

NB: It is noted that a Foreshore Reservation is not currently included in the Planning and Development (Local Planning Schemes) Regulations 2015 *(Model Scheme Text), however, is currently being contemplated as part of the State's Planning Reform agenda to support this specific circumstance. The current process for gazetting a scheme has given rise to many varied reserves since the 2015 gazettal of that document, including several similar foreshore reserves.*

2.1.2 Local Planning Scheme Amendments

2.1.2.1 Special Control Area

What is a SCA?

A Local Government Authority (LGA) may declare a Special Control Area (SCA) over areas that are regarded as significant and where special provisions may need to apply.

To enable targeted planning measures to be applied to locations with the highest coastal hazard exposure, a local planning scheme (LPS) amendment can be progressed. This should be informed by SPP 2.6, to classify vulnerable areas as a Special Control Area (SCA).

An SCA overlay typically includes a mapped area that special development conditions apply to. The requirements of a SCA apply in addition to the underlying planning controls dictated by the planning scheme and state framework, such as zoning, building requirements and matters of significance.

Why implement a SCA?

A coastal hazard SCA could be designed to address erosion or inundation separately or relate to combined coastal hazard risk. The effect of the SCA includes further development regulation to manage hazard exposure, which should be assessed on a case-by-case basis to control over the intensification of land where coastal risks are prominent. For example, a development that might otherwise be exempt from development approval would require a planning approval in addition to a building approval.

This may also include referencing a local planning policy to describe assessment procedures and development standards on land prone to coastal hazard, to provide government specific mechanisms for managing coastal risk in areas where it is most relevant.

Where would a coastal hazard SCA apply?

An SCA can facilitate land use changes and development control within that area. The SCA can be determined by the position of either the 2120 coastal processes setback line, or the inundation extent of the 500-year ARI event in the year 2120, whichever is the more landward.

An SCA should be applied to relate specifically to land subject to coastal processes (as recommended in WAPC, 2019). The SCA is allocated a number and depicted on the Scheme Map (as an overlay map).

> A Special Control Area is suitable across the CHRMAP area. There may be some merit in consolidating the existing CSA for Flood Prone Areas in to the SCA for Coastal Hazard Planning. This will need to be investigated as the Flood Prone Areas SCA also sits within the Greater Bunbury Region Scheme.

2.1.2.2 Local Planning Policy (LPP)

LPPs are prepared and adopted according to the provisions in Part 2 Division 2 of the Deemed Provisions of the relevant local planning scheme. An LPP can be prepared in respect of any matter related to the planning and development of the Scheme area. The LPP may apply to a particular class or classes of matter specified in the policy and may apply to the whole of the Scheme area or to parts specified in the policy.

An LPP can provide more detail and guidance on what sort of development would be acceptable and will also assist the LGA in making planning decisions on coastal development requiring the exercise of discretion (e.g., it might specify appropriate design responses for individual development proposals; relocatable dwellings; prescribed setbacks; finished floor levels). The policy would further identify the Council's intention to require notifications on title as a condition of development approval.

> A Local Planning Policy responsive to coastal hazard management is suitable across the CHRMAP area.

2.1.3 Notifications on Titles

Supported by a suitable SCA, there is an opportunity to require the provision of a Section 70A Notification on the Title of land as a condition of any planning approval to alert prospective purchasers of the potential coastal hazard impacts on the lot, as required by SPP2.6. These Notifications can only be applied where triggered by a Subdivision or Development Application. These can either be general alerts or more specific time-limited approvals (e.g., where the temporary use of land in hazard areas is allowed, where appropriate, until hazards materialise, while ensuring that the LGA maintains discretion over development in these areas).

The proponent may apply for an extension to the approval if the approval expires before hazards occur, whilst the LGA would be in a position to require demolition or removal of compromised structures if hazards occur ahead of the Notification timeframe. This option potentially supports landowners with larger risk appetites but may also be a source of future opportunities for conflicts, which will need ongoing management (funding, monitoring, reporting, etc.).

A Notice of Title planning instrument is suitable across the CHRMAP area and there may need to be some alignment with existing Notifications linked to the flood prone nature of some areas.

2.1.4 Compulsory Acquisition

Compulsory acquisition is an option where no other planning instrument has been able to suitably set aside land for coastal hazard processes, when hazards have advanced to a stage where land exceeds tolerable risk thresholds. This would require the reservation of land for public purposes via a scheme amendment. Options include:

- Purchase of the land by the LGA if the owner is willing to sell it by ordinary sale under Section 190 of the Planning and Development Act (2005) (PD Act)
- Compulsory taking by the LGA without agreement under Section 191 of the PD Act coupled with the Land Administration Act (1997).

If the land remains zoned (within an SCA overlay) then the above options are not available. This instrument should be carefully considered in relation to any protective structures being proposed.

2.1.5 Other Instruments

Innovative planning instruments, such as ‘leaseback of land’ and ‘land swaps’ may be considered. While there is growing interest in these and much work interstate on these matters, these instruments have not been tested in the WA planning context and are not explicitly provided for or anticipated under the State’s current planning framework. However, some research into these treatments may be suitable and palatable for the community for locations where “coastal retreat” is possible to adjacent location (for the purpose of settlement relocation). In such a scenario, the nature of compensation may be limited to depreciating assets rather than the combination of land and structures.

Considerations of other instruments should be informed by research, implementation case studies from other locations, suitability to the local context, and receptiveness of decision-makers and the community.

2.1.6 Structure Planning

Structure Plans are prepared and approved prior to the subdivision or development of land in development areas identified within the Local Council Planning Scheme, or where required by WAPC.

In areas where further development or redevelopment of land is possible or anticipated, structure plans should incorporate the requirements of the CHRMAP, ensuring an appropriate coastal foreshore reserve is included, siting development outside of the hazard zone, particularly residential development, and avoiding or suitably filling low-lying areas to circumvent inundation impacts. This is important so as not to increase the number of buildings and assets that are exposed to coastal hazards, so resources can be focused on managing the residual risk existing development is exposed to.

2.2 LGA Specific Land Use Planning Instruments

2.2.1 Shire of Capel

There is urgent need to establish a response to coastal hazards within the Shire's planning legislative framework.

The Shire of Capel has previously contemplated coastal planning and foreshore management principles in the Coastal Strategy 2005, Local Planning Strategy 2021, Local Planning Scheme No. 7 and the Peppermint Grove Land Use Strategy 2013. Many of the general recommendations remain relevant and are typical management actions (as opposed to planning recommendations). Some require minor amendment or review to improve clarity and strength, and these are noted in this implementation report. In addition, there is an urgent need to establish a response to coastal hazards within the Shire's town planning legislative framework.

Structure Planning may be effective in the coastal zone where some property development is considered adjacent Peppermint Grove Beach (MU1), Dalyellup (MU3), or in future development opportunities along the Capel River, and in the low-lying area east of Peppermint Grove Beach (MU1 and MU2).

Recommended land use planning instruments are detailed in Table 2-1.

Table 2-1 Land use planning recommendations for the Shire of Capel

Action	Description	Timing	Cost
LU1	The Shire shall prepare an amendment to the Local Planning Scheme No. 8 to include provisions relating to the coastal erosion and inundation hazard zones to 2120 as identified in this study. The amendment shall be inserted at Schedule 6 – Special Control Areas, and a new line shall be added to the table to insert SCA9 – Coastal Hazard Risk Area. SCA9 shall read as per Table 2-2.	Immediate	N/A
LU2	The Shire shall prepare an amendment to the Local Planning Scheme No. 8 to include a Foreshore Reserve encompassing all public land under the control of the Shire (excluding public roads) within the coastal erosion and inundation hazard zones to 2120 as identified in this study.	Aligned with LU1	N/A

Action	Description	Timing	Cost
	The amendment shall be inserted at Part 2 – Reserves Land, Clause 14 – Local Reserves (in Table 1). A new Reserve name shall be included and shall read: 'Foreshore' The Foreshore Reserve should include the following objectives: ▪ set aside areas for foreshore reserved abutting a body of water or water course ▪ provide for the protection of natural values and processes, including a coastal retreat ▪ to accommodate a range of active and passive recreational uses that would be capable of relocation or rehabilitation		
LU3	The Shire should prepare a Local Planning Policy (LPP) to be linked to the SCA under Local Planning Scheme No. 8 and provide guidance for applicants and decision-makers in relation to assessment procedures and development standards on land prone to coastal hazards, which may include recommended finished floor levels where impacted by inundation or siting of development to the least vulnerable portion of a lot for both erosion and inundation where possible. The LPP may also specify appropriate design responses for individual development proposals e.g., relocatable dwellings, prescribed setbacks and revegetation responses.	Aligned with LU1	$15,000
LU4	In areas where further development or redevelopment of land is possible or anticipated, structure plans should incorporate the requirements of the CHRMAP, ensuring an appropriate coastal foreshore reserve is included and that any low-lying areas are adequately avoided or suitably filled to avoid inundation impacts. Existing and proposed structure plans should be reviewed to adhere to SPP2.6 and account for the risks identified in the CHRMAP	At application	N/A
LU5	The Shire shall notify all landholders that may be affected by coastal hazards by 2120 directly. Supported by a suitable SCA, there is an opportunity to require the provision of a Section 70A notification on the Title of land as a condition of any planning approval to alert prospective purchasers of the potential coastal hazard impacts on the lot, as required by SPP2.6. These notifications can only be applied where triggered by a Subdivision or Development Application. These can either be general alerts or more specific time limited approvals (e.g., where the temporary use of land in hazard areas is allowed, where appropriate, until hazards materialise, while ensuring that the Shire maintains discretion over development in these areas). The proponent may apply for an extension to the approval if the approval expires before hazards occur, whilst the Shire would be in a position to require demolition or removal of compromised structures if hazards occur ahead of predicted timeframe. This option potentially supports	Immediate	No cost to the Shire. The cost is borne by Landowners / land managers

Action	Description	Timing	Cost
	landowners with larger risk appetites. The LPP should include details of this potential framework.		
LU6	The Shire should review existing leasehold facilities located within the hazard zone and notify the lessee of the CHRMAP. Leases should be reviewed at renewal timeframes to determine the suitability and/or length of future leases. The Foreshore Reservation in LU7 below establishes the zone of interest.	Immediate	N/A

Table 2-2 Content for Shire of Capel local planning scheme amendment appendix in accordance with LU1.

Item	Recommended Text
Name of Area	SCA 9 – Coastal Hazard Risk Area
Purpose	To identify areas subject to coastal erosion and inundation on the Scheme Map as a Special Control area and provide measures to ensure that land use and development within its boundaries are regulated and managed
Objectives	▪ To ensure land in the coastal zone is continuously provided for coastal foreshore management, public access, recreation and conservation. ▪ To ensure public safety and reduce risk associated with coastal erosion and inundation. ▪ To avoid inappropriate land use and development of land at risk from coastal erosion and inundation. ▪ To ensure land use and development does not accelerate coastal erosion or inundation risks; or have a detrimental impact on the functions of public reserves. ▪ To ensure that development addresses the Capel to Leschenault Coastal Hazard Risk Management and Adaptation Plan 2023 prepared in accordance with State Planning Policy No. 2.6 State Coastal Planning Policy (as amended) and any relevant local planning policy.
Additional Provisions	1. All proposed development within the SCA requires approval 2. In considering proposed structure plans, subdivision or development applications due regard shall be given to – a) the Capel to Leschenault Coastal Hazard Risk Management and Adaptation Plan 2023. b) State Planning Policy 2.6 -State Coastal Planning Policy; and c) Relevant local planning policies. 3. Where subdivision or development applications are received within SCA 9, the local government shall require a notification pursuant to section 70A of the Transfer of Land Act 1983 to be placed on the Certificate(s) of Title of the subject land, at the cost of the landowner and to the satisfaction of the local government. The notification is to read as follows for land within the coastal hazard area at 2050: *"Vulnerable Coastal Area – This lot is located in an area likely to be subject to coastal erosion and/or inundation over the next 100 years and is subject to conditions of development approval which require removal and/or rehabilitation of development to pre-development conditions if any one of the following events occurs:* *a) the most landward part of the Horizontal Shoreline Datum being within [insert here the distance equivalent of the S1 Erosion Allowance (allowance for the current risk of erosion) for the subject lot as per the Shire of Capel Coastal Hazard Risk Management Adaptation Plan as amended from time to time] metres of the most seaward part of the lot boundary.*

Item	Recommended Text
	b) a public road no longer being available or able to provide legal access to the property. *c) when water, sewerage or electricity to the lot is no longer available as they have been removed/decommissioned by the relevant authority due to coastal hazards."* The notification is to read as follows for land within the coastal hazard area from 2051 - 2120: *"Vulnerable Coastal Area – This lot is located in an area likely to be subject to coastal erosion and/or inundation over the next 100 years"* 4. Notwithstanding the provisions of above (1), (2) and (3) development approval is not required within SCA 9 for the following development if such development is otherwise exempt from requiring development approval under the Scheme: a) buildings or structures not used for human habitation. b) extensions to an existing single, grouped or multiple dwelling where the net floor area of the proposed extensions is no more than 50m2; and c) a change of use where no works are proposed.
Advice Notes	On the occasion of any development approval pursuant to the Additional Provisions of SCA 9, the following "Advice Notes" indicate suitable and tested advice to be provided to applicants: ▪ The development subject of this approval may be impacted by coastal hazards in the short to medium term (likely by 2050). Should the development be affected by coastal hazards in the future as predicted, the development and any associated works are likely to require partial or complete relocation. The local government is under no obligation to assist or protect structures from coastal erosion/inundation threats and accepts no liability and will pay no costs associated with relocation or any protection from or damages caused by coastal processes. ▪ The applicant is advised that the Horizontal Shoreline Datum means the active limit of the shoreline under storm activity, as defined in State Planning Policy 2.6 – State Coastal Planning Policy. ▪ The applicant is advised that the [insert here *the distance equivalent of the S1 Erosion Allowance (allowance for the current risk of erosion) for the subject lot as per the Shire of Capel Coastal Hazard Risk Management Adaptation Plan as amended from time to time*] metre distance between the Horizontal Shoreline Datum and the most seaward part of the lot boundary is the S1 value for this location which is obtained from the Capel to Leschenault Coastal Hazard Risk Management Adaptation Plan 2023. S1 is the allowance for absorbing the current risk of storm erosion, as defined in State Planning Policy 2.6 – State Coastal Planning Policy (2013). ▪ Should the development be affected by Coastal Hazards in the future the landowner will be responsible for relocating/removing the development and all costs associated. The local government is under no obligation to assist or protect structures from coastal erosion/inundation threats and accepts no liability and will pay no costs associated with any protection from or damages caused by coastal processes. ▪ In relation to condition [x insert here], upon removal of the development the site is to be rehabilitated to pre-development condition which comprises of a bare earth lot, free of any buildings, demolition rubble or remnants of the approved development.

2.2.2 City of Bunbury

The City and its partners have acknowledged coastal based hazard for many decades since the flooding experienced from Cyclone Alby in 1978. Planning conditions have been used to support an 'accommodate' option in the suburb of East Bunbury since that time, with flood-prone land noted via planning instruments in the Greater Bunbury Region Scheme and the City's Local Planning Scheme No. 8. A recent CHRMAP has also been prepared for Koombana Bay. The Koombana Bay, Casuarina Drive and Leschenault Inlet Master Plans refer to flooding and coastal vulnerability, as well as the importance of the waterfront environment.

There is urgent need to establish a response to coastal hazards within the City's planning legislative framework.

However, few provisions exist within the City's planning instruments to directly respond to the broader coastal hazard challenge and there is an urgent need to establish a response within the town planning legislative framework to best manage the challenge and make the associated risks more apparent / visible.

Structure Planning may be effective in the coastal zone where some property development or redevelopment may be considered in low lying areas along the Leschenault Inlet and Koombana Bay (MU5), however, the whole of the City is generally built out and unlikely to experience this pathway.

Recommended land use planning instruments are detailed in Table 2-3.

Table 2-3 Land use planning recommendations for the City of Bunbury

Action	Description	Timing	Cost
LU1	The City shall prepare an amendment to the Local Planning Scheme No. 8 to include provisions relating to the coastal erosion and inundation hazard zones to 2120 as identified in this study. The amendment shall be inserted Schedule 7 and shall read: *Coastal Hazard Risk Area Special Control Area* and include the information provided in Table 2-4.	Immediate	$5,000
LU2	The City shall prepare an amendment to the Local Planning Scheme No. 8 to include a Foreshore Reserve encompassing all public land within the coastal erosion and inundation hazard zones to 2120 as identified in this study. The amendment shall be inserted at Part II – Reserves, Clause 14 (3). A new Reserve name shall be included and shall read: 'Foreshore' The Objectives of the reserve shall read: ▪ set aside areas for foreshore reserved abutting a body of water or water course ▪ provide for the protection of natural values and processes, including a coastal retreat ▪ to accommodate a range of active and passive recreational uses that would be capable of relocation or rehabilitation	Aligned with LU1	$5,000
LU3	The City should prepare a Local Planning Policy (LPP) to be linked to the SCA under Local Planning Scheme No. 8 and provide guidance for applicants and decision-makers in relation to assessment procedures and development standards on land prone to coastal hazards, which may include recommended finished floor levels where impacted by inundation or siting of development to the least vulnerable portion of a lot for both erosion and inundation where possible. The LPP may also	Aligned with LU1	$25,000

Action	Description	Timing	Cost
	specify appropriate design responses for individual development proposals e.g., relocatable dwellings, prescribed setbacks and revegetation responses. The preparation of the LPP should also comprise a review of design guidelines which are located within the same zone, such as the Grand Canals Design Guidelines, to ensure there is no misinterpretation of the role and power of each document. Consolidation is recommended where it can be achieved.		
LU4	In areas where further development or redevelopment of land is possible or anticipated, structure plans should incorporate the requirements of the CHRMAP, ensuring an appropriate coastal foreshore reserve is included and that any low-lying areas are adequately avoided or suitably filled to avoid inundation impacts. Existing and proposed structure plans should be reviewed to ensure they adhere to SPP2.6 and account for the risks identified in the CHRMAP.	At application	N/A
LU5	The City shall notify all landholders that may be affected by coastal hazards by 2120 directly. Supported by a suitable SCA, there is an opportunity to require the provision of a Section 70A notification on the Title of land as a condition of any planning approval to alert prospective purchasers of the potential coastal hazard impacts on the lot, as required by SPP2.6. These notifications can only be applied where triggered by a Subdivision or Development Application. These can either be general alerts or more specific time limited approvals (e.g., where the temporary use of land in hazard areas is allowed, where appropriate, until hazards materialise, while ensuring that the City maintains discretion over development in these areas). The proponent may apply for an extension to the approval if the approval expires before hazards occur, whilst the Shire would be in a position to require demolition or removal of compromised structures if hazards occur ahead of predicted timeframe. This option potentially supports landowners with larger risk appetites. The LPP should include details of this potential framework.	Immediate	N/A
LU6	The City should review existing leasehold facilities located within the hazard zone and notify the lessee of the CHRMAP. Leases should be reviewed at renewal timeframes to determine the suitability and/or length of future leases. The Foreshore Reservation in LU2 establishes the zone of interest.	Immediate	N/A

Table 2-4 Content for City of Bunbury local planning scheme amendment appendix in accordance with LU1.

Item	Recommended Text
Name of Area	Coastal Hazard Risk Area Special Control Area
Purpose	To provide guidance for land use and development within areas subject to coastal erosion and inundation
Objectives	▪ To ensure land in the coastal zone is continuously provided for coastal foreshore management, public access, recreation and conservation. ▪ To ensure public safety and reduce risk associated with coastal erosion and inundation.

Item	Recommended Text
	▪ To avoid inappropriate land use and development of land at risk from coastal erosion and inundation. ▪ To ensure land use and development does not accelerate coastal erosion or inundation risks; or have a detrimental impact on the functions of public reserves. ▪ To ensure that development addresses the Capel to Leschenault Coastal Hazard Risk Management and Adaptation Plan 2023 prepared in accordance with State Planning Policy No. 2.6 State Coastal Planning Policy (as amended) and any relevant local planning policy.
Additional Provisions	1. All proposed development within the SCA requires approval 2. In considering proposed structure plans, subdivision or development applications due regard shall be given to – a) the Capel to Leschenault Coastal Hazard Risk Management and Adaptation Plan 2023. b) State Planning Policy 2.6 - State Coastal Planning Policy; and c) Relevant local planning policies. 3. Where subdivision or development applications are received within SCA1, the local government shall require a notification pursuant to section 70A of the Transfer of Land Act 1983 to be placed on the Certificate(s) of Title of the subject land, at the cost of the landowner and to the satisfaction of the local government. The notification is to read as follows: *"Vulnerable Coastal Area – This lot is located in an area likely to be subject to coastal erosion and/or inundation over the next 100 years"* 4. Notwithstanding the provisions of above (1), (2) and (3) development approval is not required within SCA1 for the following development if such development is otherwise exempt from requiring development approval under the Scheme: a) temporary or non-permanent structures not used for human habitation. b) extensions to an existing single, grouped or multiple dwelling where the net floor area of the proposed extensions is no more than 50m2; and c) a change of use where no new structures are proposed.
Advice Notes	On the occasion of any development approval pursuant to the Additional Provisions of SCA 1, the following "Advice Notes" indicate suitable and tested advice to be provided to applicants: ▪ The development subject of this approval may be impacted by coastal hazards in the short to medium term (likely by 2050). Should the development be affected by coastal hazards in the future as predicted, the development and any associated works are likely to require partial or complete relocation. The local government is under no obligation to assist or protect structures from coastal erosion/inundation threats and accepts no liability and will pay no costs associated with relocation or any protection from or damages caused by coastal processes. ▪ The applicant is advised that the Horizontal Shoreline Datum means the active limit of the shoreline under storm activity, as defined in State Planning Policy 2.6 – State Coastal Planning Policy (2013). ▪ The applicant is advised that the [x insert here] metre distance between the Horizontal Shoreline Datum and the most seaward part of the lot boundary is the S1 value for this location which is obtained from the Capel to Leschenault Coastal Hazard Risk Management Adaptation Plan 2023. S1 is the allowance for absorbing the current risk

Item	Recommended Text
	of storm erosion, as defined in State Planning Policy 2.6 – State Coastal Planning Policy (2013). ▪ Should the development be affected by Coastal Hazards in the future the applicant will be responsible for relocating/removing the development and all costs associated. The local government is under no obligation to assist or protect structures from coastal erosion/inundation threats and accepts no liability and will pay no costs associated with any protection from or damages caused by coastal processes. ▪ In relation to condition [x insert here], upon removal of the development the site is to be rehabilitated to pre-development condition which comprises of a bare earth lot, free of any buildings, demolition rubble or remnants of the approved development.

2.2.3 Shire of Harvey

The Shire has previously contemplated coastal planning and foreshore management principles in its Local Planning Strategy, it's District Planning Scheme No. 1 and it's Shire of Harvey Coastal CHRMAP which deals with the open coastline area of the Shire (excluded from this study). In addition, a number of conditions limit development close to waterbodies for reasons of visual landscape amenity and to respond to known flooding issues which are also recognised in the Greater Bunbury Region Scheme.

There remains a need to establish a response to coastal hazards within the Shire's town planning legislative framework.

There remains a need to establish a response to coastal hazards within the Shire's town planning legislative framework, which is clear and reflects the outcomes of this CHRMAP and also comprises the recommendations of the Shire of Harvey Coastal CHRMAP.

Structure Planning may be effective in the coastal zone where some property development or redevelopment may be considered adjacent the Leschenault Estuary foreshore (Cathedral Avenue) and adjacent the Collie River (MU9 and MU11).

Recommended land use planning instruments are detailed in Table 2-5.

Table 2-5 Land use planning recommendations for the Shire of Harvey

Action	Description	Timing	Cost
LU1	The Shire shall prepare an amendment to the District Planning Scheme No. 1 to include provisions relating to the coastal erosion and inundation hazard zones to 2120 as identified in this study and in the Shire of Harvey Coastal CHRMAP. The amendment shall insert a new Clause at *Part VIII – General Development Requirements, Clause 8.14* and shall read: *8.14 Coastal Hazard Risk Area Special Control Area* *a) Coastal Hazard Risk Area (Special Control Area) shown on the Scheme Map as SCA with a [insert colour here] border and a number and included in Appendix 16 – Special Control Areas.* The amendment shall also include insertion of Appendix 16 – Special Control Areas and include the information provided in Table 2-6.	Immediate	$15,000
LU2	The Shire shall prepare an amendment to the District Planning Scheme No. 1 to include a Foreshore Reserve encompassing all public land within the coastal erosion and inundation hazard zones to 2120 as identified in this study, which is not included in the	Aligned with LU1	$5,000

Action	Description	Timing	Cost
	Regional Open Space Regional Reserve within the Greater Bunbury Region Scheme. No amendment to the existing planning scheme text is required as the document does not reference these specifically, however, a new legend and mapping will be required for the relevant scheme maps.		
LU3	The Shire should prepare a Local Planning Policy (LPP) to be linked to the SCA under District Planning Scheme No. 1 and provide guidance for applicants and decision-makers in relation to assessment procedures and development standards on land prone to coastal hazards, which may include recommended finished floor levels where impacted by inundation or siting of development to the least vulnerable portion of a lot for both erosion and inundation where possible. The LPP may also specify appropriate design responses for individual development proposals e.g., relocatable dwellings, prescribed setbacks and revegetation responses.	Aligned with LU1	$15,000
LU4	In areas where further development or redevelopment of land is possible or anticipated, structure plans should incorporate the requirements of the CHRMAP, ensuring an appropriate coastal foreshore reserve is included and that any low-lying areas are adequately avoided or suitably filled to avoid inundation impacts. Existing and proposed structure plans should be reviewed to ensure they adhere to SPP2.6 and account for the risks identified in the CHRMAP.	At application	N/A
LU5	The Shire shall notify all landholders that may be affected by coastal hazards by 2120 directly. Supported by a suitable SCA, there is an opportunity to require the provision of a Section 70A notification on the Title of land as a condition of any planning approval to alert prospective purchasers of the potential coastal hazard impacts on the lot, as required by SPP2.6. These notifications can only be applied where triggered by a Subdivision or Development Application. These can either be general alerts or more specific time limited approvals (e.g., where the temporary use of land in hazard areas is allowed, where appropriate, until hazards materialise, while ensuring that the City maintains discretion over development in these areas). The proponent may apply for an extension to the approval if the approval expires before hazards occur, whilst the Shire would be in a position to require demolition or removal of compromised structures if hazards occur ahead of predicted timeframe. This option potentially supports landowners with larger risk appetites. The LPP should include details of this potential framework.	Immediate	N/A
LU6	The Shire should review existing leasehold facilities located within the hazard zone and notify the lessee of the CHRMAP. Leases should be reviewed at renewal timeframes to determine the suitability and/or length of future leases. The Foreshore Reservation in LU7 below establishes the zone of interest.	Immediate	N/A
LU7	The Shire should undertake a review of its Local Planning Scheme generally, to provide for the updated Model Provisions	In line with suitable timeframes	TBC (a broader review is

Action	Description	Timing	Cost
	from the Planning and Development (Local Planning Schemes) Regulations 2015. During this review, the Foreshore Reserve noted in LU2 can be introduced in the model format, and should include the following objectives: ▪ set aside areas for foreshore reserved abutting a body of water or water course ▪ provide for the protection of natural values and processes, including a coastal retreat ▪ to accommodate a range of active and passive recreational uses that would be capable of relocation or rehabilitation In this review, a detailed consolidation of Clauses and provisions modelled on the current planning framework can be inserted.	as required by the WAPC and orderly and proper planning	required based on the age of the existing scheme)
LU8	Notwithstanding LU7, if the preparation of scheme amendments noted in LU1 and LU2 precede the scheme review recommended in LU7, the amendment should also comprise a review of other clauses within the existing scheme, to ensure there is no overlay between a number of clauses which would cause confusion or create onerous red tape. This includes consideration of Clause 7.2, 7.3, 8.8, Schedule 3 (3.7 Area 6). Schedule 4 (4.4), Schedule 6 (6.3) and Schedule 15 (Area 1 and Area 6). Consolidation is recommended where it can be achieved	Aligned with LU1	$5,000

Table 2-6 Content for Shire of Harvey local planning scheme amendment appendix in accordance with LU1.

Item	Recommended Text
Name of Area	SCA 1 – Coastal Hazard Risk Area
Purpose	To provide guidance for land use and development within areas subject to coastal erosion and inundation
Objectives	▪ To ensure land in the coastal zone is continuously provided for coastal foreshore management, public access, recreation and conservation. ▪ To ensure public safety and reduce risk associated with coastal erosion and inundation. ▪ To avoid inappropriate land use and development of land at risk from coastal erosion and inundation. ▪ To ensure land use and development does not accelerate coastal erosion or inundation risks; or have a detrimental impact on the functions of public reserves. ▪ To ensure that development addresses the Capel to Leschenault Coastal Hazard Risk Management and Adaptation Plan 2023 prepared in accordance with State Planning Policy No. 2.6 State Coastal Planning Policy (as amended) and any relevant local planning policy.
Additional Provisions	1. All proposed development within the SCA requires approval 2. In considering proposed structure plans, subdivision or development applications due regard shall be given to – a) the Capel to Leschenault Coastal Hazard Risk Management and Adaptation Plan 2023. b) State Planning Policy 2.6 -State Coastal Planning Policy; and

Item	Recommended Text
	b) Relevant local planning policies. 3. Where subdivision or development applications are received within SCA1, the local government shall require a notification pursuant to section 70A of the Transfer of Land Act 1983 to be placed on the Certificate(s) of Title of the subject land, at the cost of the landowner and to the satisfaction of the local government. The notification is to read as follows for land within the coastal hazard area at 2050: *"Vulnerable Coastal Area – This lot is located in an area likely to be subject to coastal erosion and/or inundation over the next 100 years and is subject to conditions of development approval which require removal and/or rehabilitation of development to pre-development conditions if any one of the following events occurs:* *a) the most landward part of the Horizontal Shoreline Datum being within [x insert here] metres of the most seaward part of the lot boundary.* *b) a public road no longer being available or able to provide legal access to the property.* *c) when water, sewerage or electricity to the lot is no longer available as they have been removed/decommissioned by the relevant authority due to coastal hazards."* The notification is to read as follows for land within the coastal hazard area from 2051 - 2120: *"Vulnerable Coastal Area – This lot is located in an area likely to be subject to coastal erosion and/or inundation over the next 100 years"* 4. Notwithstanding the provisions of above (1), (2) and (3) development approval is not required within SCA1 for the following development if such development is otherwise exempt from requiring development approval under the Scheme: a) temporary or non-permanent structures not used for human habitation. b) extensions to an existing single, grouped or multiple dwelling where the net floor area of the proposed extensions is no more than 50m2; and c) a change of use where no new structures are proposed.
Advice Notes	On the occasion of any development approval pursuant to the Additional Provisions of SCA 1, the following "Advice Notes" indicate suitable and tested advice to be provided to applicants: ▪ The development subject of this approval may be impacted by coastal hazards in the short to medium term (likely by 2050). Should the development be affected by coastal hazards in the future as predicted, the development and any associated works are likely to require partial or complete relocation. The local government is under no obligation to assist or protect structures from coastal erosion/inundation threats and accepts no liability and will pay no costs associated with relocation or any protection from or damages caused by coastal processes. ▪ The applicant is advised that the Horizontal Shoreline Datum means the active limit of the shoreline under storm activity, as defined in State Planning Policy 2.6 – State Coastal Planning Policy (2013). ▪ The applicant is advised that the [x insert here] metre distance between the Horizontal Shoreline Datum and the most seaward part of the lot boundary is the S1 value for this location which is obtained from the Capel to Leschenault Coastal Hazard Risk Management Adaptation Plan 2023. S1 is the allowance for absorbing the current risk of storm erosion, as defined in State Planning Policy 2.6 – State Coastal Planning Policy (2013).

Item	Recommended Text
	▪ Should the development be affected by Coastal Hazards in the future the applicant will be responsible for relocating/removing the development and all costs associated. The local government is under no obligation to assist or protect structures from coastal erosion/inundation threats and accepts no liability and will pay no costs associated with any protection from or damages caused by coastal processes. ▪ In relation to condition [x insert here], upon removal of the development the site is to be rehabilitated to pre-development condition which comprises of a bare earth lot, free of any buildings, demolition rubble or remnants of the approved development.

NB: It is noted that the Shire of Harvey Coastal CHRMAP includes a recommendation to increase the regional open space reservation in the Greater Bunbury Region Scheme. This may not be necessary if the Foreshore reservation is included in the scheme amendment or scheme review for areas outside of the Regional Reservation. The Foreshore Reserve will ensure visibility of the foreshore management role of the reserve and not imply a 'recreational' component. Both actions should be considered together.

2.2.4 Shire of Dardanup

The Shire has previously contemplated management principles, with a particular focus on flooding impacts and reliance on the Greater Bunbury Region Scheme Floodplain Management Policy 2017. However, few provisions exist within the Sire's planning instruments to directly respond to the broader coastal hazard challenge and there is a need to establish a response within the town planning legislative framework to best manage the challenge and make the associated risks more apparent / visible.

Structure Planning may be effective in the riverine zone where some property development may be considered adjacent Collie River in Eaton North and along the Eaton foreshore where some large lots remain at Leake Street and closer to the Collie River mouth (MU10).

Coastal hazard management needs to be established in the planning legislative framework and improve the visibility coastal risk exposure.

Recommended land use planning instruments are detailed in Table 2-7.

Table 2-7 Land use planning recommendations for the Shire of Dardanup

Action	Description	Timing	Cost
LU1	The Shire shall prepare an amendment to the Local Planning Scheme No. 3 to include provisions relating to the coastal erosion and inundation hazard zones to 2120 as identified in this study. The amendment shall be inserted at Clause *9.1 Operation of Special Control Areas* of the current scheme. A new Clause 9.1.1 c) shall be inserted and shall read: *c) Coastal Hazard Risk Area (Special Control Area) shown on the Scheme Map as SCA with a [insert colour here] border and a number and included in Appendix XV – Special Control Areas.* The amendment shall also include insertion of Appendix XV – Special Control Areas and include the information provided in Table 2-8.	Immediate	$10,000
LU2	The Shire shall prepare an amendment to the Local Planning Scheme No. 3 to include a Foreshore Reserve encompassing all public land within the coastal erosion and inundation hazard zones	Aligned with LU1	$5,000

Action	Description	Timing	Cost
	to 2120 as identified in this study, which is not included in the Regional Open Space Regional Reserve within the Greater Bunbury Region Scheme. No amendment to the existing planning scheme text is required as the document does not reference these specifically, however, a new legend and mapping will be required for the relevant scheme maps.		
LU3	The Shire should prepare a Local Planning Policy (LPP) to be linked to the SCA under Local Planning Scheme No. 3 and provide guidance for applicants and decision-makers in relation to assessment procedures and development standards on land prone to coastal hazards, which may include recommended finished floor levels where impacted by inundation or siting of development to the least vulnerable portion of a lot for both erosion and inundation where possible. The LPP may also specify appropriate design responses for individual development proposals e.g., relocatable dwellings, prescribed setbacks and revegetation responses.	Aligned with LU1	$15,000
LU4	In areas where further development or redevelopment of land is possible or anticipated, structure plans should incorporate the requirements of the CHRMAP, ensuring an appropriate coastal foreshore reserve is included and that any low-lying areas are adequately avoided or suitably filled to avoid inundation impacts. Existing and proposed structure plans should be reviewed to ensure they adhere to SPP2.6 and account for the risks identified in the CHRMAP.	At application	N/A
LU5	The Shire shall notify all landholders that may be affected by coastal hazards by 2120 directly. Supported by a suitable SCA, there is an opportunity to require the provision of a Section 70A notification on the Title of land as a condition of any planning approval to alert prospective purchasers of the potential coastal hazard impacts on the lot, as required by SPP2.6. These notifications can only be applied where triggered by a Subdivision or Development Application. These can either be general alerts or more specific time limited approvals (e.g., where the temporary use of land in hazard areas is allowed, where appropriate, until hazards materialise, while ensuring that the Shire maintains discretion over development in these areas). The proponent may apply for an extension to the approval if the approval expires before hazards occur, whilst the Shire would be in a position to require demolition or removal of compromised structures if hazards occur ahead of predicted timeframe. This option potentially supports landowners with larger risk appetites. The LPP should include details of this potential framework.	Immediate	N/A
LU6	The Shire should review existing leasehold facilities located within the hazard zone and notify the lessee of the CHRMAP. Leases should be reviewed at renewal timeframes to determine the suitability and/or length of future leases. The Foreshore Reservation in LU7 below establishes the zone of interest.	Immediate	N/A
LU7	The Shire should undertake a review of its Local Planning Scheme generally, to provide for the updated Model Provisions from the Planning and Development (Local Planning Schemes) Regulations 2015.	In line with suitable timeframes as required	TBC (a broader review is required

Action	Description	Timing	Cost
	During this review, the Foreshore Reserve noted in LU2 can be introduced in the model format, and should include the following objectives: ▪ set aside areas for foreshore reserved abutting a body of water or water course ▪ provide for the protection of natural values and processes, including a coastal retreat ▪ to accommodate a range of active and passive recreational uses that would be capable of relocation or rehabilitation In this review, a detailed consolidation of Clauses and provisions modelled on the current planning framework can be inserted.	by the WAPC and orderly and proper planning	based on the age of the existing scheme)
LU8	Notwithstanding LU7, if the preparation of scheme amendments noted in LU1 and LU2 precede the scheme review recommended in LU7, the amendment should also comprise a review of other clauses within the existing scheme, to ensure there is no overlap between a number of clauses which may cause confusion or create onerous red tape. This includes consideration of Part 4 – Miscellaneous; Clause 4.6 Protection of Shores, Colie River Relief Floodway, Clause 4.9, and Floodway considerations in Appendix VIII – Additional Requirements – Small Holdings Zones (Area 9, 10 & 15). Consolidation is recommended where it can be achieved.	Aligned with LU1	$5,000

Table 2-8 Content for Shire of Dardanup local planning scheme amendment appendix in accordance with LU1.

Item	Recommended Text
Name of Area	SCA 1 – Coastal Hazard Risk Area
Purpose	To provide guidance for land use and development within areas subject to coastal erosion and inundation
Objectives	▪ To ensure land in the coastal zone is continuously provided for coastal foreshore management, public access, recreation and conservation. ▪ To ensure public safety and reduce risk associated with coastal erosion and inundation. ▪ To avoid inappropriate land use and development of land at risk from coastal erosion and inundation. ▪ To ensure land use and development does not accelerate coastal erosion or inundation risks; or have a detrimental impact on the functions of public reserves. ▪ To ensure that development addresses the Capel to Leschenault Coastal Hazard Risk Management and Adaptation Plan 2023 prepared in accordance with State Planning Policy No. 2.6 State Coastal Planning Policy (as amended) and any relevant local planning policy.
Additional Provisions	1. All proposed development within the SCA requires approval 2. In considering proposed structure plans, subdivision or development applications due regard shall be given to – a) the Capel to Leschenault Coastal Hazard Risk Management and Adaptation Plan 2023. b) State Planning Policy 2.6 -State Coastal Planning Policy; and c) Relevant local planning policies.

<table>
<tr><th>Item</th><th>Recommended Text</th></tr>
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3. Where subdivision or development applications are received within SCA1, the local government shall require a notification pursuant to section 70A of the Transfer of Land Act 1983 to be placed on the Certificate(s) of Title of the subject land, at the cost of the landowner and to the satisfaction of the local government.
The notification is to read as follows for land within the coastal hazard area at 2050:
"Vulnerable Coastal Area – This lot is located in an area likely to be subject to coastal erosion and/or inundation over the next 100 years and is subject to conditions of development approval which require removal and/or rehabilitation of development to pre-development conditions if any one of the following events occurs:
a) the most landward part of the Horizontal Shoreline Datum being within [x insert here] metres of the most seaward part of the lot boundary.
b) a public road no longer being available or able to provide legal access to the property.
c) when water, sewerage or electricity to the lot is no longer available as they have been removed/decommissioned by the relevant authority due to coastal hazards."

The notification is to read as follows for land within the coastal hazard area from 2051 - 2120:
"Vulnerable Coastal Area – This lot is located in an area likely to be subject to coastal erosion and/or inundation over the next 100 years"
4. Notwithstanding the provisions of above (1), (2) and (3) development approval is not required within SCA1 for the following development if such development is otherwise exempt from requiring development approval under the Scheme:
a) temporary or non-permanent structures not used for human habitation.
b) extensions to an existing single, grouped or multiple dwelling where the net floor area of the proposed extensions is no more than 50m2; and
c) a change of use where no new structures are proposed.
</td></tr>
<tr><td>Advice Notes</td><td>
On the occasion of any development approval pursuant to the Additional Provisions of SCA 1, the following "Advice Notes" indicate suitable and tested advice to be provided to applicants:
▪ The development subject of this approval may be impacted by coastal hazards in the short to medium term (likely by 2050). Should the development be affected by coastal hazards in the future as predicted, the development and any associated works are likely to require partial or complete relocation. The local government is under no obligation to assist or protect structures from coastal erosion/inundation threats and accepts no liability and will pay no costs associated with relocation or any protection from or damages caused by coastal processes.
▪ The applicant is advised that the Horizontal Shoreline Datum means the active limit of the shoreline under storm activity, as defined in State Planning Policy 2.6 – State Coastal Planning Policy (2013).
▪ The applicant is advised that the [x insert here] metre distance between the Horizontal Shoreline Datum and the most seaward part of the lot boundary is the S1 value for this location which is obtained from the Capel to Leschenault Coastal Hazard Risk Management Adaptation Plan 2023. S1 is the allowance for absorbing the current risk of storm erosion, as defined in State Planning Policy 2.6 – State Coastal Planning Policy (2013).
▪ Should the development be affected by Coastal Hazards in the future the applicant will be responsible for relocating/removing the development and all costs associated. The local government is under no obligation to assist or protect structures from coastal erosion/inundation threats and accepts no liability and will pay no costs associated with any protection from or damages caused by coastal processes.
</td></tr>
</table>

Item	Recommended Text
	▪ In relation to condition [x insert here], upon removal of the development the site is to be rehabilitated to pre-development condition which comprises of a bare earth lot, free of any buildings, demolition rubble or remnants of the approved development.

NB: There will be some foreshore areas included in the regional open space reservation in the Greater Bunbury Region Scheme, where this CHRMAP recommends including the Foreshore reservation in the scheme amendment or scheme review for areas outside of the Regional Reservation. The Foreshore Reserve will ensure visibility of the foreshore management role of the reserve and not imply a 'recreational' component. Both actions should be considered together.

3 FUNDING OPTIONS

The Stage G Risk Treatment Report presents a summary of financial and economic implications to inform the local governments of the potential cost of coastal hazards over the planning timeframe and the cost to implement the recommended treatment Options. A summary of the costs of recommended Options is also provided for each MU in Section 8 of this report.

This section identifies all revenue-raising mechanisms available for obtaining funds to assist implementation. Funding mechanisms considered include:

- Operating budget, general rates and coastal management fund
- Special area rates / differential rating
- Yearly budgeting
- Levies
- Lease land management
- State grants
- Federal grants

3.1 Beneficiary (user) pays Operating Budget, General Rates and Coastal Management Fund

The individual land managers within the study area should consider establishing a coastal management fund that includes specific allowance for managing and adapting to the risk posed by coastal erosion and inundation. The purpose of this fund includes:

- To allocate a percentage of the organisation's operating budget for coastal management. The percentage and amounts will vary for each organisation but between 0.5% and 3.0% is proposed.
- To save funds routinely so that when triggers are met the established management actions can be implemented efficiently.
- Acknowledge coastal management costs are forecast to increase in line with sea level rise and the realisation of coastal hazard projections.

3.2 Specified Area Rate

Where adaptation Options are designed to protect specific sections of coastal land and assets, such as private property, it is recommended that the LGAs progress the establishment of a specified area rate. The rate can be applied to those beneficiaries within the 100-year hazard zone, and the amount raised should consider the estimated 100-year cost for each Option and the Benefit Distribution Analysis (BDA) report.

3.3 Levies

It is recommended the LGAs investigate the feasibility of establishing a particular levee for coastal management that would be a transparent source of the coastal management fund discussed above.

3.4 Lease Land Management

Coastal land vested with coastal managers in the study area and leased to third parties represents a unique scenario whereby implementation of some Options may require specific lease clauses, but there is also potential to raise funds for coastal management. During considerations of lease renewal, coastal managers should consider the land use, vulnerability of the land, projected timeframe of unacceptable vulnerability, length of lease, recommended implementation Options and need for any specific clause around triggers or required management actions by the lessee. Increases in lease amounts may be able to raise funds to help offset the cost of management.

3.5 State Grants - CoastWA

CoastWA aims to implement a strategic response to the growing impacts of coastal hazards to ensure sustainable land use and development on the coast for the long-term. CoastWA has committed $33.5 million of funding over five years from 2021-26. For further information visit https://www.wa.gov.au/government/document-collections/coastwa-grants It comprises the following grant programs:

- Coastal Adaptation and Protection grants
- Hotspot Coastal Adaptation and Protection Major Project Fund
- Coastwest grants
- Coastal Management Plan Assistance Program

There are also two other grant programs relevant to coastal hazard risk management in WA:

- Royalties for Regions
- Local Government Financial Assistance Grants

The Department of Transport administers the Coastal Adaptation and Protection (CAP) grants and the Hotspot Coastal Adaptation and Protection (H-CAP) Major Project Fund. CAP grants provide financial assistance for local projects that identify and manage coastal hazards. The program aims to build partnerships with local coastal managers, such as local governments and help them understand and adapt to coastal hazards. CAP Grants fund up to 50% of project costs. H-CAP supports projects which design and implement adaptation Options at coastal erosion hotpots identified by the DoT in recent years. Invitations to apply for H-CAP are sent directly to eligible coastal managers (those with a completed CHRMAP and an identified erosion hotspot) There are two identified erosion hotspots – The Cut in MU7 and Koombana Beach in MU5.

Coastwest grants support eligible coastal land managers and community organisations to undertake projects that manage and enhance WA's coastal environments through rehabilitation, restoration and preventative actions. Coastwest grants are administered by the Department of Planning, Lands and Heritage.

Coastal Management Plan Assistance Program (CMPAP) grants support eligible coastal land managers to develop adaptation and management plans and strategies for coastal areas that are, or are predicted to become, under pressure from a variety of challenges. CMPAP grants are administered by the Department of Planning, Lands and Heritage.

Other WA grant programs which may provide funding for coastal projects include Royalties for Regions and Local Government Financial Assistance Grants.

Royalties for Regions is facilitated by Department of Primary Industries and Regional Development and promotes and facilitates economic, business and social development in regional Western Australia for the benefit of all Western Australians. For further information visit: http://www.drd.wa.gov.au/rfr/whatisrfr/Pages/default.aspx

Local Government Financial Assistance Grants are administered by the Department of Local Government, Sport and Cultural Industries. They are grants funded by the Commonwealth Government and are distributed among 137 local governments in WA each year. The grants allow councils to spend the funds according to local priorities. For further information visit: https://www.dlgsc.wa.gov.au/local-government/local-governments/financial-assistance-grants

It should be noted that State funding mechanisms require matching cash contributions from the land manager, and as such, funding will still need to be sourced through one or more of the other available measures. State funding grants may also restrict access to funding where public monies would partially or predominantly benefit private landowners or users.

Because coastal hazards and coastal land management will continue to evolve and are unlikely to be resolved by 2026 (beyond the term of the CoastWA Grants), long-term sustainable funding is likely to be required from the State.

3.6 Federal Grants

Federal grants are variable and often unpredictable, but it is important for coastal managers to stay aware of any funding and grant programs available. Early planning and preparation will mean more-competitive applications can be prepared quickly when grants are announced.

On 13 February 2022 the Australian Government announced the $50 million Coastal and Estuarine Risk Mitigation Program which is funded by the Emergency Response Fund. This program supports projects that reduce the impact of disasters on coastal communities. Successful applicants were announced on 4 November 2022. The Coastal and Estuarine Risk Mitigation Program will help drive long term resilience and sustainability by delivering priority projects that mitigate the impact of disasters on communities and economies.

Areas of focus for the Program include:

- Adaptation and resilience actions, including investment in grey infrastructure and green-blue infrastructure (which includes nature-based solutions)
- Planning, including local and regional risk assessments and mapping, business case development, preparation of community focused regional coastal management programs; and
- Investment in monitoring infrastructure and activities to understand the coastal and estuarine zone over time.

For more information visit https://nema.gov.au/programs/emergency-response-fund/coastal-estuarine-risk-mitigation-program#Overview

It should be noted that Federal funding mechanisms may require matching cash contributions from the land manager, and as such, funding may still need to be sourced through one or more of the other available measures. Federal funding grants may also restrict access to funding where public monies would partially or predominantly benefit private landowners or users.

3.7 Beneficiary (user) Pays

‘User Pays’ principles essentially dictate that the beneficiaries of adaptation Options should pay for them. Mechanisms for fund raising may include:

- Specified Area Rates – as described above and considering the findings of the BDA.
- Mechanisms for visitors to the town, as user of the coastline, to contribute. This could be in the form of a levee applied to their accommodation, or paid parking at key tourist sites.
- Developer contributions where specific developments benefit from their coastal location

4 STAKEHOLDER AND COMMUNITY ENGAGEMENT

Following development of draft recommended options for implementation a second meeting of the Coastal Community Advisory Group (CCAG) was held in November 2022. The intent of Meeting Two was to seek feedback on the project team final recommendations. The meeting confirmed many of the values of the broader community engagement and Meeting One outcomes. The meeting was also able to highlight a number of practical improvements to the CHRMAP documents, notably surrounding communication and engagement, which have been incorporated into updated versions. Ongoing education and engagement as noted in this report will build capacity in the community. Further detail on the second meeting of the CCAG is provided in 9Appendix A as part of the updated Engagement Summary Report.

5 SHORT-TERM IMPLEMENTATION

The coastal adaptation pathway includes short-term, medium-term and long-term actions. Short-term actions are anticipated to be implemented by 2035, corresponding to a 10-15 year planning horizon; medium-term actions implementation would occur before 2050 (15-30); while long-term actions would be implemented beyond 2050, towards 2120.

The proposed short-term coastal management actions (i.e. "Options"), for each Management Unit, are summarised in Section 8 and include the following information:

- Recommended risk treatment Options
- Responsibility – the entity will be the risk management owner
- Planning timeframe
- Approvals required
- Inclusion of trigger points and their monitoring requirements into planning schemes
- Costs
- Short-term actions were designed to be compatible with medium and long-term adaptation actions.

5.1 Key assumptions

The timeframes envisaged in the coastal adaptation pathways are not absolute. These timeframes are related to the current state of local land planning, coastal processes knowledge and climate projections, as outlined in the CHRMAP. Therefore, the timeframes are typically not aligned on "worst-case" scenarios but instead consider risk-adjusted and/or consensus-based adjustments and quantifications. Other Options may be envisaged, particularly if land planning practices, coastal processes knowledge or climate projections are changed. Therefore, the implementation pathway will evolve overtime.

The Options have been selected based on information gathered through all the previous CHRMAP project stages. Although the Multi-Criteria Analysis and Cost Benefit Analysis have been key gateway decision points for selecting many Options. The preparation of the MCA and CBA required interpretation and approximations, particularly regarding the criteria and cost quantifications, and have limitations. Also, the proposed Options have been developed only at a conceptual level to draw comparisons between several Options.

The CHRMAP proposed Options should be the subject of further investigations, surveys, policy review, environmental impact investigation, development approval and authorities endorsement, local stakeholder and community engagement, preliminary design, detailed design, costing and any other applicable preparation work required prior to be implemented. The Options should be optimised and modified following such additional investigations.

An example of this could be changes to Management Unit boundaries, to optimise Option effectiveness and to reduce costs. It may also be practical to develop a staged implementation approach to some of these management actions to test their effectiveness and to refine design of subsequent stages (e.g. staged installation of beach groynes). Some interim management Options may also be progressed, such as the development of emergency evacuation procedures and systems, until inundation protection measures can be fully implemented.

5.2 Further Investigations

Information gaps identified in the CHRMAP should be gathered early. Some of these gaps can be closed by the collection of data, as discussed further in Section 6. Other information gaps can be closed during the preliminary and/or detailed design phase when specific or detailed analysis of available data, information, modelling, and projections are carried out. The "governance/support" role currently undertaken by the PNP should continue with funding support for coordination of coastal management, planning, engineering and research in the study area.

A number of the recommended investigations may already exist in LGA technical or planning documents. The CHRMAP recommended investigations have been scoped specifically to meet coastal hazard planning elements introduced in the State Coastal Planning Policy 2.6.

The following investigations are recommended:

1. Preparation of Asset Management Plans by each LGA, which identify existing infrastructure and recreational facilities in the coastal erosion and inundation hazard zone and provides direction to:
    a. Progressively relocate non-critical assets (PMR2) away from the coastal hazard zone once they reach the end of asset life or replace assets with suitably durable and/or sacrificial infrastructure. This may include vulnerable recreational car parks; recreational amenities such as public ablutions; barbeque/picnic/shade areas; playground and other recreational equipment; and access structures such as ramps, stairs and paths and fences, etc.
    b. Plan for the relocation of critical service infrastructure outside of the coastal hazard zone once they reach the end of asset life, or at a minimum, modify the service infrastructure asset so that it does not run parallel to the coastline where possible and can be progressively removed when exposed to intolerable risk levels. This may include public safety infrastructure.
2. Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat. Seek legal advice regarding the basis of agreements with landholders and whether opt-ins can be time constrained.
3. Sand source feasibility study – Several MU's have recommended Options which require sand nourishment, both for erosion management (such as beach groynes including sand nourishment) and inundation management (such as raising beach levels to improve coastal drainage). The availability of suitable sand for beach nourishment works is unfortunately not well understood in the study area. It is recommended that a sand source feasibility is undertaken for the PNP to determine the capacity and cost of local sand supplies. This study should consider both land-based and marine sand sources as well as evaluate potential environmental impacts and approvals required. Cost estimates in this CHRMAP have assumed that a reliable source of sand in reasonable proximity to the study area may be available. If this assumption is incorrect, costs may increase and affect the CHRMAP recommendations.
4. Rock source feasibility study – Similar to the above but for armour rock suitable for building coastal management structures. Several MU's have recommended Options requiring armour rock which needs to be fit for purpose. An analysis of the availability of such rock suitable for marine works, with suitable density, quarry yields, close location and tolerable costs should be undertaken. Potential environmental impacts should be considered in the rock source feasibility study, as well as any approvals required. Cost estimates in this CHRMAP have assumed that a reliable source of rock can be found in the study area. If this assumption is incorrect, costs may increase and affect the CHRMAP recommendations.
5. Emergency evacuation planning – A review of emergency evacuation plans in the study area should be undertaken to assess if the evacuation plans are suitable for managing the projected coastal hazards. Existing documents may need to be updated or revised as required. Plans should detail emergency response to coastal erosion and flooding impacts, as well as storm damage causing infrastructure to collapse into the public foreshore or coastal environment. Evacuation planning for inundation should clearly identify appropriate evacuation routes, assess their suitability, and plan for upgrades required to meet future LGA developments. Scenario planning could also be undertaken to test the plans.

6. Foreshore Management Plans (FMPs) - Updated foreshore management plans for the study areas may increase the protective capacity of the natural dune system. Foreshore management plans should address:
   a. The requirements of SPP2.6 and its supporting documentation
   b. The findings of this CHRMAP
   c. Potential environmental issues such as biodiversity and environmental impacts, and detail a weed management strategy for the coastline
   d. Incorporate findings of Asset Management Plans as appropriate
   e. Include recommendations for closing excess beach access points, ensuring appropriately fenced and signed paths, signage for dune repair and clear signage for 4-wheel drive access and permissibility
   f. Develop an education strategy for coastal and environmental management. The strategy should work to inform the community about the CHRMAP and FMP and their findings and use suitable engagement methods such as infographics, FAQ's. The education strategy should also include appropriate on-ground signage and information for beach access, camping and 4-wheel driving, where applicable.
   g. Monitor impacts of 4WD vehicles (where applicable) and general beach access on nesting habitats and migratory bird species in dune areas
   h. Determine the need for a bush fire management plan for the dune and coastal areas
7. Coastal Hazard Mapping Study – the study partners should consider an advocacy program with the support of organisations such as the Western Australian Local Government Association (WALGA) and Local Government Planners Association (LGPA) to achieve a state-wide coastal mapping database similar to the Fire and Emergency Services (FESA) mapping of bushfire prone areas recognised as a result of applying *State Planning Policy 3.7: Planning in Bushfire Prone Areas*. Such mapping could become a vital knowledge-building tool for communities across the state coming to terms with increasing coastal hazards. NB: it is recognised that only areas where a CHRMAP has been completed and endorsed could be mapped accurately, however, other identified coastal hazard hotspots could be included in this mapping with future studies determining the extent of the coastal hazard risk area. This undertaking would complement the local-scale education strategies.

6 MONITORING

Monitoring is essential to managing coastal hazards, tracking when coastal hazards reach trigger points, understanding the coastline evolution, capturing changes to vulnerabilities and measuring the success of coastal management actions.

Coastal monitoring will inform the short-term implementation phase and increase the knowledge base for subsequent CHRMAP revisions and targeted investigations. The CHRMAP implementation report outlines:

- Review of existing coastal monitoring programs
- Review of coastal hazard projects outlined in erosion hazard assessment
- Recommend coastal monitoring activities to identify trigger points, to record dilapidation, to record when trigger points occur and to include indicative costs of monitoring works
- Recommend Trigger points
- Recommend CHRMAP review

6.1 Review of Existing Coastal Monitoring

The following coastal monitoring activities are currently undertaken in the study area and should be continued:

1. Beach width and photo monitoring led by the PNP
2. Oblique aerial photography twice per year – by PNP
3. Inundation extent monitoring – actively being prepared for by PNP
4. Shoreline vegetation movement analysis from aerial photos undertaken by DoT
5. Water level monitoring at the Bunbury Storm Surge Barrier undertaken by DoT
6. Wave monitoring by the Southern Ports, Bunbury
7. Bathymetric survey of entire study area to minimum 10m depth by DoT
8. Wind recording in Bunbury by the BOM

6.2 Recommended Coastal Monitoring Activities

The monitoring activities described below are designed to identify the impacts of the recommended Options and to record the evolution of the coastal trigger points. Indicative costs for budgeting purposes are provided.

Should any Option be modified, or other coastal projects be undertaken (such as maritime, or recreation/tourism projects) where coastal hazard risk management is not the primary focus, they should be subject to the same CHRMAP principles and require their own monitoring program appropriate to their location, size and objectives. The following coastal monitoring activities are recommended:

1. Routine beach and dune surveys, in the form of beach profiles, are recommended every six months, following the summer and winter seasons, every 400m along the coast. Beach profiles may be spaced more closely where Options include trigger points monitoring and/or to support specific project requirements. The beach survey may also be continuous along the coast using LiDAR or other appropriate technique with a view to capture more accurately coastal processing, while allowing the processing of beach profile data. At the minimum, beach profiles should be carried out every two years following winter. Additionally, surveys can be undertaken immediately following severe storms producing significant beach erosion. These are useful for recording historical events, confirming the presence of bedrock, and calibrating models. Beach profile datasets should include the location of the Horizontal Shoreline Datum (HSD). The beach profiles must extend from the edge of the coastal cadastral boundary down to the

Lowest Astronomical Tide (LAT). The survey datasets should be centralised into a database, which includes previous historical beach profiles and quality control information such as survey date, datum, survey mark, beach material encountered (rock vs sand) and method used.

2. Corresponding monitoring photos should be taken at the same time as beach surveys – particularly for inundation events as it is often impractical to organise detailed survey at short notice.
3. Regular monitoring of the coastal management structures (Protection Structure Audit – NR2) – e.g., seawalls, groynes, breakwaters and storm surge barrier. These should be undertaken with consistent methodology to allow comparison between inspections. These can be commenced immediately, and the initial assessment would identify an appropriate review schedule for each structure, or if there is an issue with an asset. Such assessment would occur yearly to blend into the existing LGA asset management reporting systems.
4. Geotechnical investigations are proposed to determine the presence of bedrock below the beach. When bedrock is located relatively near the surface, it can provide some natural protection to erosion and reduce the scope of works. However, in low-lying areas, the presence of bedrock may not significantly mitigate the coastal hazards. Such investigation may be carried out by ground penetration radar, test pits or survey observations following beach erosion events.

6.3 Trigger Points

The CHRMAP consider four types of trigger points, as follows:

- **Proximity trigger**: Where the most landward part of the Horizontal Shoreline Datum (HSD) is within the Storm Erosion Allowance of the most seaward point of a public asset of interest or private property lot boundary. Due to the high value of the foreshore reserve, the foreshore reserve may be considered to be "the most seaward point". If individual assets have a specific distance-based trigger relating to the HSD then the beach and dune survey activities described above should be used to collect topographic data that can be used to map the updated HSD position.
- **Access trigger**: Where a public road is considered no longer available or able to provide legal access to the property
- **Utilities trigger**: When water, sewage, communications or electricity to the lot is no longer available as they have been removed/decommissioned by the relevant authority due to coastal hazards.
- **Damage trigger**: Any property within the hazard zone and within a dedicated Special Control Area, that is damaged by a coastal hazard from an extreme weather event shall require LGA approval before being repaired. The review process should involve re-fit of minor or moderately damaged assets to accommodate coastal hazards in the future; or removal and redevelopment outside the hazard zone for damaged assets.

This list follows a sequential / prioritisation order. That is, a "proximity trigger" is recommended over a "damage trigger".

6.4 CHRMAP Review

This CHRMAP should be updated at least every 10 years to maintain currency and should be a "living document". An earlier review should be considered when the following event occurs:

- Substantial storm events generating severe coastal hazards approaching or exceeding the CHRMAP projections
- Significant changes to land-use planning – such as complex amendments to a Local Planning Scheme or the Greater Bunbury Region Scheme, or the full review of either of these documents.

- New information becomes available which substantially affects the summary of local community values and assets (natural or built). This may typically occur when consulting the community regarding other documents such as the Local Planning Scheme or Foreshore Management Plan, or the occurrence of a significant storm event.
- Hazard modelling for the study area should be updated given any of the following:
  - recent data collection
  - planning changes
  - updates in climate change science, specifically local sea level rise projections
  - coastal engineering methodology
  - changes to the CHRMAP success criteria by coastal land managers
  - triggers are reached

Ongoing coastal management operations within the study area should consider the status of both short and long-term adaptation strategy progress, including assessment of the performance and review of any identified strategies.

Monitoring of CHRMAP outcomes, actions and future updates should always include consultation with stakeholders and the community to make sure any changes are communicated, and that the stakeholders positions are reflected in the coastal management outcomes.

7 MEDIUM AND LONG-TERM IMPLEMENTATION

Medium (15 – 30 years) and long-term (30 – 100 years) implementation provides a strategic consideration of how the PNP and its member organisations will adapt to long-term climate change impacts. Therefore, medium- and long-term implementation are not described in detail in the CHRMAP. Longer-term responses include:

- Actioning the revised planning instruments
- Managing coastal retreat
- Exhausting the SPP2.6 hierarchy of actions, high value assets may be protected where sustainable impacts and funding are identified/prioritised
- Providing temporary/interim hazard protection may also become more costly and a change in adaptation pathway could be required. For example, as sea level rise progresses, it is likely that Options using sand or rock resources to protect assets near the coast may become unsustainable.

Recommended medium and long-term actions are summarised in Section 8. In addition, long-term adaptation strategies/pathways have been recommended for each MU for both erosion and inundation that will allow for the continuous function of local communities whilst accommodating the increasing burden of coastal hazards. The long-term strategy informs future planning instruments, supports monitoring, recommends planning reviews and underpins collaboration between coastal land managers, stakeholders and the community.

The two primary coastal management actions mitigating erosion hazards are:

- Planned / Managed retreat (PMR4 – Voluntary Acquisition): Use the planning instruments and long-term plan to systematically move assets with low adaptive capacity out of the hazard zone
- Protect (several possible Options): Undertake works as necessary to prevent erosion to assets

The three coastal management actions mitigating inundation hazards are:

- Planned / Managed retreat (PMR4 – Voluntary Acquisition): Use the planning instruments and long-term plan to systematically move assets with low adaptive capacity out of the hazard zone
- Accommodate (Design Assets to Withstand Impacts – AC1): limit damage from inundation events through finished floor level requirements
- Protect (Levee / Barrier – PR6): Undertake works as necessary to prevent or limit inundation of assets exposed along the coast

8 RECOMMENDATIONS SUMMARY

All recommendations are provided in Table 8-1 to Table 8-11 for each individual MU. Note that inundation is not a concern for MU3 or MU4.

Table 8-1 MU1 Recommendations

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Recommended Short-Term Option to address Erosion is Planned / Managed Retreat – Voluntary Acquisition (PMR4)	▪ Acquisition assumed in the same year as hazard line identifies parcels as vulnerable ▪ Coastal hazards impact few properties in the short term, so the focus is to manage foreshore reserves and coastal amenities, undertake coastal monitoring, and prepare for implementation in medium to long-term	▪ LGA	▪ Completed CHRMAP	▪ $13.1M at NPV 4% for whole 100-year timeframe	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays	x	x	x		
Recommended Short-Term Option to address Inundation is a Levee (PR6) in combination with MU2	For MU1: To address the inundation of Stirling Wetland ▪ Consider / masterplan for two levees on either side of the Capel River, each 2km long. ▪ Complete implementation by 2035 ▪ Included higher contingency (+50%) to cover additional environmental treatment, revegetation, local drainage challenges For MU2: To address the inundation of Stirling Wetland: ▪ Consider / masterplan for new culverts with one-way valves installed at Higgins Cut with some associated earthworks ▪ Higher contingency than usual (+50%) to cover additional environmental treatment, revegetation, local drainage challenges ▪ Complete installation by 2035 To address coastal inundation at the Minninup Drain Outlet, from flowing to connect with Stirling Wetlands: ▪ Consider / masterplan for levee at 300m long ▪ Complete installation by 2035 ▪ This may be slower to implement than beach nourishment. ▪ Higher contingency than usual (+50%) to cover additional environmental treatment, revegetation, and local drainage challenges	▪ LGA	▪ Confirmation of SLR in accordance with projections to 2035 ▪ Confirmation of approach through preliminary and detailed design	▪ $4.7M at NPV 4% ▪ BDA analysis estimates a fair and reasonable breakdown of % costs to different benefiting parties is: ▪ Private Landholders at ~9% ▪ Shire at ~3% ▪ WA State Government at ~88%	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays			x	x	
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	▪ Item cost for investigations and management plans	▪ LGA	▪ Completed CHRMAP	▪ $100,000	▪ Operational	x	x			
Leaving assets unprotected (PMR1)	▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve	▪ LGA	▪ Storm damage	▪ $415,000 ▪ (Plus 3% annual maintenance of $12,450 pa)	▪ Operational	x	x	x		

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Demolition / removal / relocation of asset from inside hazard area (PMR2)	▪ Preparation of Asset Management Plan ▪ To 2035 for public-built assets ▪ Allows for removal of toilet block at Wave Walk ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ Removal / Relocation of assets as required	▪ LGA	▪ Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable	▪ $993,000 ▪ (Plus 1% annual maintenance of $9,930 pa)	▪ Operational ▪ Grants	x	x	x		
Prevention of further development / prohibit expansion of existing use rights (PMR3)	▪ Item cost for investigations and management plans ▪ Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat. ▪ Seek legal advice regarding the basis of agreements with landholders and whether opt-ins can be time constrained	▪ LGA	▪ Completed CHRMAP	▪ $100,000 ▪ (Plus 1% annual maintenance of $1,000 pa)	▪ Operational ▪ Grants	x	x			
Design assets to withstand impacts (AC1)	▪ Item cost for investigations and management plans – primarily any case-by-case work needed for public assets	▪ LGA	▪ Completed CHRMAP	▪ $200,000 ▪ (Plus 1% annual maintenance of $2,000 pa)	▪ Operational ▪ Grants	x	x			
Monitoring (NR1)	▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ Routine 6-monthly beach profiles following the summer and winter periods. Minimum every two years in Spring	▪ LGA ▪ Can seek support and assistance from DoT	▪ Completed CHRMAP ▪ Severe storm event(s)	▪ $20,000 ▪ (Plus 10% annual maintenance of $2,000 pa)	▪ Operational ▪ Grants	x	x	x		
Notification on Title (NR3)	▪ Item cost for investigations and implementation plans	▪ LGA ▪ Can seek support and assistance from DPLH, WALGA	▪ Completed CHRMAP	▪ $250,000 ▪ (Plus 1% annual maintenance of $2,500 pa)	▪ Operational ▪ Grants	x	x			
Emergency evacuation plans (NR4)	▪ Item cost for investigations and evacuation plans	▪ LGA	▪ Completed CHRMAP	▪ $250,000 ▪ (Plus 1% annual maintenance of $2,500 pa)	▪ Operational ▪ Grants	x	x			
INVESTIGATION 1 Sand Source Feasibility Study	▪ Determine the capacity and cost of local sand supplies, including both land-based and marine sources ▪ Likely require repetition over Medium-term as market changes ▪ Focus for this MU is appropriate fill for inundation levee, but requirements of ad hoc sand nourishment and earthworks to raise land heights should be included	▪ LGA ▪ Can seek support from neighbouring LGA's, PNP, and state departments	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated to allow a larger budget which will reduce risk and increase confidence in the study outcomes	▪ Operational ▪ Grants	x	x		x	
INVESTIGATION 2 Rock Source Feasibility Study	▪ Analyse the availability of rock in terms of density, quarry yields, location and costs ▪ Likely require repetition over Medium-term as market changes ▪ Focus for this MU is smaller armour rocks that may be needed for embankments	▪ LGA ▪ Can seek support from neighbouring LGA's, PNP, and state departments	▪ Completed CHRMAP	▪ $20,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
INVESTIGATION 3 Update Foreshore Management Plans (FMPs)	▪ An updated FMP could emphasise on the protective capacity of the natural dune system. FMP updates should address the requirements of SPP2.6 and incorporate the findings of this CHRMAP ▪ Prepare an updated Foreshore Management Plan and include recommendations for closing excess beach access points, appropriately fenced and signed paths, signed and patrolled vehicle and boat launching exclusion area and signage for dune repair	▪ LGA	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x	x	x	x
Recommended Medium and Long-term pathway to address erosion is Planned / Managed Retreat – Voluntary Acquisition (PMR4)	▪ Implement when triggers are met ▪ See explanation in Land Use Planning Section of this report	▪ LGA	▪ HSD within 14m of property boundary	▪ $13.1M at NPV 4% over 100-year timeframe	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays				x	x
Recommended Medium and Long-term pathway to address Inundation is a Levee (PR6) in combination with MU2	▪ Target 2035 installation ▪ Monitor and maintain infrastructure and carry out reviews in accordance with new information and CHRMAP updates.	▪ LGA	▪ Updated CHRMAP	▪ Annual maintenance estimate of approximately $0.1M pa	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays				x	x

Table 8-2 MU2 Recommendations

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Recommended Short-Term Option to address Erosion is Planned / Managed Retreat – Voluntary Acquisition (PMR4)	▪ Acquisition assumed in same year as hazard line identifies parcels as vulnerable ▪ Coastal hazards impact few properties in the short term, so the focus is to manage foreshore reserves and coastal amenities, undertake coastal monitoring, and prepare for implementation in medium to long-term ▪ Properties affected in the Short-term are Agricultural/Rural. Case-by-case consideration is needed to consider infrastructure at risk.	▪ LGA	▪ Completed CHRMAP ▪ HSD within 10-28m of property boundary – varies across MU.	▪ $36.6M at NPV 4% over 100-year timeframe	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays	x	x	x		
Recommended Short-Term Option to address Inundation is a Levee (PR6) in combination with MU1	For MU1: To address the inundation of Stirling Wetland ▪ Consider / masterplan two levees either side of the Capel River, each 2km long ▪ 2035 implementation ▪ Higher contingency (+50%) to cover additional environmental treatment, revegetation, local drainage challenges For MU2: To address the inundation of Stirling Wetland: ▪ Assumes new culverts with one-way valves installed at Higgins Cut with some associated earthworks ▪ Higher contingency than usual (+50%) to cover any treatment, revegetation, local drainage challenges ▪ Assume 2035 installation To address coastal inundation at the Minninup Drain Outlet, from flowing to connect with Stirling Wetlands: ▪ Assumes levee at 300m long ▪ Assume 2035 implementation ▪ Higher contingency than usual (+50%) to cover additional environmental treatment, revegetation, and local drainage challenges	▪ LGA	▪ Confirmation of Sea Level Rise (SLR) in accordance with projections to 2035 ▪ Confirmation of approach through preliminary and detailed design	▪ $4.7M at NPV 4% ▪ BDA analysis estimates a breakdown of % costs to different benefiting parties should be: ▪ Private Landholders at ~9% ▪ Shire at ~3% ▪ WA State Government at ~88%	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays			x	x	
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	▪ Item cost for investigations and management plans	▪ LGA	▪ Completed CHRMAP	▪ $150,000	▪ Operational	x	x			
Leaving assets unprotected (PMR1)	▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve	▪ LGA	▪ Storm damage	▪ $244,000 ▪ (Plus 3% annual maintenance of $7,320 pa)	▪ Operational	x	x	x		

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Demolition / removal / relocation of asset from inside hazard area (PMR2)	▪ Preparation of Asset Management Plan ▪ To 2035 for public built assets ▪ Allows for removal of building at Wave Walk ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ Removal / Relocation of assets as required	▪ LGA	▪ Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable	▪ $537,000 ▪ (Plus 1% annual maintenance of $5,370)	▪ Operational ▪ Grants	x	x	x		
Prevention of further development / prohibit expansion of existing use rights (PMR3)	▪ Item cost for investigations and management plans ▪ Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat. Seek legal advice regarding the basis of agreements with land holders and whether opt-ins can be time constrained	▪ LGA	▪ Completed CHRMAP	▪ $100,000 ▪ (Plus 1% annual maintenance of $1,000)	▪ Operational ▪ Grants	x	x			
Design assets to withstand impacts (AC1)	▪ Item cost for investigations and management plans – primarily any case-by-case work needed for public assets	▪ LGA	▪ Completed CHRMAP	▪ $200,000 ▪ (Plus 1% annual maintenance of $2,000)	▪ Operational ▪ Grants	x	x			
Monitoring (NR1)	▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ Routine 6-monthly beach profile following the summer and winter periods. Minimum every two years in Spring	▪ LGA ▪ Can seek support and assistance from DoT	▪ Completed CHRMAP ▪ Severe storm event(s)	▪ $20,000 ▪ (Plus 10% annual maintenance of $2,000)	▪ Operational ▪ Grants	x	x	x		
Notification on title (NR3)	▪ Item cost for investigations and implementation plans	▪ LGA ▪ Can seek support and assistance from DPLH, WALGA	▪ Completed CHRMAP	▪ $250,000 ▪ (Plus 1% annual maintenance of $2,500)	▪ Operational ▪ Grants	x	x			
Emergency evacuation plans (NR4)	▪ Item cost for investigations and evacuation plans	▪ LGA	▪ Completed CHRMAP	▪ $250,000 ▪ (Plus 1% annual maintenance of $2,500)	▪ Operational ▪ Grants	x	x			
INVESTIGATION 1 Sand Source Feasibility Study	▪ Determine the capacity and cost of local sand supplies, including both land-based and marine sources ▪ Likely require repetition over Medium-term ▪ Focus for this MU is appropriate fill for inundation levee, but requirements of ad hoc sand nourishment and earthworks to raise land heights should be included	▪ LGA ▪ Can seek support from neighbouring LGA's, PNP, and state departments	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	
INVESTIGATION 2 Rock Source Feasibility Study	▪ Analyse the availability of rock in terms of density, quarry yields, location and costs ▪ Likely require repetition over Medium-term ▪ Focus for this MU is smaller armour rock that may be needed for river and levee	▪ LGA ▪ Can seek support from neighbouring LGA's, PNP, and state departments	▪ Completed CHRMAP	▪ $20,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
INVESTIGATION 3 Update Foreshore Management Plans (FMPs)	▪ Prepare an updated Foreshore Management Plan ▪ An updated FMP could help increase the protective capacity of the natural dune system. Updates should address the requirements of SPP2.6 and incorporate the findings of this CHRMAP	▪ LGA	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x	x	x	x
Recommended Medium and Long-term pathway to address erosion is Planned / Managed Retreat – Voluntary Acquisition (PMR4)	▪ Implement when triggers are met ▪ See explanation in Land Use Planning Section of this report	▪ LGA	▪ HSD within 10-28m of property boundary – varies across MU.	▪ $36.6M at NPV 4%	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays				x	x
Recommended Medium and Long-term pathway to address Inundation is a Levee (PR6) in combination with MU2	▪ Assumes 2035 installation as described in second row of this table ▪ Monitoring and maintenance of infrastructure and design reviews in accordance with new information and CHRMAP updates.	▪ LGA	▪ Updated CHRMAP	▪ Annual maintenance estimate of approximately $0.1M	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays				x	x

Table 8-3 MU3 Recommendations

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Recommended Short-Term Option to address Erosion is Planned / Managed Retreat – Voluntary Acquisition (PMR4)	▪ Acquisition assumed in same year as hazard line identifies parcels as vulnerable ▪ Coastal hazards impact few properties in the short term, so the focus is to manage foreshore reserves and coastal amenities, undertake coastal monitoring, and prepare for implementation in medium to long-term	▪ LGA	▪ Completed CHRMAP ▪ HSD within 24-29m of property boundary – varies across MU.	▪ $10.6M at NPV 4% for whole 100-year timeframe	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays	x	x	x		
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	▪ Item cost for investigations and management plans	▪ LGA	▪ Completed CHRMAP	▪ $150,000	▪ Operational	x	x			
Leaving assets unprotected (PMR1)	▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve	▪ LGA	▪ Storm damage	▪ $501,000 ▪ (Plus 3% annual maintenance of $15,030)	▪ Operational	x	x	x		
Demolition / removal / relocation of asset from inside hazard area (PMR2)	▪ Preparation of Asset Management Plan ▪ To 2035 for public built assets ▪ Allows for removal of building at Wave Walk ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ Removal / Relocation of assets as required	▪ LGA	▪ Audit of assets within 2035 erosion hazard zone and identification of assets where damage would be unacceptable	▪ $1,102,000 ▪ (Plus 1% annual maintenance of $11,020)	▪ Operational ▪ Grants	x	x	x		
Prevention of further development / prohibit expansion of existing use rights (PMR3)	▪ Item cost for investigations and management plans ▪ Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat. Seek legal advice regarding the basis of agreements with land holders and whether opt-ins can be time constrained	▪ LGA	▪ Completed CHRMAP	▪ $100,000 ▪ (Plus 1% annual maintenance of $1,000)	▪ Operational ▪ Grants	x	x			
Monitoring (NR1)	▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ Routine 6-monthly beach profile following the summer and winter periods. Minimum every two years in Spring	▪ LGA ▪ Can seek support and assistance from DoT	▪ Completed CHRMAP ▪ Severe storm event(s)	▪ $20,000 ▪ (Plus 10% annual maintenance of $2,000)	▪ Operational ▪ Grants	x	x	x		
Notification on title (NR3)	▪ Item cost for investigations and implementation plans	▪ LGA ▪ Can seek support and assistance from DPLH, WALGA	▪ Completed CHRMAP	▪ $250,000 ▪ (Plus 1% annual maintenance of $2,500)	▪ Operational ▪ Grants	x	x			
INVESTIGATION 1 Sand Source Feasibility Study	▪ Determine the capacity and cost of local sand supplies, including both land-based and marine sources ▪ Likely require repetition over Medium-term ▪ Focus for this MU is appropriate sand for ad hoc sand nourishment	▪ LGA ▪ Can seek support from neighbouring LGA's, PNP, and state departments	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants			x		

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
INVESTIGATION 2 Update Foreshore Management Plans (FMPs)	▪ Prepare an updated Foreshore Management Plan ▪ An updated FMP could help increase the protective capacity of the natural dune system. Updates should address the requirements of SPP2.6 and incorporate the findings of this CHRMAP	▪ LGA	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x	x	x	x
Recommended Medium and Long-term pathway to address erosion is Planned / Managed Retreat – Voluntary Acquisition (PMR4)	▪ Implement when triggers are met ▪ See explanation in Land Use Planning Section of this report	▪ LGA	▪ HSD within 24-29m of property boundary – varies across MU.	▪ $10.6M at NPV 4%	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays				x	x

Table 8-4 MU4 Recommendations

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Recommended Short-Term Option to address Erosion is Planned / managed Retreat combining Leaving Assets Unprotected (PMR1); Removal of Assets from Inside Hazard Area (PMR2), and Prevention of Further Development (PMR3)	▪ Audit of assets within 2035 erosion hazard zone and identification of assets where damage would be unacceptable to determine between PMR1 and PMR2 ▪ Investigation to determine acceptable foreshore amenity facilities within hazard zone	▪ LGA	▪ Completed CHRMAP	▪ Included under component items below	▪ Operational ▪ Grants	x	x	x		
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	▪ Item cost for investigations and management plans	▪ LGA	▪ Completed CHRMAP	▪ $150,000	▪ Operational	x	x			
Leaving assets unprotected (PMR1)	▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve	▪ LGA	▪ Storm damage	▪ $59,000 ▪ (Plus 3% annual maintenance of $1,770)	▪ Operational	x	x	x		
Demolition / removal / relocation of asset from inside hazard area (PMR2)	▪ Preparation of Asset Management Plan ▪ To 2035 for public built assets ▪ Allows for removal of building at Wave Walk ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ Removal / Relocation of assets as required	▪ LGA	▪ Audit of assets within 2035 erosion hazard zone and identification of assets where damage would be unacceptable	▪ $129,000 ▪ (Plus 1% annual maintenance of $1,290)	▪ Operational ▪ Grants	x	x	x		
Prevention of further development / prohibit expansion of existing use rights (PMR3)	▪ Item cost for investigations and management plans ▪ Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat. Seek legal advice regarding the basis of agreements with land holders and whether opt-ins can be time constrained	▪ LGA	▪ Completed CHRMAP	▪ $50,000 ▪ (Plus 1% annual maintenance of $500)	▪ Operational ▪ Grants	x	x			
Monitoring (NR1)	▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ Routine 6-monthly beach profiles following the summer and winter periods. Minimum every two years in Spring	▪ LGA ▪ Can seek support and assistance from DoT	▪ Completed CHRMAP ▪ Severe storm event(s)	▪ $20,000 ▪ (Plus 10% annual maintenance of $2,000)	▪ Operational ▪ Grants	x	x	x		
Notification on title (NR3)	▪ Item cost for investigations and implementation plans	▪ LGA ▪ Can seek support and assistance from DPLH, WALGA	▪ Completed CHRMAP	▪ $50,000 ▪ (Plus 1% annual maintenance of $500)	▪ Operational ▪ Grants	x	x			

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
INVESTIGATION 1 Sand Source Feasibility Study	▪ Determine the capacity and cost of local sand supplies, including both land-based and marine sources ▪ Likely require repetition over Medium-term ▪ Focus for this MU is appropriate sand for ad hoc sand nourishment	▪ LGA ▪ Can seek support from neighbouring LGA's, PNP, and state departments	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	
INVESTIGATION 2 Update Foreshore Management Plans (FMPs)	▪ Prepare an updated Foreshore Management Plan ▪ An updated FMP could help increase the protective capacity of the natural dune system. Updates should address the requirements of SPP2.6 and incorporate the findings of this CHRMAP	▪ LGA	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x	x	x	x
Recommended Medium and Long-term pathway to address Erosion is Planned / managed Retreat combining Leaving Assets Unprotected (PMR1); Removal of Assets from Inside Hazard Area (PMR2), and Prevention of Further Development (PMR3)	▪ Implement when triggers are met ▪ See explanation in Land Use Planning Section of this report	▪ LGA	▪ HSD within 11m of low-value public assets, equivalent of approximately half of storm erosion allowance for this MU (21m)	▪ Included under component items	▪ Operational ▪ Grants				x	x

Table 8-5 MU5 Recommendations

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Recommended Short-Term Option to address Erosion is Protection with Groynes (PR2)	▪ Assumes 15 rock groynes 100m long, 400m apart ▪ 13 on ocean coast and 2 in Koombana Bay ▪ 2020 Implementation ▪ Interim management may use Beach Renourishment as temporary protection while implementation of primary option is organised	▪ LGA	▪ Completed CHRMAP ▪ Monitoring ▪ Confirmation of design, costs and funding ▪ Construction likely to be staged	▪ $83.5M at NPV 4% for whole 100-year timeframe ▪ Detailed design and costings estimated at $250,000 ▪ BDA analysis estimates a fair and reasonable breakdown of % costs to different benefiting parties is: ▪ Private Landholders at ~3% ▪ City at ~64% ▪ WA State Government at ~34%	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays	x	x	x		
Recommended Short-Term Option to address Inundation is to replace storm surge barrier (PR6)	▪ Replacement of storm surge barrier at the Leschenault Inlet ▪ 2035 Implementation	▪ State Government with DoT likely to be the lead agency with support by LGA	▪ Completed CHRMAP ▪ Monitoring ▪ Confirmation of design, costs and funding ▪ Confirmation of SLR in accordance with projections to 2035	▪ $17.9M at NPV 4% ▪ Detailed design and costings estimated at $250,000	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays	x	x	x		
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	▪ Item cost for investigations and management plans	▪ LGA	▪ Completed CHRMAP	▪ $150,000	▪ Operational	x	x			
Leaving assets unprotected (PMR1)	▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve	▪ LGA	▪ Storm damage ▪ Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable	▪ $2,011,000 ▪ (Plus 3% annual maintenance of $60,330)	▪ Operational	x	x	x		
Demolition / removal / relocation of asset from inside hazard area (PMR2)	▪ Preparation of Asset Management Plan ▪ To 2035 for public built assets ▪ Allows for removal of building at Wave Walk ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ Removal / Relocation of assets as required	▪ LGA	▪ Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable	▪ $4,506,000 ▪ (Plus 1% annual maintenance of $45,060)	▪ Operational ▪ Grants	x	x	x		

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Prevention of further development / prohibit expansion of existing use rights (PMR3)	▪ Item cost for investigations and management plans ▪ Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat. Seek legal advice regarding the basis of agreements with land holders and whether opt-ins can be time constrained	▪ LGA	▪ Completed CHRMAP	▪ $100,000 ▪ (Plus 1% annual maintenance of $1,000)	▪ Operational ▪ Grants	x	x			
Design assets to withstand impacts (AC1)	▪ Item cost for investigations and management plans – primarily any case-by-case work needed for public assets	▪ LGA	▪ Completed CHRMAP	▪ $500,000 ▪ (Plus 1% annual maintenance of $5,000)	▪ Operational ▪ Grants	x	x			
Monitoring (NR1)	▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ routine 6-monthly beach profile following the summer and winter periods. Minimum every two years in Spring	▪ LGA ▪ Can seek support and assistance from DoT	▪ Completed CHRMAP ▪ Severe storm event(s)	▪ $30,000 ▪ (Plus 10% annual maintenance of $3,000)	▪ Operational ▪ Grants	x	x	x		
Protection Structure Audit (NR2)	▪ Item cost to inspect condition, influence on sediment transport and inundation and remaining design life on all coastal management structures ▪ Includes ocean coast seawalls Outer Harbour breakwater and spur groynes, Casuarina Harbour breakwaters and causeway, Koombana Bay groynes and Dolphin Discovery Centre buried seawall	▪ LGA ▪ DoT ▪ Koombana Sailing Club ▪ Southern Ports, Bunbury	▪ Completed CHRMAP	▪ $75,000 ▪ (Plus 2% annual maintenance of $1,500)	▪ Operational ▪ Grants		x	x		
Notification on title (NR3)	▪ Item cost for investigations and implementation plans	▪ LGA ▪ Can seek support and assistance from DPLH, WALGA	▪ Completed CHRMAP	▪ $250,000 ▪ (Plus 1% annual maintenance of $2,500)	▪ Operational ▪ Grants	x	x			
Emergency evacuation plans (NR4)	▪ Item cost for investigations and evacuation plans	▪ LGA	▪ Completed CHRMAP	▪ $250,000 ▪ (Plus 1% annual maintenance of $2,500)	▪ Operational ▪ Grants	x	x			
INVESTIGATION 1 Sand Source Feasibility Study	▪ Determine the capacity and cost of local sand supplies, including both land-based and marine sources ▪ Likely require repetition over Medium-term ▪ Focus for this MU is bulk sand nourishment for ocean coast, but should also consider the need for appropriate fill to raise height of land in inundation hazard zone	▪ LGA ▪ Can seek support from neighbouring LGA's, PNP, Southern Ports and state departments	▪ Completed CHRMAP	▪ $60,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	
INVESTIGATION 2 Rock Source Feasibility Study	▪ Analyse the availability of rock in terms of density, quarry yields, location and costs ▪ Likely require repetition over Medium-term ▪ Focus for this MU is armour and core rock of all sizes	▪ LGA ▪ Can seek support from neighbouring LGA's, PNP, Southern Ports and state departments	▪ Completed CHRMAP	▪ $60,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
INVESTIGATION 3 Update Foreshore Management Plans (FMPs)	▪ Prepare an updated Foreshore Management Plan ▪ An updated FMP could help increase the protective capacity of the natural dune system. Updates should address the requirements of SPP2.6 and incorporate the findings of this CHRMAP	▪ LGA	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x	x	x	x
Recommended Medium and Long-term pathway to address Erosion is Protection with Groynes (PR2)	▪ Monitoring will determine need for additional stages of groynes in future and the eventual need for major refurbishment or replacement of the structures and associated beach renourishment	▪ LGA	▪ Monitoring ▪ Updated CHRMAP	▪ $83.5M at NPV 4% for whole 100-year timeframe ▪ Annual maintenance estimate of approximately $1.0M	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays				x	x
Recommended Medium and Long-term pathway to address Inundation is to replace storm surge barrier (PR6)	▪ Monitoring and maintenance of infrastructure and design and performance reviews in accordance with new information and CHRMAP updates. ▪ Secondary components may include the need for additional levees and drainage improvements as sea level rise progresses	▪ LGA	▪ Monitoring ▪ Updated CHRMAP	▪ Annual maintenance estimate of approximately $0.25M	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays				x	x

Table 8-6 MU6 Recommendations

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Recommended Short-Term Option to address Erosion is Protection with Groynes (PR2)	▪ Assumes 5 rock groynes 75m long, 300m apart along ocean coast: 800m revetment seawall along estuary coast ▪ 2035 Implementation	▪ Southern Ports, Bunbury ▪ LGA	▪ Completed CHRMAP ▪ Monitoring ▪ Confirmation of design, costs and funding ▪ Construction likely to be staged	▪ $8.8M at NPV 4% for whole 100-year timeframe ▪ Detailed design and costings estimated at $200,000	▪ Operational ▪ Grants	x	x	x		
Recommended Short-Term Option to address Inundation is a Levee (PR6)	▪ Assumes 700m levee to cover ocean frontage (400m east of port and 300m on west) ▪ Assume 2020 implementation ▪ Does not address inundation risk from estuary frontage. Further investigation is required as the broader PR6 Option comprising a new storm surge barrier at The Cut did not perform better than the base case for any discount rate	▪ Southern Ports, Bunbury	▪ Completed CHRMAP ▪ Monitoring ▪ Confirmation of design, costs and funding ▪ Confirmation of SLR in accordance with projections to 2035	▪ $1.2M at NPV 4% ▪ Detailed design and costings estimated at $150,000 ▪ Further Investigation of Options for inundation that come from estuary frontage - $150,000	▪ Operational ▪ Grants	x	x	x		
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	▪ Item cost for investigations and management plans	▪ LGA ▪ Southern Ports, Bunbury	▪ Completed CHRMAP	▪ $50,000	▪ Operational	x	x			
Leaving assets unprotected (PMR1)	▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve	▪ Southern Ports, Bunbury	▪ Storm damage ▪ Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable	▪ $360,000 ▪ (Plus 3% annual maintenance of $10,800)	▪ Operational	x	x	x		
Demolition / removal / relocation of asset from inside hazard area (PMR2)	▪ Preparation of Asset Management Plan ▪ To 2035 for public built assets ▪ Allows for removal of building at Wave Walk ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ Removal / Relocation of assets as required	▪ Southern Ports, Bunbury	▪ Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable	▪ $791,000 ▪ (Plus 1% annual maintenance of $7,910)	▪ Operational ▪ Grants	x	x	x		
Prevention of further development / prohibit expansion of existing use rights (PMR3)	▪ Item cost for investigations and management plans ▪ Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat. Seek legal advice regarding the basis of agreements with land holders and whether opt-ins can be time constrained ▪ For this MU controlled by Southern Ports, Bunbury it is envisaged the work may incorporate appropriate clauses into operational and strategic planning and lease conditions.	▪ Southern Ports, Bunbury	▪ Completed CHRMAP	▪ $30,000 ▪ (Plus 1% annual maintenance of $3,00)	▪ Operational ▪ Grants	x	x			

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Design assets to withstand impacts (AC1)	▪ Item cost for investigations and management plans – primarily any case-by-case work needed for public assets	▪ Southern Ports, Bunbury	▪ Completed CHRMAP	▪ $100,000 ▪ (Plus 1% annual maintenance of $1,000)	▪ Operational ▪ Grants	x	x			
Monitoring (NR1)	▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ Routine 6-monthly beach profiles following the summer and winter periods. Minimum every two years in Spring	▪ Southern Ports, Bunbury ▪ Can seek support and assistance from LGA, DoT	▪ Completed CHRMAP ▪ Severe storm event(s)	▪ $10,000 ▪ (Plus 10% annual maintenance of $1,000)	▪ Operational ▪ Grants	x	x	x		
Protection Structure Audit (NR2)	▪ Item cost to inspect condition, influence on sediment transport and inundation and remaining design life on all coastal management structures ▪ Includes Port seawall and Port Breakwaters for Inner Harbour	▪ Southern Ports, Bunbury	▪ Completed CHRMAP	▪ $50,000 ▪ (Plus 2% annual maintenance of $1,500)	▪ Operational ▪ Grants		x	x		
Notification on title (NR3)	▪ Item cost for investigations and implementation plans ▪ For this MU controlled by Southern Ports, Bunbury it is envisaged the work may incorporate appropriate clauses into operational and strategic planning and lease conditions.	▪ Southern Ports, Bunbury ▪ Can seek support and assistance from LGA, DPLH, WALGA	▪ Completed CHRMAP	▪ $50,000 ▪ (Plus 1% annual maintenance of $500)	▪ Operational ▪ Grants	x	x			
Emergency evacuation plans (NR4)	▪ Item cost for investigations and evacuation plans	▪ Southern Ports, Bunbury	▪ Completed CHRMAP	▪ $100,000 ▪ (Plus 1% annual maintenance of $1,000)	▪ Operational ▪ Grants	x	x			
INVESTIGATION 1 Sand Source Feasibility Study	▪ Determine the capacity and cost of local sand supplies, including both land-based and marine sources ▪ Likely require repetition over Medium-term ▪ Focus for this MU is sand nourishment for Southern Ports ocean and estuary frontage, but should also consider the need for appropriate fill to raise height of land in inundation hazard zone	▪ Southern Ports, Bunbury ▪ Can seek support from neighbouring LGA's, PNP, Southern Ports and state departments	▪ Completed CHRMAP	▪ $40,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	
INVESTIGATION 2 Rock Source Feasibility Study	▪ Analyse the availability of rock in terms of density, quarry yields, location and costs ▪ Likely require repetition over Medium-term ▪ Focus for this MU is armour and core rock of all sizes	▪ LGA ▪ Can seek support from neighbouring LGA's, PNP, and state departments	▪ Completed CHRMAP	▪ $40,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
INVESTIGATION 3 Update Foreshore Management Plans (FMPs)	▪ Prepare an updated Foreshore Management Plan ▪ An updated FMP could help increase the protective capacity of the natural dune system. Updates should address the requirements of SPP2.6 and incorporate the findings of this CHRMAP ▪ For this MU controlled by Southern Ports Bunbury it is envisaged the work may incorporate appropriate clauses into operational and strategic planning and lease conditions as well as a joint approach with neighbouring LGA's.	▪ Southern Ports, Bunbury ▪ LGA	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x	x	x	x
Recommended Medium and Long-term pathway to address Erosion is Protection with Groynes (PR2)	▪ Monitoring will determine need for additional stages of groynes in future and the eventual need for major refurbishment or replacement of the structures and associated beach renourishment	▪ Southern Ports, Bunbury ▪ LGA	▪ Monitoring ▪ Updated CHRMAP	▪ $8.8M at NPV 4% for whole 100-year timeframe ▪ Annual maintenance estimate of approximately $0.2M	▪ Operational ▪ Grants				x	x
Recommended Medium and Long-term pathway to address Inundation is a Levee (PR6)	▪ Monitoring and maintenance of infrastructure and design and performance reviews in accordance with new information and CHRMAP updates. ▪ Secondary components may include the need for additional levees and drainage improvements as sea level rise progresses	▪ LGA	▪ Monitoring ▪ Updated CHRMAP	▪ Annual maintenance estimate of approximately $20,000	▪ Operational ▪ Grants				x	x

Table 8-7 MU7 Recommendations

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Recommended Short-Term Option to address Erosion is Protection with Groynes (PR2)	▪ Assumes 2 rock groynes 75m long on ocean-side beach: 320m revetment seawall along estuary coast ▪ 2050 Implementation ▪ Only monitoring and confirmation of concept design required in short-term	▪ LGA	▪ Completed CHRMAP ▪ Monitoring ▪ Confirmation of design, costs and funding ▪ Construction likely to be staged	▪ $2.0M at NPV 4% for whole 100-year timeframe ▪ Detailed design and costings estimated at $200,000	▪ Operational ▪ Grants ▪ Levies	x	x	x		
Recommended Short-Term Option to address Inundation is Design assets to withstand impacts (AC1)	▪ See AC1	▪ See AC1	▪ See AC1	▪ See AC1	▪ Operational ▪ Grants ▪ Levies	x	x	x		
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	▪ Item cost for investigations and management plans	▪ LGA	▪ Completed CHRMAP	▪ $50,000	▪ Operational	x	x			
Leaving assets unprotected (PMR1)	▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve	▪ LGA	▪ Storm damage ▪ Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable	▪ $88,000 ▪ (Plus 3% annual maintenance of $2,640)	▪ Operational	x	x	x		
Demolition / removal / relocation of asset from inside hazard area (PMR2)	▪ Preparation of Asset Management Plan ▪ To 2035 for public built assets ▪ Allows for removal of building at Wave Walk ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ Removal / Relocation of assets as required	▪ LGA	▪ Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable	▪ $194,000 ▪ (Plus 1% annual maintenance of $1,940)	▪ Operational ▪ Grants	x	x	x		
Design assets to withstand impacts (AC1)	▪ Item cost for investigations and management plans – primarily any case-by-case work needed for public assets	▪ LGA	▪ Completed CHRMAP	▪ $50,000 ▪ (Plus 1% annual maintenance of $5,00)	▪ Operational ▪ Grants ▪ Levies	x	x	x		
Monitoring (NR1)	▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ Routine 6-monthly beach profiles following the summer and winter periods. Minimum every two years in Spring	▪ LGA ▪ Can seek support and assistance from Southern Ports, Bunbury and DoT	▪ Completed CHRMAP ▪ Severe storm event(s)	▪ $20,000 ▪ (Plus 10% annual maintenance of $2,000)	▪ Operational ▪ Grants	x	x	x		
Protection Structure Audit (NR2)	▪ Item cost to inspect condition, influence on sediment transport and inundation and remaining design life on all coastal management structures ▪ Includes structures at The Cut	To be confirmed between: ▪ LGA's ▪ DoT ▪ DBCA ▪ Southern Ports, Bunbury	▪ Completed CHRMAP	▪ $50,000 ▪ (Plus 2% annual maintenance of $1,500)	▪ Operational ▪ Grants		x	x		

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Notification on title (NR3)	▪ Item cost for investigations and implementation plans	▪ LGA ▪ Can seek support and assistance from DPLH, WALGA	▪ Completed CHRMAP	▪ $50,000 ▪ (Plus 1% annual maintenance of $500)	▪ Operational ▪ Grants	x	x			
INVESTIGATION 1 Sand Source Feasibility Study	▪ Determine the capacity and cost of local sand supplies, including both land-based and marine sources ▪ Likely require repetition over Medium-term ▪ Focus for this MU is sand nourishment for ocean and estuary frontage, but should also consider the need for appropriate fill to raise height of land in inundation hazard zone	To be confirmed between: ▪ LGA's ▪ DoT ▪ DBCA ▪ Southern Ports, Bunbury	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	
INVESTIGATION 2 Rock Source Feasibility Study	▪ Analyse the availability of rock in terms of density, quarry yields, location and costs ▪ Likely require repetition over Medium-term ▪ Focus for this MU is armour and core rock of all sizes	To be confirmed between: ▪ LGA's ▪ DoT ▪ DBCA ▪ Southern Ports, Bunbury	▪ Completed CHRMAP	▪ $60,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	
INVESTIGATION 3 Update Foreshore Management Plans (FMPs)	▪ Prepare an updated Foreshore Management Plan ▪ An updated FMP could help increase the protective capacity of the natural dune system. Updates should address the requirements of SPP2.6 and incorporate the findings of this CHRMAP ▪ For this MU a joint approach with Southern Ports Bunbury is recommended.	▪ LGA ▪ Southern Ports, Bunbury	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x	x	x	x
Recommended Medium and Long-term pathway to address Erosion is Protection with Groynes (PR2)	▪ Monitoring will determine need for additional stages of groynes in future and the eventual need for major refurbishment or replacement of the structures and associated beach renourishment	▪ LGA	▪ Monitoring ▪ Updated CHRMAP	▪ $2.0M at NPV 4% for whole 100-year timeframe ▪ Annual maintenance estimate of approximately $90,000	▪ Operational ▪ Grants ▪ Levies				x	x
Recommended Medium and Long-term pathway to address Inundation is Design assets to withstand impacts (AC1)	▪ Monitoring ▪ Secondary components may include the need for additional levees and drainage improvements as sea level rise progresses	▪ LGA	▪ Monitoring ▪ Updated CHRMAP	▪ Included as part of Monitoring (NR1)	▪ Operational ▪ Grants ▪ Levies				x	x

Table 8-8 MU8 Recommendations

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Recommended Short-Term Option to address Erosion is Protection with Groynes (PR2)	▪ Assumes 8 rock groynes, 30m long, 100m apart to cover estuary coast from Venezia Blvd north ▪ Assumes 6 groynes to cover section of river foreshore ▪ 2035 Implementation	▪ LGA	▪ Completed CHRMAP ▪ Monitoring ▪ Confirmation of design, costs and funding ▪ Construction likely to be staged	▪ $2.0M at NPV 4% for whole 100-year timeframe ▪ Detailed design and costings estimated at $250,000	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays	x	x	x		
Recommended Short-Term Option to address Inundation requires further investigation	▪ Further investigation is required as the broader PR6 Option comprising a new storm surge barrier at The Cut did not perform better than the base case for any discount rate. It is recommended a feasibility analysis is undertaken to assess its effectiveness with consideration of freshwater flooding events and further civil and maritime design considerations as to what scale of facility would be required.	▪ Jointly between State Government and LGA's	▪ Completed CHRMAP ▪ Monitoring ▪ Investigation of Options, design, costs and funding ▪ Confirmation of SLR in accordance with projections to 2035	▪ Further feasibility investigations estimated at $200,000	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays	x	x	x		
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	▪ Item cost for investigations and management plans	▪ LGA	▪ Completed CHRMAP	▪ $100,000	▪ Operational	x	x			
Leaving assets unprotected (PMR1)	▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve	▪ LGA	▪ Storm damage ▪ Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable	▪ $111,000 ▪ (Plus 3% annual maintenance of $3,330)	▪ Operational	x	x	x		
Demolition / removal / relocation of asset from inside hazard area (PMR2)	▪ Preparation of Asset Management Plan ▪ To 2035 for public built assets ▪ Allows for removal of building at Wave Walk ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ Removal / Relocation of assets as required	▪ LGA	▪ Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable	▪ $244,000 ▪ (Plus 1% annual maintenance of $2,440)	▪ Operational ▪ Grants	x	x	x		
Prevention of further development / prohibit expansion of existing use rights (PMR3)	▪ Item cost for investigations and management plans ▪ Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat. Seek legal advice regarding the basis of agreements with land holders and whether opt-ins can be time constrained	▪ LGA	▪ Completed CHRMAP	▪ $100,000 ▪ (Plus 1% annual maintenance of $1,000)	▪ Operational ▪ Grants	x	x			
Design assets to withstand impacts (AC1)	▪ Item cost for investigations and management plans – primarily any case-by-case work needed for public assets	▪ LGA	▪ Completed CHRMAP	▪ $500,000 ▪ (Plus 1% annual maintenance of $5,000)	▪ Operational ▪ Grants	x	x			
Monitoring (NR1)	▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ Routine 6-monthly beach profiles following the summer and winter periods. Minimum every two years in Spring	▪ LGA ▪ Can seek support and assistance from DoT	▪ Completed CHRMAP ▪ Severe storm event(s)	▪ $30,000 ▪ (Plus 10% annual maintenance of $3,000)	▪ Operational ▪ Grants	x	x	x		

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Protection Structure Audit (NR2)	▪ Item cost to inspect condition, influence on sediment transport and inundation and remaining design life on all coastal management structures ▪ Includes walls along Collie R.	▪ LGA	▪ Completed CHRMAP	▪ $50,000 ▪ (Plus 2% annual maintenance of $1,000)	▪ Operational ▪ Grants		x	x		
Notification on title (NR3)	▪ Item cost for investigations and implementation plans	▪ LGA ▪ Can seek support and assistance from DPLH, WALGA	▪ Completed CHRMAP	▪ $250,000 ▪ (Plus 1% annual maintenance of $2,500)	▪ Operational ▪ Grants	x	x			
Emergency evacuation plans (NR4)	▪ Item cost for investigations and evacuation plans	▪ LGA	▪ Completed CHRMAP	▪ $250,000 ▪ (Plus 1% annual maintenance of $2,500)	▪ Operational ▪ Grants	x	x			
INVESTIGATION 1 Sand Source Feasibility Study	▪ Determine the capacity and cost of local sand supplies, including both land-based and marine sources ▪ Likely require repetition over Medium-term ▪ Focus for this MU is sand nourishment for estuary coast, but should also consider the need for appropriate fill to raise height of land in inundation hazard zone	▪ LGA ▪ Can seek support from neighbouring LGA's, PNP, Southern Ports and state departments	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	
INVESTIGATION 2 Rock Source Feasibility Study	▪ Analyse the availability of rock in terms of density, quarry yields, location and costs ▪ Likely require repetition over Medium-term ▪ Focus for this MU is small to medium armour rock	▪ LGA ▪ Can seek support from neighbouring LGA's, PNP, Southern Ports and state departments	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	
INVESTIGATION 3 Update Foreshore Management Plans (FMPs)	▪ Prepare an updated Foreshore Management Plan ▪ An updated FMP could help increase the protective capacity of the natural dune system. Updates should address the requirements of SPP2.6 and incorporate the findings of this CHRMAP	▪ LGA	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x	x	x	x
Recommended Medium and Long-term pathway to address Erosion is Protection with Groynes (PR2)	▪ Monitoring will determine need for additional stages of groynes in future and the eventual need for major refurbishment or replacement of the structures and associated beach renourishment	▪ LGA	▪ Monitoring ▪ Updated CHRMAP	▪ $2.0M at NPV 4% for whole 100-year timeframe ▪ Annual maintenance estimate of approximately $50,000	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays				x	x
Recommended Medium and Long-term pathway to address inundation requires further investigation	▪ Further investigation is required as the broader PR6 Option comprising a new storm surge barrier at The Cut did not perform better than the base case for any discount rate. It is recommended a feasibility analysis is undertaken to assess its effectiveness with consideration of freshwater flooding events and further civil and maritime design considerations as to what scale of facility would be required.	▪ Jointly between State Government and LGA's	▪ Monitoring ▪ Updated CHRMAP	▪ To be determined following further investigations	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays				x	x

Table 8-9 MU9 Recommendations

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Recommended Short-Term Option to address Erosion is Protection with Groynes (PR2)	▪ Assumes 63 rock groynes, 30m long, approximately 100m apart or as required to treat 25% of shoreline in MU ▪ Locations to be determined ▪ 2020 Implementation	▪ LGA	▪ Completed CHRMAP ▪ Monitoring ▪ Confirmation of design, costs and funding ▪ Construction likely to be staged	▪ $15.5M at NPV 4% for whole 100-year timeframe ▪ Detailed design and costings estimated at $250,000	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays	x	x	x		
Recommended Short-Term Option to address Inundation requires further investigation	▪ Further investigation is required as the broader PR6 Option comprising a new storm surge barrier at The Cut did not perform better than the base case for any discount rate. It is recommended a feasibility analysis is undertaken to assess its effectiveness with consideration of freshwater flooding events and further civil and maritime design considerations as to what scale of facility would be required.	▪ Jointly between State Government and LGA's	▪ Completed CHRMAP ▪ Monitoring ▪ Investigation of Options, design, costs and funding ▪ Confirmation of SLR in accordance with projections to 2035	▪ Further feasibility investigations estimated at $200,000	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays	x	x	x		
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	▪ Item cost for investigations and management plans	▪ LGA	▪ Completed CHRMAP	▪ $150,000	▪ Operational	x	x			
Leaving assets unprotected (PMR1)	▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve	▪ LGA	▪ Storm damage ▪ Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable	▪ $351,000 ▪ (Plus 3% annual maintenance of $10,530)	▪ Operational	x	x	x		
Demolition / removal / relocation of asset from inside hazard area (PMR2)	▪ Preparation of Asset Management Plan ▪ To 2035 for public built assets ▪ Allows for removal of building at Wave Walk ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ Removal / Relocation of assets as required ▪ Allows for removal of building – Leschenault Discovery Centre	▪ LGA	▪ Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable	▪ $853,000 ▪ (Plus 1% annual maintenance of $8,530)	▪ Operational ▪ Grants	x	x	x		
Prevention of further development / prohibit expansion of existing use rights (PMR3)	▪ Item cost for investigations and management plans ▪ Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat. Seek legal advice regarding the basis of agreements with land holders and whether opt-ins can be time constrained	▪ LGA	▪ Completed CHRMAP	▪ $150,000 ▪ (Plus 1% annual maintenance of $1,500)	▪ Operational ▪ Grants	x	x			
Design assets to withstand impacts (AC1)	▪ Item cost for investigations and management plans – primarily any case-by-case work needed for public assets	▪ LGA	▪ Completed CHRMAP	▪ $500,000 ▪ (Plus 1% annual maintenance of $5,000)	▪ Operational ▪ Grants	x	x			

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Monitoring (NR1)	▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ Routine 6-monthly beach profiles following the summer and winter periods. Minimum every two years in Spring	▪ LGA ▪ Can seek support and assistance from DoT	▪ Completed CHRMAP ▪ Severe storm event(s)	▪ $30,000 ▪ (Plus 10% annual maintenance of $3,000)	▪ Operational ▪ Grants	x	x	x		
Protection Structure Audit (NR2)	▪ Item cost to inspect condition, influence on sediment transport and inundation and remaining design life on all coastal management structures ▪ Includes walls along Collie R.	▪ LGA	▪ Completed CHRMAP	▪ $50,000 ▪ (Plus 2% annual maintenance of $1,000)	▪ Operational ▪ Grants		x	x		
Notification on title (NR3)	▪ Item cost for investigations and implementation plans	▪ LGA ▪ Can seek support and assistance from DPLH, WALGA	▪ Completed CHRMAP	▪ $250,000 ▪ (Plus 1% annual maintenance of $2,500)	▪ Operational ▪ Grants	x	x			
Emergency evacuation plans (NR4)	▪ Item cost for investigations and evacuation plans	▪ LGA	▪ Completed CHRMAP	▪ $250,000 ▪ (Plus 1% annual maintenance of $2,500)	▪ Operational ▪ Grants	x	x			
INVESTIGATION 1 Sand Source Feasibility Study	▪ Determine the capacity and cost of local sand supplies, including both land-based and marine sources ▪ Likely require repetition over Medium-term ▪ Focus for this MU is sand nourishment for estuary coast, but should also consider the need for appropriate fill to raise height of land in inundation hazard zone	▪ LGA ▪ Can seek support from neighbouring LGA's, PNP, Southern Ports and state departments	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	
INVESTIGATION 2 Rock Source Feasibility Study	▪ Analyse the availability of rock in terms of density, quarry yields, location and costs ▪ Likely require repetition over Medium-term ▪ Focus for this MU is small to medium armour rock	▪ LGA ▪ Can seek support from neighbouring LGA's, PNP, Southern Ports and state departments	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	
INVESTIGATION 3 Update Foreshore Management Plans (FMPs)	▪ Prepare an updated Foreshore Management Plan ▪ An updated FMP could help increase the protective capacity of the natural dune system. Updates should address the requirements of SPP2.6 and incorporate the findings of this CHRMAP	▪ LGA	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x	x	x	x
Recommended Medium and Long-term pathway to address Erosion is Protection with Groynes (PR2)	▪ Monitoring will determine need for additional stages of groynes in future and the eventual need for major refurbishment or replacement of the structures and associated beach renourishment	▪ LGA	▪ Monitoring ▪ Updated CHRMAP	▪ $15.5M at NPV 4% for whole 100-year timeframe ▪ Annual maintenance estimate of approximately $0.2M	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays				x	x

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Recommended Medium and Long-term pathway to address inundation requires further investigation	▪ Further investigation is required as the broader PR6 Option comprising a new storm surge barrier at The Cut did not perform better than the base case for any discount rate. It is recommended a feasibility analysis is undertaken to assess its effectiveness with consideration of freshwater flooding events and further civil and maritime design considerations as to what scale of facility would be required.	▪ Jointly between State Government and LGA's	▪ Monitoring ▪ Updated CHRMAP	▪ To be determined following further investigations	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays				x	x

Table 8-10 MU10 Recommendations

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Recommended Short-Term Option to address Erosion is Protection with Beach Renourishment (PR1)	▪ Sand nourishment along bank of river for 2,400m ▪ Assumes suitable sand source available (grain size, volume, cleanliness. proximity) ▪ 2035 implementation	▪ LGA	▪ Completed CHRMAP ▪ Monitoring ▪ Confirmation of design, costs and funding ▪ Construction likely to be staged	▪ $1.0M at NPV 4% for whole 100-year timeframe ▪ Annual cost estimate of approximately $50,000	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays	x	x	x		
Recommended Short-Term Option to address Inundation requires further investigation	▪ Further investigation is required as the broader PR6 Option comprising a new storm surge barrier at The Cut did not perform better than the base case for any discount rate. It is recommended a feasibility analysis is undertaken to assess its effectiveness with consideration of freshwater flooding events and further civil and maritime design considerations as to what scale of facility would be required.	▪ Jointly between State Government and LGA's	▪ Completed CHRMAP ▪ Monitoring ▪ Investigation of Options, design, costs and funding ▪ Confirmation of SLR in accordance with projections to 2035	▪ Further feasibility investigations estimated at $200,000	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays	x	x	x		
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	▪ Item cost for investigations and management plans	▪ LGA	▪ Completed CHRMAP	▪ $150,000	▪ Operational	x	x			
Leaving assets unprotected (PMR1)	▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve	▪ LGA	▪ Storm damage ▪ Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable	▪ $44,000 ▪ (Plus 3% annual maintenance of $1,320)	▪ Operational	x	x	x		
Demolition / removal / relocation of asset from inside hazard area (PMR2)	▪ Preparation of Asset Management Plan ▪ To 2035 for public built assets ▪ Allows for removal of building at Wave Walk ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ Removal / Relocation of assets as required	▪ LGA	▪ Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable	▪ $97,000 ▪ (Plus 1% annual maintenance of $970)	▪ Operational ▪ Grants	x	x	x		
Prevention of further development / prohibit expansion of existing use rights (PMR3)	▪ Item cost for investigations and management plans ▪ Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat. Seek legal advice regarding the basis of agreements with land holders and whether opt-ins can be time constrained	▪ LGA	▪ Completed CHRMAP	▪ $250,000 ▪ (Plus 1% annual maintenance of $2,500)	▪ Operational ▪ Grants	x	x			
Design assets to withstand impacts (AC1)	▪ Item cost for investigations and management plans – primarily any case-by-case work needed for public assets	▪ LGA	▪ Completed CHRMAP	▪ $150,000 ▪ (Plus 1% annual maintenance of $1,500)	▪ Operational ▪ Grants	x	x			
Monitoring (NR1)	▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ Routine 6 monthly beach profiles following the summer and winter periods. Minimum every two years in Spring	▪ LGA ▪ Can seek support and assistance from DoT	▪ Completed CHRMAP ▪ Severe storm event(s)	▪ $20,000 ▪ (Plus 10% annual maintenance of $2,000)	▪ Operational ▪ Grants	x	x	x		

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Notification on title (NR3)	▪ Item cost for investigations and implementation plans	▪ LGA ▪ Can seek support and assistance from DPLH, WALGA	▪ Completed CHRMAP	▪ $250,000 ▪ (Plus 1% annual maintenance of $2,500)	▪ Operational ▪ Grants	x	x			
Emergency evacuation plans (NR4)	▪ Item cost for investigations and evacuation plans	▪ LGA	▪ Completed CHRMAP	▪ $250,000 ▪ (Plus 1% annual maintenance of $2,500)	▪ Operational ▪ Grants	x	x			
INVESTIGATION 1 Sand Source Feasibility Study	▪ Determine the capacity and cost of local sand supplies, including both land-based and marine sources ▪ Likely require repetition over Medium-term ▪ Focus for this MU is sand nourishment for river shoreline, but should also consider the need for appropriate fill to raise height of land in inundation hazard zone	▪ LGA ▪ Can seek support from neighbouring LGA's, PNP, Southern Ports and state departments	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	
INVESTIGATION 2 Update Foreshore Management Plans (FMPs)	▪ Prepare an updated Foreshore Management Plan ▪ An updated FMP could help increase the protective capacity of the natural dune system. Updates should address the requirements of SPP2.6 and incorporate the findings of this CHRMAP	▪ LGA	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x	x	x	x
Recommended Medium and Long-term pathway to address Erosion is Protection with Beach Renourishment (PR1)	▪ Monitoring will determine frequency and ongoing volume requirements beach renourishment	▪ LGA	▪ Monitoring ▪ Updated CHRMAP	▪ $1.0M at NPV 4% for whole 100-year timeframe ▪ Annual cost estimate of approximately $50,000	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays				x	x
Recommended Medium and Long-term pathway to address inundation requires further investigation	▪ Further investigation is required as the broader PR6 Option comprising a new storm surge barrier at The Cut did not perform better than the base case for any discount rate. It is recommended a feasibility analysis is undertaken to assess its effectiveness with consideration of freshwater flooding events and further civil and maritime design considerations as to what scale of facility would be required.	▪ Jointly between State Government and LGA's	▪ Monitoring ▪ Updated CHRMAP	▪ To be determined following further investigations	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays				x	x

Table 8-11 MU11 Recommendations

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Recommended Short-Term Option to address Erosion is Protection with Beach Renourishment (PR1)	▪ Nourishment along bank of river for 2,400m ▪ Assumes suitable sand source available (grain size, volume, cleanliness. proximity) ▪ 2035 implementation	▪ LGA	▪ Completed CHRMAP ▪ Monitoring ▪ Confirmation of design, costs and funding ▪ Construction likely to be staged	▪ $1.0M at NPV 4% for whole 100-year timeframe ▪ Annual cost estimate of approximately $50,000	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays	x	x	x		
Recommended Short-Term Option to address Inundation requires further investigation	▪ Further investigation is required as the broader PR6 Option comprising a new storm surge barrier at The Cut did not perform better than the base case for any discount rate. It is recommended a feasibility analysis is undertaken to assess its effectiveness with consideration of freshwater flooding events and further civil and maritime design considerations as to what scale of facility would be required.	▪ Jointly between State Government and LGA's	▪ Completed CHRMAP ▪ Monitoring ▪ Investigation of Options, design, costs and funding ▪ Confirmation of SLR in accordance with projections to 2035	▪ Further feasibility investigations estimated at $200,000	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays	x	x	x		
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	▪ Item cost for investigations and management plans	▪ LGA	▪ Completed CHRMAP	▪ $150,000	▪ Operational	x	x			
Leaving assets unprotected (PMR1)	▪ To 2035 for low-value public assets ▪ Assumes a clean-up rate following damage/loss ▪ No private land acquisition included ▪ Maintenance assumes ongoing allowance for foreshore reserve	▪ LGA	▪ Storm damage ▪ Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable	▪ $44,000 ▪ (Plus 3% annual maintenance of $1,320)	▪ Operational	x	x	x		
Demolition / removal / relocation of asset from inside hazard area (PMR2)	▪ Preparation of Asset Management Plan ▪ To 2035 for public built assets ▪ Allows for removal of building at Wave Walk ▪ Maintenance assumes ongoing allowance for foreshore reserve ▪ Removal / Relocation of assets as required	▪ LGA	▪ Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable	▪ $97,000 ▪ (Plus 1% annual maintenance of $970)	▪ Operational ▪ Grants	x	x	x		
Prevention of further development / prohibit expansion of existing use rights (PMR3)	▪ Item cost for investigations and management plans ▪ Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat. Seek legal advice regarding the basis of agreements with land holders and whether opt-ins can be time constrained	▪ LGA	▪ Completed CHRMAP	▪ $100,000 ▪ (Plus 1% annual maintenance of $1,000)	▪ Operational ▪ Grants	x	x			
Design assets to withstand impacts (AC1)	▪ Item cost for investigations and management plans – primarily any case-by-case work needed for public assets	▪ LGA	▪ Completed CHRMAP	▪ $150,000 ▪ (Plus 1% annual maintenance of $1,500)	▪ Operational ▪ Grants	x	x			
Monitoring (NR1)	▪ Beach survey for storm behaviour and to track HSD and inundation levels ▪ Routine 6-monthly beach profiles following the summer and winter periods. Minimum every two years in Spring	▪ LGA ▪ Can seek support and assistance from DoT	▪ Completed CHRMAP ▪ Severe storm event(s)	▪ $10,000 ▪ (Plus 10% annual maintenance of $1,000)	▪ Operational ▪ Grants	x	x	x		

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Notification on title (NR3)	▪ Item cost for investigations and implementation plans	▪ LGA ▪ Can seek support and assistance from DPLH, WALGA	▪ Completed CHRMAP	▪ $100,000 ▪ (Plus 1% annual maintenance of $1,000)	▪ Operational ▪ Grants	x	x			
Emergency evacuation plans (NR4)	▪ Item cost for investigations and evacuation plans	▪ LGA	▪ Completed CHRMAP	▪ $100,000 ▪ (Plus 1% annual maintenance of $1,000)	▪ Operational ▪ Grants	x	x			
INVESTIGATION 1 Sand Source Feasibility Study	▪ Determine the capacity and cost of local sand supplies, including both land-based and marine sources ▪ Likely require repetition over Medium-term ▪ Focus for this MU is sand nourishment for river shoreline, but should also consider the need for appropriate fill to raise height of land in inundation hazard zone	▪ LGA ▪ Can seek support from neighbouring LGA's, PNP, Southern Ports and state departments	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x		x	
INVESTIGATION 2 Update Foreshore Management Plans (FMPs)	▪ Prepare an updated Foreshore Management Plan ▪ An updated FMP could help increase the protective capacity of the natural dune system. Updates should address the requirements of SPP2.6 and incorporate the findings of this CHRMAP	▪ LGA	▪ Completed CHRMAP	▪ $30,000 ▪ Assumes only undertaken for this MU in isolation, but synergies should be investigated.	▪ Operational ▪ Grants	x	x	x	x	x
Recommended Medium and Long-term pathway to address Erosion is Protection with Beach Renourishment (PR1)	▪ Monitoring will determine frequency and ongoing volume requirements beach renourishment	▪ LGA	▪ Monitoring ▪ Updated CHRMAP	▪ $1.0M at NPV 4% for whole 100-year timeframe ▪ Annual cost estimate of approximately $50,000	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays				x	x
Recommended Medium and Long-term pathway to address inundation requires further investigation	▪ Further investigation is required as the broader PR6 Option comprising a new storm surge barrier at The Cut did not perform better than the base case for any discount rate. It is recommended a feasibility analysis is undertaken to assess its effectiveness with consideration of freshwater flooding events and further civil and maritime design considerations as to what scale of facility would be required.	▪ Jointly between State Government and LGA's	▪ Monitoring ▪ Updated CHRMAP	▪ To be determined following further investigations	▪ Operational ▪ Grants ▪ Specified Area Rate ▪ Levies ▪ User Pays				x	x

9 SUMMARY AND NEXT STEPS

In this report, one or more Options have been recommended to proceed for further investigation and/or implementation for each MU for both erosion and inundation. The recommendations have considered the CBA results holistically as well as being cognisant of the findings of previous stages of the CHRMAP.

The next stage for the project is to complete four Final CHRMAP summary reports – one for each local government - which will incorporate the findings of all the previous chapter reports including this one.

APPENDIX A
ENGAGEMENT SUMMARY REPORT

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Code	Page/Section	Topic	Issue	Suggested changes	General Comments	Response
B001	page 20/Stage C	Community values	Inclusion of local surf breaks/waves value CHRMAP survey of beach-wave users - 26 th July 2021 to 10 th September 2021. - 181 survey responses = 84 CHRMAP values survey responses online, 97 hard copy - 56 'pins' on the map. - Whilst 'place of residence' was not included in the survey, approximately 30% .. 54 respondents .."visited beaches in the City of Bunbury most often." Bunbury Boardriders Club has 147 members Who utilise the western beaches on a daily-weekly basis and visit unique Surf-wave locations around Bunbury	- Review 'Bunbury Region Wave Map 2023' (BRWM_23) - Contact/Provide on-line consult opportunity for local-regional Boardriders / Surf Clubs - Provide on-line consult opportunity for PUBLIC/non-Club affiliated residenrts , prior to final CHRMAP release - Update 'BRWM_23' respective of weighted community consult - Update CHRMAP 2023 final	Well done, what a massive effort for the document!	Edits have been made to the document to acknowledge its status as a strategic planning document and noting the future work required before implementation of adaptation options on the ground. The CHRMAP recommends protection for Bunbury Back Beach going forward. Groynes have been identified as the most cost-effective option to implement this pathway based on available information. High-level concept design work has been undertaken to allow budget estimates. Further consideration of the local coastal processes, design and costs is required before these recommendations can be progressed to seek funding, environmental impact assessment and approvals/endorsement. It is recommended further localised engagement takes place through this process, including with the Bunbury Boardriders Club, with reference to the Bunbury Region Wave Map 2023.
B002			Groynes	No groynes - old technology. Preferred optins are: 1. artificail reef. 2. sand dumping. Move assets (road etc). With the environment and tourisim being more and more important in the future we need to protect our unique back beach. Groynes will be an eyesore, impedes walking/beach use, reduce social amenity	Other Council areas in WA are using artificail reefs so why cant Bunbury. The environment is more important that doing the cheapest option.	Edits have been made to the document to acknowledge its status as a strategic planning document and noting the future work required before implementation of adaptation options on the ground. The CHRMAP recommends protection for Bunbury Back Beach and Koomaban Bay going forward. Groynes have been identified as the most cost-effective option to implement this pathway based on available information. High-level concept design work has been undertaken to allow budget estimates. Further consideration of the local coastal processes, design and costs is required before these recommendations can be progressed. Composite protection options may be effective for Bunbury Back Beach, including sections of sand nourishment in combination with seawalls and offshore breakwaters instead of groynes. Following cost-benefit analysis Managed Retreat is not recommended. Artificial reefs are not well-suited to coastal protection in this part of WA as the low tidal range means they are often ineffective during ocean storms with high water levels from storm surge. It is recommended further localised engagement takes place through this process, including with local community members and stakeholders as design work is progressed to ensure the protection pathway is representative of and appropriate to the City and community.
B003					The Capel to Leschenault Coastal Hazard Risk Management & Adaption Plan (CHRMAP) is useful but only in so far as it sets out a collation of some general information about the Bunbury coast in the one document. Beyond this, the usefulness of the CHRMAP is problematic and we encourage the City of Bunbury to act with caution. This document is inadequate as means to direct and action any coastal hazard risk management. The City has considerable responsibility now to ensure the major environmental, social, and economic consequences of this CHRMAP upon the community, and how this community interacts with and values this precious coastal asset, are meaningful and reasonable. The City of Bunbury Surf Life Saving Club has several key concerns with this CHRMAP process, as well as the conclusions reached and how this document will be applied in future decision The CHRMAP document has been advertised on the City of Bunbury web page as a "draft plan to improve understanding of our changing coastline and to help inform future coastal planning" yet the document in the link states it is a final CHRMAP. The language in the body of the final CHRMAP does not use the word draft or suggested or still to be determined, instead stating it details an implementation plan ready to action. Most concerningly, it appears the scope of the problem to be addressed is not yet fully understood. Although it is not yet fully understood, fixed solutions are set out and costed and ready to be actioned, alarmingly for benefit in 2120, not now or necessarily between now and 2120. This is a giant leap frog ahead without due process to guide action, resulting in largely under-informed, disconnected, if not unrealistic recommendations. This, and the obvious lack limited engagement with the Surf Life Saving club and the community more broadly is worrying.	Edits have been made to the document to acknowledge its status as a strategic planning document and noting the future work required before implementation of adaptation options on the ground. The document was advertised as a final draft seeking full and complete feedback from the public considering its intended format and content. It is recognised that further engagement will be required. Notwithstanding, there was repeated and legitimate attempts to engage with the public and stakeholders during the process and the project team acknowledges that the involvement of the public and stakeholders was limited for the level of impact expected on the Bunbury coastline. The document has been updated to include recommendations for further localised engagement takes place through this process, including with local community members and stakeholders as design work is progressed to ensure the protection pathway is representative of and appropriate to the City and community. We note that there have been some concerns on the methodology, the hazard maps and what it means for the Bunbury community in terms of implementation which is understandable. Public consultation is a key component of CHRMAP project so that issues can be identified and communicated in the process. Most effective solutions can be planned when supported by the community. The document follows the requirements of both technical content and format per State Planning Policy 2.6. The methodology prescribed by SPP2.6 has been used to come up with a conservative allowance for coastal hazards so it can be used to identify vulnerable assets and plan for their adaptation. The method is not structured to come up with the best estimate of shoreline position at a given timeframe. The process is based upon the best available data and represents a conservative estimate that includes allowance for uncertainty. In order to refine coastal hazard allowances, the CHRMAP data collection and investigation recommendations can be implemented. Other implementation actions are trigger based, which the coastal monitoring can assist with. In summary the CHRMAP has been completed using best currently available information. The purpose of the project is to conservatively identify an allowance for coastal hazards to allow identification of vulnerable assets to inform future planning and risk management. SPP2.6 defines an appropriate measure to assess the varied positive and negative impacts of coastal hazard management options through a Multi-Criteria Assessment framework. Criteria set consider environmental, social, and economic sustainability, as well as more fundamental factors such as effectiveness (does it work). Ongoing reviews and a presumption that more public and stakeholder feedback will be forthcoming based on the response to the draft CHRMAP, will help to refine these criteria and improve the long term CHRMAP actions. The document was undertaken using available information at the time over an 18 month period. It is expected that new information will continue to come to light beyond the conclusion of this project, which is why the CHRMAP recommends regular reviews (as also required by SPP 2.6). The CHRMAP recommends protection for Bunbury Back Beach and Koombana Bay going forward. Groynes have been identified as the most cost-effective option to implement this pathway based on available information. High-level concept design work has been undertaken to allow budget estimates. Further consideration of the local coastal processes, design and costs is required before these recommendations can be progressed to seek funding, environmental impact assessment and approvals / endorsement. Composite protection options may be effective for Bunbury Back Beach, including sections of sand nourishment in combination with seawalls and offshore breakwaters instead of groynes. It is recommended further localised engagement takes place through this process, including with the Bunbury Surf Life Saving Club.

As the City will be aware, the City of Bunbury Surf Life Saving Club is the oldest regional lifesaving club in Western Australia, with history at the Bunbury Back Beach dating back to the early 1900's. The club community is extensive, and the membership has a wealth of current and historical knowledge about the Bunbury Back Beach and the Bunbury coast more generally, none of which has been engaged with.
The Surf Life Saving Club provides an essential, volunteer community service. It is a community use that requires a home in situ on the beach, now and in 100 years' time. Preserving this, and the beauty and function and accessibility of our coastline is paramount to the Club and its membership.
We suggest these same aspirations and values equally apply to the overall Bunbury community and its future sustainability plus highly valued, way of coastal life.
In this context, key concerns are:

Planning actions to deliver now that serve a 100-year horizon lacks sophistication. We are aware of considerable industry criticism about this method in the CHRMAP framework. It is apparent that to take this 'background' anywhere, far more detailed, careful investigation, science, engagement, and evaluation is required.
The methodology for suggested management actions and their cost appears arbitrary and to grossly undervalue the impact and cost on landowners and the community impacted by the 100-year coastal hazard line. This cannot be underestimated. The coastal values survey in the CHRMAP is superficial at best.
Community and stakeholder involvement was stated in the CHRMAP document to be a critical component of the CHRMAP process. However, the number of survey responses and workshop participants compared to population and/or impacted people and landowners, is not considered meaningful let alone statistically valid. It is alarming that consultation (not engagement) with only a handful of individual community representatives is largely the basis for (hugely expensive and dramatic if not detrimental) preferred risk mitigation actions.

For a shared environmental project across a large stretch of coast with many government agencies involved, it is concerning this exercise does not include an overarching strategic view or a strategic evaluation of issues then solutions between and across Management Units and Local Government areas. There are no actions and/or responses that leverage from and address principles of environmental, social, and economic sustainability, ideally for net community benefit at short, medium as well as longer term horizons.

The documentation is highly repetitive, high level and generic. This exercise appears largely desktop lacking detailed new, meaningful, site specific data and analysis, or only vague references to how this will be obtained let alone factored in. This information is required to inform decision making, not worked out afterwards.

The report is voluminous and not easy for the average person to follow, which makes it inaccessible to the community to understand. The very low turnout at the singular drop-in information session reiterates and demonstrates a low understanding in the community broadly about this project and implications of the recommendations it makes.

The lack of reference to historical coastal erosion, which is understood to be available back to the 1950's, has not been referenced. This history would appear to show limited coastal erosion along much of this coastline in the last 80 years, including in the last approximately 30 years when climate change and sea level rise has been accelerating.

It would appear short term, (relatively) low-cost protective measures, such as regeneration of existing dunes and improved management of the coastal environs now, is overlooked yet may deliver considerable benefits.
In addition to the Waterfront project, which will have considerable coastal impact and is not examined in any detail, an artificial reef and wave pillow are presently being pursued for installation in the City of Bunbury. Why is a combination of solutions, and for varying time horizons, relative to different thresholds or climate events eventuating (or not), even recognising likely technological advancement, not explored?

Stage 3 of the Bunbury Waterfront project, Environmental Review process has only just begun yet appears referenced as a certainty in this CHRMAP. Extensive documents including a more detailed CHARMAP and environmental assessments for this was only released for public comment this week and is yet to be approved.
Flooding is an historical issue in Bunbury. It appears the solution for the inlet and East Bunbury is reasonably straightforward, substantively raising the inlet flood gate height to address sea level change.
For South Bunbury, the CHRMAP demonstrates consequence of future sea level rise with no intervention however the possible solutions to address this are vague. This issue requires close examination and community engagement ahead of any action. This is an existing drainage and waterway problem, not just a new coastal hazard matter.

					Proposed x 15 Rock Groins along Back Beach The monitoring activities described in the CHRMAP document are presently absent but are duly identified as being required first. This information is required to identify the impacts of the recommended Options, used to guide decisions about which really is the best solution or suite of solutions to pursue. This is therefore critical for future successful implementation in both the short term and long term. The question we ask prior to any Option being undertaken; will the City of Bunbury undertake the monitoring recommendations as recommended in CHRMAP? Site specific monitoring and investigation is also recommended to be undertaken and this is considered pivotal in managing coastal hazard risk. Will the City of Bunbury also undertake this recommendation prior to any decision making? The City of Bunbury Surf Life Saving Club strongly recommends that further investigation and monitoring of site-specific zones is critical prior to any discussion or decision about which option is best. The suggestion of so many groins is a dramatic and expensive change and other options may preferential or at least pursued at variable thresholds. This requires very careful environmental, social, and economic evaluation, as well as community engagement, before these suggestions advance anywhere. Ongoing lease of coastal facilities On page 65 of the CHRMAP, LU6 suggests a review of all coastal leasehold facilities. This action is critical to the future of the Surf Life Saving Club but seems brushed over. As it continues to do, the Surf Club expects to work closely with the city as it manages this important community asset, with aim to preserve viability now and well into the future. This is a harsh coastal environment and as the city is aware, to remain fit for purpose, the City of Bunbury Surf Life Saving Club building has been redeveloped over its 100+ year history. Knowledge of the process, timeline, and framework that the City of Bunbury has developed in respect to the Final CHRMAP recommendations must be communicated and collaborated with the key stakeholders. Has the City of Bunbury developed this framework and timeline of process and implementation, and if yes, when will this be communicated to stakeholders to ensure their future planning can be knowledgeable and informed? Realistically future proofing the club's viability and its physical premises is critical to the role the City of Bunbury Surf Life Saving Club has within the community and the wider south west region.	
B004					Recently, staff from DBCA has been working on the sand dunes in the vicinity of the path from the Mindalong Beach car park over the dunes to Mindalong Beach. They did some cursory work on the path itself but mostly stabilising the sand dunes against blowouts caused by foot traffic by people avoiding the hazardous steep path from the seaward lookout down to the beach. This is the classic situation of placing an ambulance at the bottom of a cliff, instead of a fence at the top. If the steep path down to the beach was made less hazardous, people would not climb down the dunes to avoid it. I have seen people having to assist their dogs to climb up the big benches made in the sand on the path. At the bottom, fabric with big spaces has been pegged in over the sand benches, making it difficult not to trip over toes caught in the fabric. The obvious solution is to install proper steps on the steep part of the track.	
B005	Page 33 Section 4.4	Coastal Assets and Community Values	The list of 'key coastal, estuarine and riverine values identified by participants across the whole study area' neglects to include Ocean Drive as a key value, including the various facilities adjacent to this road (e.g. parks, car parks, surf lifesaving club, café, paths, lighting, toilets, landscaped gardens etc.). Ocean Drive is the most regionally significant route in the City of Bunbury as it provides crucial access and enjoyment of the coast to both residents and visitors alike.	Under the list of 'key coastal, estuarine and riverine values identified by participants across the whole study area', add the following point: •Ocean Drive, including the various facilities adjacentto this road (e.g. parks, car parks, surf lifesavingclub, café, paths, lighting, toilets, landscapedgardens etc.).	The draft CHRMAP needs to specify the significant existing coastal assets, such as Ocean Drive and the various facilities adjacent (e.g. parks, car parks, surf lifesaving club, café, paths, lighting, toilets, landscaped gardens etc.), that must be protected to ensure the future economic and social wellbeing of the City of Bunbury.	The comments are acknowledged and will be considered in future coastal management but are considered outside the consultant's scope of work for this project. It has been recommended the Foreshore Management Plan be updated for this area. Monitoring should inform futher decision making, as recommended in the CHRMAP.
	Page 34 Section 4.4	Coastal Assets and Community Values	The list of 'key issues and concerns / risks to the coastal values' neglects to include the loss of the current high level of access to the coast and its amenities by residents and tourists.	Under the list of 'key issues and concerns / risks to the coastal values', add the following point: •The loss of the current high level of access to the coast and its amenities by residents and tourists.		The detailed comments are acknowledged. Ocean drive and associated public land and infrastructure have been quantified in the assets and values identification stage and again consdered in the assessment and design and costing of options. The value associated with these is a contributing factor to the recommendation of protection for this section of coast. With regard to suggestions to further detail around recommendations, edits have been made to the document to acknowledge its status as a strategic planning document and noting the future work required before implementation of adaptation options on the ground. The CHRMAP includes 'Beach erosion and its environmental, social and financial impacts', which considers community values of access to the beach and financial impacts to tourism functions. These comments now form part of the final reporting, and will be available for consideration during future coastal management investigations.

Page 35 Section 4.4 Table 4-1	Coastal Assets and Community Values	The 'snapshot of assets at risk' column for MU5 – Bunbury in Table 4-1 lists 'approximately 340 roads at risk of inundation by 2120; 57 by erosion'. However, there is no distinction made to the importance of some roads over others, particularly Ocean Drive which is not only the most regionally significant route in MU5 – Bunbury study area, but also the City of Bunbury more generally, as it provides crucial access and amenities, and hence enjoyment of the open coast to both residents and visitors alike.	Under the 'Snapshot of Assets at Risks' column for MU5 –Bunbury in Table 4.1 add the following point: •The regionally significant route of Ocean Drive,including the various facilities adjacent to this road, is at immediate risk of erosion.		
Page 36 Section 4.5 Table 4-2	Success Criteria	The following two 'success criteria' in Table 4-2 are supported:"• Maintain critical infrastructure supporting the community (roads, utilities). •Manage and maintain coastal infrastructurethat provides access to the water andsupports the lifestyle enjoyed by people inthe region." However, and again, there is no proper distinction made to the importance of some roads and their utilities and coastal infrastructure over others. In this respect, roads such as Ocean Drive, including its utilities / services, and the coastal infrastructure / facilities within the road reserve and reserves adjoining (i.e. seaward side), hold greater importance and significance to Bunbury's economic and social wellbeing, and should have higher independent recognition.	Re-word the following two 'success criteria' as follows: •Maintain critical infrastructure supporting the community (roads, utilities), with priority given to roads and their utilities that have provide the greatest economic and social benefits to the City of Bunbury and region generally. •Manage and maintain coastal infrastructure thatprovides access to the water and supports thelifestyle enjoyed by people in the region, with prioritygiven to coastal infrastructure that have provide thegreatest economic and social benefits to the City ofBunbury and region generally.	The suggested wording will not serve to increase maintenance of Ocean Drive further.	
Page 52 Section 7.1.5 Table 7-2	Recommended option(s) for further consideration for each MU	The recommended option of 'PR2 – Groynes' for MU5 – Bunbury in Table 7-2 is supported, but with caution, as careful design, location, and construction is required in order to ensure these are effective, longstanding solutions that requirement minimal ongoing maintenance, and don't cause excessive sand accretion and / or seagrass accumulation in some locations, and erosion in others. Groynes often solve the problem for one location, only to shift the problem further along the coast in the direction of the longshore drift.	No change - recommendation supported without change.		
Page 53 Section 7.1.5 Table 7-3	Recommended option(s) for further consideration for each MU	The recommended option of 'PR6 – Storm Surge Barrier' for MU5 – Bunbury in Table 7-3 is supported.	No change - recommendation supported without change.		
Page 60 8.1.1.2.1	Special Control Area	A special control area (SCA) based on the position of the 2120 coastal processes setback line is cautiously supported, however, there needs to be proper consultation on the final manner and form of such SCA to ensure that any development regulation to manage hazard exposure, will be (as stated) assessed on a case-by-case basis to control over the intensification of land where coastal risks are prominent (and real). Ideally, the SCA should be used as a statutory instrument for application of a comprehensive local planning policy (LPP) for the proper assessment of applications for development approval.	This section should state that an SCA can and should be used as a statutory instrument for application of a local planning policy that gives proper criteria (including performance approaches) for the assessment of applications for development approval in the SCA.	This is included in the advertised draft at Table 81.	
Page 61 8.1.1.2.2	Local Planning Policy	A comprehensive LPP that is used for development assessment is recommended over any inflexible, regulatory-like provisions in an SCA.	This section should be revised to identify that an LPP can and should be used for proper assessment of applications for development approval in any SCA.	This is included in the advertised draft at Table 81.	

Page 61 8.1.1.2.3	Notifications on Titles	Notifications on title triggered by development or subdivision approval applications are the most sensible instrument for private properties that are not likely to be subject to coastal erosion until well after 2050, allowing these to be redeveloped and enjoyed / benefitted from over the ordinary lifespan of the redevelopment before the risk presents. Notwithstanding this, the wording of such notification(s) will be important.	No change - recommendation supported without change.		
Page 65 Section 8.2 Table 8-2	Content for City of Bunbury local planning scheme amendment appendix in accordance with LU1.	The 'Additional Provisions' of the SCA in Table 8-2 are supported because they require due regard to be given to local planning policies, and the wording of the notification is the standard adopted by the Western Australian Planning Commission (WAPC).	No change - recommendation supported without change.		
Page 74 Section 8.7.1 Table 8-3	Short-Term Recommendations	The short-term erosion and inundation recommendations in Table 8-3 for MU5 – Bunbury of 'Protection with Groynes (PR2)' and 'Replace storm surge barrier (PR6)' respectively are supported. However, again a level of caution is urged as careful design, location and construction is required in order to ensure groynes are effective, longstanding solutions that requirement minimal ongoing maintenance, and don't cause excessive sand accretion and / or seagrass accumulation in some locations, and erosion in others. Groynes often solve the problem for one location, only to shift the problem further along the coast in the direction of the longshore drift.	Under the 'Erosion Recommendations' column for MU5 – Bunbury, add the following point: • Groynes to be designed, located and constructed carefully in order to ensure they are effective, longstanding solutions that requirement minimal ongoing maintenance, and do not cause excessive sand accretion and / or seagrass accumulation in some locations, and erosion in others.		
Page 79 Section 8.7.2 Table 8-5	Medium and Long-Term Recommendations	The recommendations of 'Design assets to withstand impacts (AC1)' and 'Protection Structure Audit (NR2)' in Table 8-5 (MU5 – Bunbury) are supported, particularly the latter citing the 'ocean coast seawalls generally. However, these needs to give priority to the assets and structures of Ocean Drive including the various facilities adjacent to this road of regional significance (e.g. parks, car parks, surf lifesaving club, café, paths, lighting, toilets, landscaped gardens etc.). It is inappropriate to leave this to 'case-by-case work needed to public assets'.	Under the 'Notes' column of recommendations 'Design assets to withstand impacts (AC1)' and 'Protection Structure Audit (NR2)' for MU5 – Bunbury, add the following point: •The assets and structures of Ocean Drive includingthe various facilities adjacent to this road of regionalsignificance (e.g. parks, car parks, surf lifesavingclub, café, paths, lighting, toilets, landscapedgardens etc.) are to be given priority in the design ofassets to withstand impacts and protection structureaudit, given their high economic and socialimportance to Bunbury and the region.		

Appendix 10.5.1-B

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Report

City of Bunbury Short-Term Coastal Action Plan

City of Bunbury

2 April 2024

Document Status

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Project Details

Project Name	City of Bunbury Short-Term Coastal Action Plan
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Environment ISO 14001 SAI GLOBAL
OHS ISO 45001 SAI GLOBAL

ACKNOWLEDGEMENT OF COUNTRY

The Board and employees of Water Technology acknowledge and respect the Aboriginal and Torres Strait Islander Peoples as the Traditional Custodians of Country throughout Australia. We specifically acknowledge the Traditional Custodians of the land on which our offices reside and where we undertake our work.

We respect the knowledge, skills and lived experiences of Aboriginal and Torres Strait Islander Peoples, who we continue to learn from and collaborate with. We also extend our respect to all First Nations Peoples, their cultures and to their Elders, past and present.

Artwork by Maurice Goolagong 2023. This piece was commissioned by Water Technology and visualises the important connections we have to water, and the cultural significance of journeys taken by traditional custodians of our land to meeting places, where communities connect with each other around waterways.

The symbolism in the artwork includes:

- *Seven circles representing each of the States and Territories in Australia where we do our work*
- *Blue dots between each circle representing the waterways that connect us*
- *The animals that rely on healthy waterways for their home*
- *Black and white dots representing all the different communities that we visit in our work*
- *Hands that are for the people we help on our journey*

2 April 2024

Stacey Meredith
Coordinator Environment and Sustainability
City of Bunbury
10 Sutherland Way
Picton WA 6229

Via email: smeredith@bunbury.wa.gov.au

Dear Stacey

City of Bunbury Short-Term Coastal Action Plan

Thank you for engaging Water Technology to prepare this Coastal Action Plan for the City of Bunbury. We trust the plan meets your requirements and we look forward to the opportunity to work with you and the City again on future projects.

Yours sincerely

K.A. Ilich

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WATER TECHNOLOGY PTY LTD

EXECUTIVE SUMMARY

The City of Bunbury (City) coastline is projected to experience significant coastal erosion and inundation which will place pressure on public and private assets along the foreshore. The City engaged Water Technology to prepare this Short-Term Coastal Action Plan. The aim of the project is to assist the City's Staff and Elected Members in prioritising, budgeting, scoping and implementing coastal actions recommended by the City's recently completed Coastal Hazard Risk Management and Adaptation Plan (CHRMAP; Water Technology, 2023) over the next 5-years (2024-25 to 2028-29 inclusive).

The City's CHRMAP addressed coastal hazard vulnerabilities for the City's shoreline by dividing it into five Management Units and recommending adaptation pathways and options to manage the coastal erosion and inundation risk in the City to give preliminary direction for future investigations and funding opportunities. The CHRMAP is a strategic planning document that considers long timeframes. While the CHRMAP provides a rationale for coastal hazard management a substantial amount of preparatory work, detailed in the CHRMAP recommendations, is required before "on-the-ground implementation" can proceed.

The CHRMAP noted that the proposed options should be the subject of further investigations, surveys, policy review, impact investigations, development approval and authorities' endorsement, local stakeholder and community engagement, preliminary design, detailed design, costing and any other applicable preparation work required prior to be implemented. The summary report noted that options should be optimised and modified following such additional investigations.

This Action Plan presents 14 coastal actions for the City to commence these investigations and confirm several of the assumptions used in the CHRMAP:

1. Storm impact monitoring.
2. Coastal management register.
3. Field photos.
4. Coastal management training for City staff.
5. Sand source feasibility study.
6. Foreshore asset audit.
7. Beach and foreshore topographic survey – provisional.
8. Emergency evacuation plan.
9. Coastal protection structure audit.
10. Update Foreshore Management Plans.
11. Geotechnical investigations.
12. Rock source feasibility study.
13. Bathymetric survey.
14. Metocean data collection.

CONTENTS

APPENDICES

LIST OF FIGURES

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1 INTRODUCTION

The City of Bunbury (City) coastline is exposed to a significant level of coastal hazard risk (specifically coastal erosion and inundation), which will place pressure on public and private assets along the foreshore. The City engaged Water Technology to prepare this Short-Term Coastal Action Plan. The aim of the project is to assist the City's Staff and Elected Members in prioritising, budgeting, scoping, and implementing the various coastal management actions that were recommended by the City's recently completed Coastal Hazard Risk Management and Adaptation Plan (CHRMAP; Water Technology, 2023) over the next 5-years (2024 to 2028 inclusive).

1.1 Project Area

The broader study area (Figure 1-1) for the Capel to Leschenault CHRMAP project covers four Local Government Areas (LGAs) - namely the Shire of Harvey, the City of Bunbury, the Shire of Dardanup, and Shire of Capel. The CHRMAP (Water Technology, 2023) addresses coastal hazard vulnerabilities for the City's shoreline – and is divided into five Management Units (MU):

- MU4 – Bunbury South
- MU5 – Bunbury (including Five Mile Brook district, Koombana Bay, Leschenault Inlet)
- MU6 – Bunbury Port (Inner Harbour)
- MU7 – The Cut
- MU8 – Bunbury East

1.2 Scope of Works

This Short-Term Coastal Action Plan includes the following components:

1. Review of CHRMAP assumptions and recommendations.
2. Liaise with the City and its Coastal Partners.
3. Confirm cost estimate for recommended activities.
4. Identify any actions required beyond the 5-year timeframe.
5. Present detailed coastal management recommendations as actions.

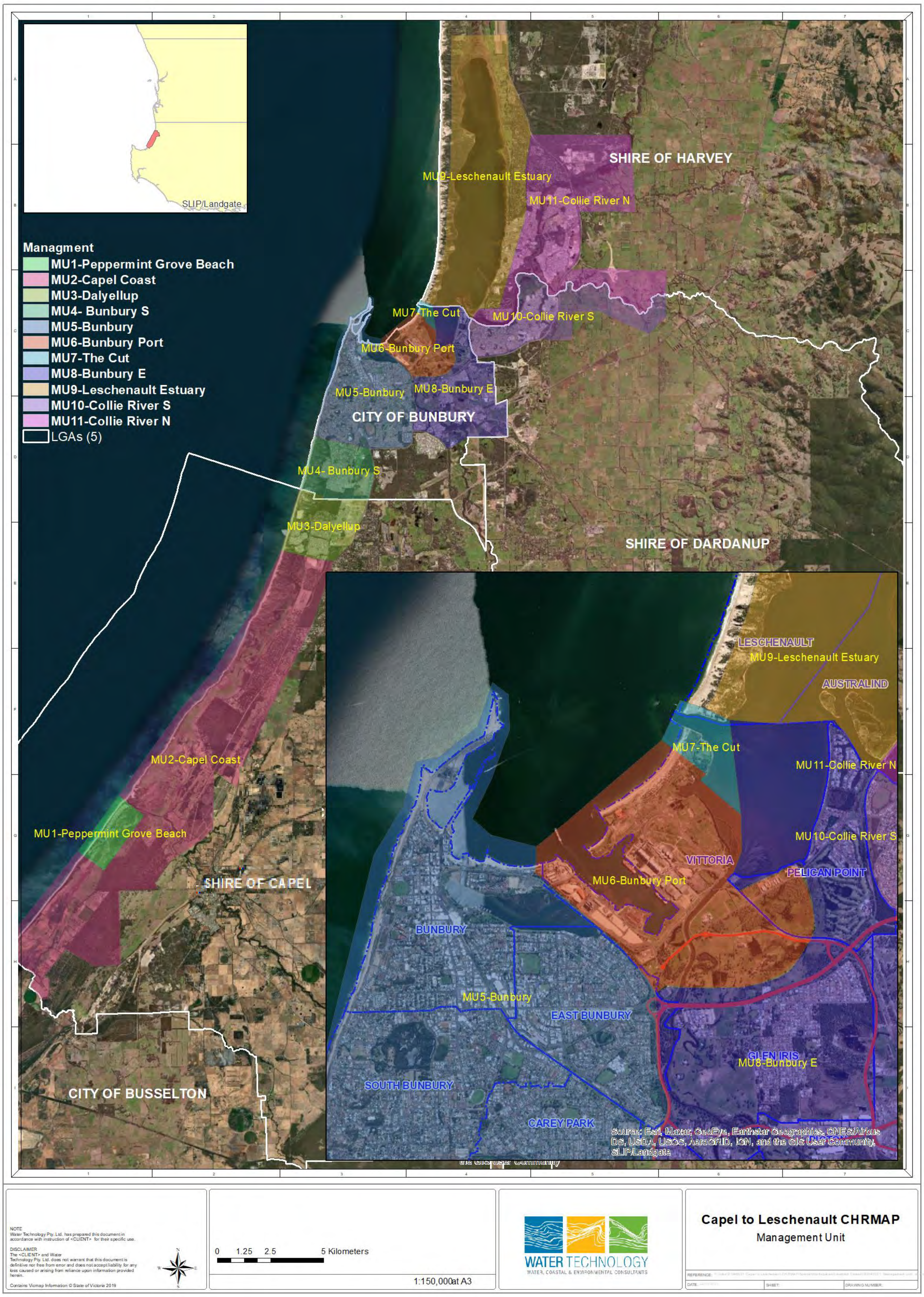

Figure 1-1 Study Area and Management Units

2 SUMMARY

The City's CHRMAP has identified a range of coastal management actions for the City to undertake over a forward 5 year planning period. These actions relate to coastal monitoring, investigation, and adaptation actions – and are presented in Table 2-1 below. The following summary information for each action is provided:

1. Overview,
2. Applicable location
3. Budget cost estimates, and
4. Timing – noting that some actions are sequential and rely on the outputs of other actions, and other actions have been ordered in terms of recommended priority and with consideration of City resources and sustainable delivery over the 5 year timeframe.

The remaining report content includes:

- The project background, including the relationship of this project to the City's CHRMAP documents, in Section 3.
- The method used to undertake investigations and prepare the recommended actions, in Section 4.
- A summary of planned coastal management actions by the City's coastal neighbours is provided in Section 5.
- Identification of actions that are likely to be required beyond the 5-year timeframe of this plan, in Section 6.
- Further descriptive information is provided for each recommendation in Section 7.

Table 2-1 Coastal monitoring, investigation and adaptation actions recommended for the next 5 years, listed by recommended year of implementation.

Action	Overview	Location	Related Actions	Cost (excl. GST)	Timing
Storm impact monitoring.	Prepare for, and undertake, storm impact monitoring during and immediately after severe ocean storm events.	CHRMAP MU's 4, 5, 6, 7, 8.	N/A.	$10,000. (Only required if an external surveyor needs to be used after a severe storm.)	2024-25 and ongoing.
Coastal management register.	Implement and maintain a coastal management register for monitoring and management actions.	CHRMAP MU's 4, 5, 6, 7, 8.	N/A.	N/A. Internal City resourcing only (in kind).	2024-25 and ongoing.
Field photos.	Collect beach and foredune monitoring photos at the same time as PNP's planned drone photography (or the provisional beach and foreshore topographic survey if undertaken by the City).	CHRMAP MU's 4, 5, 6, 7, 8. Note this covers a larger area than PNP's planned drone photography.	Linked with Beach and foreshore topographic survey by PNP.	$15,000 (excl. GST) for consultant to prepare a monitoring program and then internal City resourcing to collect photos.	2024-25, 2025-26, 2026-27. Review program in 2027-28.
Coastal management training for City staff.	The City should develop an internal coastal management training program for relevant staff.	N/A.	N/A.	Less than $5000.	2024-25 and ongoing.
Sand source feasibility study.	The City should prepare an RFQ and engage a consultant to investigate potential sand sources to use for coastal protection works.	CHRMAP MU's 4, 5, 6, 7, 8 and regional sand sources both on land and offshore.	N/A.	$75,000.	2024-25.
Coastal protection structure audit.	The City should prepare an RFQ and engage a consultant to undertake an audit of the coastal protection structures the City is responsible for the care, control and maintenance of, for including – buried seawalls at Hungry Hollow and Hayward St on Ocean Drive, and exposed seawalls at the Bunbury Surf Life Saving Club and car park at Back Beach, Marlston Waterfront seawalls, and Koombana Bay beach groynes.	CHRMAP MU's 5, 6, 7, 8.	N/A.	$48,000.	2024-25.
Beach and foreshore topographic survey – provisional.	This a provisional task which would only be required subject to review of planned data collection by PNP – see Section 4.2. If the drone data photography and conversion to a DEM does not go ahead or is it not accurate this data collection should be undertaken by the City. It is recommended to prepare an RFQ to engage a certified professional surveyor for a long-term beach and foreshore topographic survey data collection program (assumed as three years) at Bunbury back beach and Koombana Bay.	CHRMAP MU's 5, 6, 7.	Linked with Field photos.	$120,000. Assumes 6-monthly survey for 3 years: 6 surveys at $20,000.	Provisional – from 2024-25 if needed.
Emergency evacuation plan.	The City should prepare an RFQ and engage a consultant to ensure that a preliminary emergency evacuation and response plan is prepared, maintained, and implemented to ensure the safe evacuation of occupants within the City during a severe coastal inundation event and/or severe erosion event.	CHRMAP MU's 5 and 8.	N/A.	$55,000.	2025-26.
Foreshore asset audit.	Undertake a Foreshore Asset Audit in response to coastal hazard projections to 2035. The City should prepare an RFQ and engage a consultant to undertake an audit to identify existing infrastructure and recreational facilities in the coastal erosion and inundation hazard zone.	CHRMAP MU's 5 and 8.	N/A.	$71,000	2025-26.
Develop Foreshore Management Plans.	The City should prepare an RFQ and engage a consultant to prepare Foreshore Management Plans. These can increase the protective capacity of the natural dune system and provide an avenue for increased awareness and education for stakeholders and the community about coastal processes and management.	CHRMAP MU's 4, 5, 6, 7 and 8.	Informed by Foreshore asset audit.	$145,000.	2025-26 (CHRMAP MU's 4, 5, 6) and 2026-27 (CHRMAP MU's 7 and 8).
Geotechnical investigations.	Geotechnical investigations are proposed to identify the potential presence and depths of local bedrock strata below the beach. When bedrock is located relatively near the surface, it can provide some natural resistance to erosion and help inform the refinement and design of coastal management options.	CHRMAP MU's 5 and 6.	Informed by Coastal protection structure audit.	$102,000.	2025-26.
Rock source feasibility study.	The City should prepare an RFQ and engage a consultant to investigate potential rock sources to use for coastal protection works.	CHRMAP MU's 5, 6, 7, 8 and regional potential sources.	Informed by Coastal protection structure audit.	$49,000.	2026-27.

Action	Overview	Location	Related Actions	Cost (excl. GST)	Timing
Bathymetric survey.	Collect additional nearshore bathymetry data (water depths) at Bunbury back beach and Koombana Bay for future coastal processes investigations and structural option development.	CHRMAP MU5 and parts of MU 4 (south to in line with Westwood St.) and MU 6 (to the Cut.	N/A.	$43,000.	2027-28.
Metocean data collection.	Collect additional nearshore data (ocean waves, currents, and water levels) for structural option development for 12 months at Bunbury back beach in approximately 10m water depth.	Approximately 10m water depth in line with Hayward St. South Bunbury.	N/A.	$130,000.	2028-29.
Review of Short-term Coastal Action Plan.	The City should prepare an RFQ and engage a consultant to undertake a review of this Short-term Coastal Action Plan and identify the next five years of priority actions.	CHRMAP MU's 4, 5, 6, 7 and 8.	Informed by all of the above.	$25,000.	2028-29.

3 BACKGROUND

It is internationally recognised that the mean sea level has been rising globally since the nineteenth century and is predicted to rise at an increasing rate in the future (IPCC 2021). Rising sea levels and intensifying storm activity will increase the risk of coastal inundation (temporary coastal flooding), storm erosion and long-term shoreline recession. State governments across Australia have introduced obligations that require local governments to consider and plan for these hazards. In Western Australia (WA), the governing policy is the Western Australian Planning Commission's State Planning Policy No. 2.6: State Coastal Planning Policy (WAPC, 2013, herein referred to as "SPP2.6"). SPP2.6 recommends management authorities develop a CHRMAP for land use or development that is vulnerable to coastal hazards. Specific guidelines have been developed to assist in this process (WAPC, 2019).

The Peron Naturaliste Partnership (PNP) comprises the membership of nine local government authorities. The PNP's Coastal Adaptation Pathways Project identified the coastal areas of Capel, Leschenault, and Greater Bunbury as being particularly exposed to coastal hazards and climate change, which triggered the need for the Capel to Leschenault CHRMAP. The project investigated and planned for coastal hazards which are likely to affect these regions.

The project identified the strategic direction for coastal adaptation scenarios and details an implementation plan describing risk management actions to be undertaken to achieve preferred risk treatments. The CHRMAP serves as a key reference for management, planning and policy making for the short-term (0-15 years), medium-term (15-30 years), and long-term (100 years). The broader study area covers four Local Government Areas (LGAs) namely the City, Shire of Harvey, Shire of Dardanup, and Shire of Capel.

A Coastal Hazard Assessment Identified the coastal hazards in the study area that need to be considered in the CHRMAP. Hazard maps were produced defining the erosion and inundation extents for present day, 2035, 2050, and 2120. Following the Hazard Assessment, a Coastal Assets Identification investigation was undertaken to identify the potentially at-risk assets within the coastal hazard zone. All the assets in the coastal hazard zone were identified and classified into 9 categories. The quantity of each asset category by Management Unit, category and planning horizon were presented for each hazard.

Community and stakeholder involvement is a critical component of the CHRMAP process, as it defines what and how much value is placed on assets within the study area. Engagement outcomes have informed the adaptation planning process and ensured all needs are considered. This provides ownership of the CHRMAP with those that it affects, and acceptance of its outcomes. A Community Values assessment using various engagement methods was used to identify key values and concerns for the study area.

Key coastal, estuarine, and riverine values identified by participants across the whole study area as follows:

- Beaches and estuarine areas for activities like walking, swimming, snorkelling, exercise, views, fishing, surfing, and 4wDing.
- Wetlands and environmental areas for their flora and fauna diversity which participants could appreciate.
- Coastal views, walks and scenic amenity.
- The environmental and ecological function of coastal vegetation and the natural environment generally.

A Vulnerability Analysis, which constitutes the second stage of the risk identification process, was undertaken to develop likelihood, consequence, level of risk, adaptive capacity, and vulnerability ratings for the nine asset categories. Extreme vulnerability has been identified from the present day onwards. Most of this extreme vulnerability is predicted to be from erosion, except for residential and commercial inundation.

Recommended adaptation pathways and options to manage the coastal erosion and inundation risk in the City were presented to give preliminary direction for future investigations and funding opportunities.

The CHRMAP noted that the proposed options should be the subject of further investigations, surveys, policy review, impact investigations (environmental, visual and social), development approvals and authorities' endorsement, local stakeholder and community engagement, preliminary design, detailed design, costing and any other applicable preparation work required prior to being implemented. The summary report noted that options should be optimised and modified following such additional investigations.

This report presents an implementation action plan for the City to commence these investigations and confirm several of the assumptions used in the CHRMAP.

4 METHODOLOGY

4.1 Review of CHRMAP assumptions and recommendations

The City's CHRMAP (Water Technology, 2023) and Appendices were reviewed to identify potential synergies in combining the recommended priorities for each MU, into specific short-term actions across the City's coastline.

To address erosion for the City's coastline in the short-term a combination of Planned / Managed Retreat (MU4) and Protection with Groynes (MU5, MU6, MU7 and MU8) was identified in the CHRMAP as the preferred approach. To address inundation in the short-term, investigations were recommended to plan for the Bunbury Storm Surge Barrier (BSSB) to be replaced with an upgraded structure (MU5); and for confirmation of suitable levee design (MU6) as well as further design and investigations (MU7 and MU8).

The CHRMAP is a strategic planning document that considers long timeframes. The next phase of research and studies aims to consider priority items in more detail, including several additional investigations:

1. Data collection and analysis
2. Prepare an Asset Management Plan for each Management Unit
3. Sand source feasibility study
4. Rock source feasibility study
5. Update Foreshore Management Plans
6. Emergency evacuation planning
7. Environmental investigations to mitigate potential impacts
8. Economic and budgeting analysis to determine accurate costs, once detailed designs are available
9. Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat
10. Community and stakeholder engagement
11. State-wide Coastal Hazard Mapping Study and advocacy program.

The scope of this project is to focus on Items 1 to 6 above.

4.2 Liaison with the City and its Coastal Partners

As the information used in preparing the City's CHRMAP was provided in 2021 a request for information was sent to the City's coastal partners (who manages coastline adjacent to the City) and internal staff to identify any active or imminent coastal monitoring and management activities to ensure recommended actions are sympathetic to any other coastal activities underway or scheduled over the next 5 years.

4.3 Confirmation of costs for recommended activities

Cost estimates have been provided for the recommended actions in Section 7. The cost estimates are of sufficient detail to allow for an estimated total cost of implementing the 5-year plan and suitable for the City to budget internally for the coming years. The estimates have been developed through more detailed review of information available within Water Technology nationally as well as via the sourcing of local quotes from organisations in Perth and South West WA.

5 AVAILABLE COASTAL MANAGEMENT INFORMATION

5.1.1 City Information

City staff provided information on existing coastal protection structures at Back Beach and the proposed Ocean Pool development. This information is presented below along with coastal management actions to complement the CHRMAP recommendations.

5.1.1.1 Coastal Protection Structures at Back Beach

At Bunbury Back Beach, there are a number of existing coastal protection structures (seawalls) that provide a certain level of protection to key assets. This includes:

- The exposed retaining wall immediately north of the Bunbury Back Beach Cafe
- The partially buried seawalls located beneath the Bunbury Back Beach Cafe and Bunbury Surf Life Saving Club (Figure 5-1 and Figure 5-2)
- The buried seawall between Stockley Rd and William St
- The buried seawall between Beach Rd and Hayward St

The exposed and partially buried structures have unconfirmed design and construction documentation, and so during the risk-assessment process of the CHRMAP could not be assumed to provide full protection from severe design erosion events. City staff have located various documents relating to coastal works associated with these sites but further confirmation of their design specifications and construction is required. It is recommended the City liaise with the Department of Transport (DoT) to make final attempts to locate relevant records and include the structures in the Coastal Protection Structure Audit described in Section 7.2.2.

Figure 5-1 Revetment beneath Bunbury Surf Life Saving Club, June 2021.

Figure 5-2 Revetment beneath Bunbury Back Beach Café, June 2021.

Some Master plan records for the Coastal Enhancement Project from the early 2000's suggest the potential presence of additional seawall structures between the Bunbury Surf Life Saving Club and Stockley Road–- but this has not yet been confirmed by the City and requires further investigation.

City staff have located historical reporting and drawings for the two buried seawalls (MPRA, 2008). The structures are understood to have two layers of armour rocks and in the CHRMAP the design was considered as effective to resist erosion during their design life. As such, for these sections, it was assumed that the seawall will resist shoreline erosion during their intended design storm event, and this is depicted on the associated erosion mapping.

These structures should be included in the Coastal Protection Structure Audit described in Section 7.2.2. The relevant records should also be utilised in that task to convert the available information into an appropriate asset database for the City's coastal protection structures.

5.1.1.2 Proposed Ocean Pool

The construction of an ocean pool complex is proposed at Wyalup Rocky Point (less than 600m west of the Bunbury CBD), the former location of the Basalt Quarry (Figure 5-3). The scope includes the following key amenities (Bridge42, 2023):

- Lap pool, four lanes, 50 metres
- Rehabilitation pool, two lanes, 25 metres
- Entry ramp, max 1V:20H access ramp slope
- Childrens / Leisure pool
- Community room
- Toilet and change room amenities

- Café / Kiosk

The key next steps include endorsement of business case and the preferred on-going funding option, and work to develop the detailed design and secure the necessary funding. A localised geotechnical investigation was undertaken at the site to inform the business case, in the form of cone penetrometer testing. It is recommended the results of that testing are considered when scoping the geotechnical investigations outlined in Section 7.1.4

Figure 5-3 Masterplan of the Bunbury Ocean Pool and Landscaped concept (Bridge42, 2023).

5.1.1.3 Bunbury Storm Surge Barrier and Leschenault Inlet channel structures

The City and DoT have applied for the Disaster Ready Fund Round Two (2024-25) to repair the rock protection structures associated with the Bunbury storm surge barrier and Leschenault Inlet entrance channel. The rock protection structures include the training walls and rock revetments of the Leschenault Inlet entrance channel and the Koombana Bay eastern groyne (Figure 5-4). The project is proposed to be undertaken in two consecutive stages commencing with Phase 1 – the Koombana Bay eastern groyne, and then Phase 2 – the training walls and rock revetments of the Leschenault Inlet entrance channel. The scope of works excludes the storm surge barrier and the associated bunds which will require future adaptation as identified in the CHRMAP.

Figure 5-4 Bunbury Storm Surge Barrier and Leschenault Inlet channel structures – Seashore Engineering (2024)

The Leschenault Inlet Training Wall Repairs Design Report (Seashore Engineering, 2024) summarises the status of the structures and required repair and maintenance works. The report has identified that the structures' condition have deteriorated over time, and that repair works are required to ensure the structures continue to function effectively into the future. The repairs are considered an early step in a series of adaptation measures required to mitigate increasing inundation threat.

5.1.2 Coastal Partners

A suitably qualified representative of each of the relevant organisations was invited to provide a brief summary regarding any of the following undertaken since 2021 or scheduled up to and including 2028-29:

1. Coastal monitoring activities, such as beach survey, collection of bathymetry or metocean data, coastal photo monitoring.
2. Sand or rock source investigations to inform the design or construction of beach nourishment or coastal protection structures.
3. Coastal management actions – such as beach nourishment/excavation or coastal protection structure designs, plans, or construction works.
4. Foreshore Management Plan preparation or updates.

The relevant coastal partners are:

- Peron Naturaliste Partnership (PNP)
- Department of Transport (DoT)
- Southern Ports – Bunbury
- Shire of Capel
- Shire of Dardanup, and
- Shire of Harvey

The information that was provided is summarised in Table 5-1 below and has been incorporated into the recommended coastal management actions in this report.

Table 5-1 Coastal management information from City's coastal partners

Organisation	Activities completed since 2021 and/or currently underway	Activities planned before 2028-29
Peron Naturaliste Partnership (PNP)	▪ Approximately monthly beach width measurements at 8 locations within the City (Figure 5-5). ▪ Beach field photos collected along with monthly beach width measurement. ▪ Six-monthly oblique aerial photography continuing. (https://wacoastline.org/) ▪ Beach field photos at Koombana Bay CoastSnap station available via Facebook and the CoastSnap website.	▪ Drone photography and beach survey (Digital Elevation Model generated from photography) for Bunbury Back Beach and Koombana Bay (Figure 5-6) every 6 months – scheduled to commence in Autumn 2024. ▪ All other recent monitoring tasks to continue for several years. ▪ Beach field photos at a new CoastSnap station to be installed at Back Beach with photos to be available via Facebook and the CoastSnap website.

Organisation	Activities completed since 2021 and/or currently underway	Activities planned before 2028-29
Department of Transport (DoT)	▪ Occasional monitoring activities associated with management of, and strategic planning for, Casuarina Boat Harbour.	▪ Beach and bathymetric survey planned during and after proposed dredging, and Casuarina Boat Harbour northern breakwater construction associated with the Transforming Bunbury Waterfront project led by the South-West Development Commission. ▪ Refurbishment of sections of the Bunbury Storm Surge Barrier revetments. This includes potential upgrade works on the western groyne at Koombana Beach.
Shire of Capel	▪ CHRMAP endorsed by Council at 31/1/2024 meeting with some exclusions. ▪ Beach survey and field photos in partnership with PNP. ▪ Minor local beach works at Peppermint Grove beach foredune near war memorial and playground.	▪ Intend to commence priority investigations recommended in CHRMAP. ▪ Intend to update Foreshore Management Plans for Shire-managed foreshore. ▪ Set up a Capel Coast Sub-Committee to the Climate Change and Sustainability Committee with responsibility for the assistance in the implementation of the Final Capel CHRMAP. ▪ Update the Final Capel CHRMAP as necessary as new data or information becomes available.
Shire of Dardanup	▪ N/A.	▪ Intend to develop an Eaton Foreshore Management Plan.

Figure 5-5 Beach width measurement, and field photo locations – undertaken monthly from 2017 to present day by PNP.

Figure 5-6 Proposed drone photography and beach survey areas–- PNP.

6 IDENTIFICATION OF LIKELY ACTIONS BEYOND THE 5-YEAR TIMEFRAME

Recommendations from the CHRMAP have been prioritised and considered with likely sequencing in combination with the information provided by the City's coastal partners. Recommended actions for 2024-2028 are presented in Sections 2 and 7. Actions which should be carried out in 5 to 15 years are identified in Table 6-1 below.

Table 6-1 Coastal management actions likely to be required between approximately 2028 to 2038.

Action	Overview	Location
Coastal protection structure audit – Leschenault Inlet, Leschenault Estuary, Collie River.	Undertake a coastal protection structure audit the Leschenault Inlet, Leschenault Estuary and Collie River seawall/revetment/retaining structures.	Leschenault Inlet and CHRMAP MU's 7 and 8.
Green LiDAR trial.	Green LiDAR is an emerging technology for collecting bathymetry and topography survey data. It is recommended the City further consider this method in combination with contractors, DoT, Southern Ports and PNP to investigate cost-sharing of a trial data capture. See Section 6.1.1 below for more information.	CHRMAP MU's 5 and 6.
Environmental investigations.	Environmental investigations to evaluate potential impacts of preferred protection options. This may include the need for Benthic Habitat investigations.	CHRMAP MU's 5, 6, 7, 8.
Economic and budgeting analysis for coastal protection structures.	Economic and budgeting analysis to determine more developed cost estimates once detailed designs are available.	CHRMAP MU's 5 and 6.
Community and stakeholder engagement.	Ongoing, following completion of the Actions defined in this Action Plan. The City will need to continue to engage with coastal stakeholders and the community regarding the City's coastal management activities and strategies.	CHRMAP MU's 4, 5, 6, 7, 8.
Physical coastal process review.	Review coastal process data and information collected in line with this Action Plan to characterise the behaviour of the beach and foreshore. The project will aim to identify the causes for any significant behaviour (erosion, accretion, inundation events) and link to the available metocean data to allow for a more detailed hazard analysis.	CHRMAP MU's 4, 5, 6, 7, 8.
Monitoring of coastal processes.	Subject to the results of the monitoring actions outlined in this Action Plan, and the physical coastal process review detailed above monitoring of coastal process shall continue as required. Beach survey should be extended to cover CHRMAP MU's 4 and 8.	CHRMAP MU's 4, 5, 6, 7, 8.

Action	Overview	Location
Confirmation of CHRMAP cost benefit analysis assumptions.	The CHRMAP cost benefit analysis required the use of various assumptions for the Base Case scenario, as well as for the Planned / Managed Retreat and Protection options. It is recommended the City work with DPLH to confirm the assumptions used and develop appropriate methods with which to undertake cost benefit analysis for coastal management projects over long timeframes. This is likely to require the collection and analysis of local data that is fit for purpose.	CHRMAP MU's 4, 5, 6, 7, 8.
Bunbury Storm Surge Barrier replacement.	Formalise plans with DoT to progress the replacement of the Bunbury Storm Surge Barrier structure.	CHRMAP MU 5
Review and update CHRMAP.	Review and update the CHRMAP (Water Technology, 2023) to maintain its currency and ensure it remains a "living document". The completion of other tasks outlined in this Action Plan will allow for update of the hazard mapping, selection of Management Units, vulnerability analysis, cost benefit analysis and the strategic prioritisation of coastal management.	CHRMAP MU's 4, 5, 6, 7, 8.

6.1.1 Green LiDAR Trial

Green LiDAR is an emerging technology for collecting bathymetry and topography survey data. Green LiDAR uses a survey instrument that can mounted to a helicopter which effectively provides continuous high-resolution LiDAR over both land and sea floor. While the performance is subject to water and weather conditions (including impact in the surf zone), it has been reported to achieved useful data at depths of over 8m. As for other LiDAR, Green LiDAR data can be processed to a classified point cloud, and a 3D surface / DEM model supplied. Once the quality and accuracy of the outputs can be confirmed Green LiDAR may be identified as preferable option than the traditional combination of bathymetric survey using multibeam echosounder; combined with aerial LiDAR for topographic land survey. As Green LiDAR can (depending on conditions) collect data form the wave breaking zone it may allow for a continuous survey from land into nearshore waters, which is currently very difficult to achieve. The use of only one instrument could also result in competitive pricing. It is recommended the City further consider this method in combination with contractors, DoT, and Southern Ports (as the relevant coastal manager in the area), and PNP to investigate cost-sharing of a trial data capture. Historically DoT has also been able to provide similar survey as in-kind work by their survey team – this may be possible to use to compare the accuracy of the methods.

7 COASTAL MANAGEMENT ACTIONS

7.1 Monitoring and Data Collection

7.1.1 Storm Impact Monitoring

Table 7-1 Storm impact monitoring.

Recommendation	Storm impact monitoring.
Overview	Prepare for, and undertake, storm impact monitoring during and immediately after severe ocean storm events.
Location	CHRMAP MU's 4, 5, 6, 7, 8.
Cost	$10,000 (excl. GST) per survey Only required if an external surveyor needs to be used after a severe storm.
Timing	2024-25 and ongoing.
Description	In the event a significant storm event is to occur the following monitoring items are recommended to be undertaken by City staff: 1. Keep a record of storm dates, the recorded water level and wave conditions from the nearest DoT stations and buoys, and general observed erosion and inundation impacts along the coast 2. Document the inundation and erosion extent – the intention is to record the maximum extent of both using photos and basic measurements to known positions of the debris line (for inundation) or erosion scarp along the coast. Vertical measurements of the inundation level at known points will also be valuable. GPS-enabled devices can be used to record locations 3. Accurate survey of the debris line (for inundation) or erosion scarp at several locations along the coast if feasible 4. If there is sufficient time available undertake pre-storm beach profiles and beach photos 5. Post storm beach profiles and beach photos at regular monitoring locations if the event is significant 6. If there is a significant change to the profiles, consideration should be given to undertaking full hydrographic survey and 3D beach survey The proposed monitoring of the location and extents of storm impacts will allow for an increased understanding of historical coastal hazard vulnerability, and enable ground truthing, calibration, and sensitivity checks for existing and future hazard analysis.

7.1.2 Coastal Management Register

Table 7-2 Coastal management register.

Recommendation	Coastal management register.
Overview	Implement and maintain a coastal management register for monitoring and management actions.
Location	CHRMAP MU's 4, 5, 6, 7, 8.

Cost	N/A Internal City resourcing only (in kind).
Timing	2024-25 and ongoing.
Description	A record of coastal monitoring and management actions / interventions is useful to develop a documented history of what is happening along the City's coast. The register is a record of actions that can be reviewed to provide insight into the requirements of coastal management over time. It will also be helpful in identifying potential sources of change to coastal processes and recording any human intervention. Some examples of actions that should be recorded in the register are: 1. Repair/upgrade of any coastal drainage asset*. 2. Any changes to planning and development controls within the coastal hazard zone. 3. All beach nourishment works, including excavation and/or placement of sand, including works undertaken by the City's coastal partners*. 4. Inspection or repair of coastal protection structures*. 5. Coastal monitoring activities*. 6. Severe ocean storms occur causing erosion and/or inundation 7. Coastal land use approvals. 8. Revegetation works. Significant works such as those listed with a star (*) should also have more detailed records such as photography, relevant plans and survey data stored and linked to the management register. A template with example entries is shown in Appendix A.

7.1.3 Field Photos

Table 7-3 Field photos.

Recommendation	Collect field photos of the beach and foredune.
Overview	Collect beach and foredune monitoring photos at the same time as PNP's planned drone photography (or the provisional beach and foreshore topographic survey if undertaken by the City in Section 7.1.5).
Location	CHRMAP MU's 4, 5, 6, 7, 8. Note this covers a larger area than PNP's planned drone photography.
Cost	$15,000 (excl. GST) for consultant to prepare a monitoring program and then internal City resourcing to collect photos.
Timing	2024-25, 2025-26, 2026-27. Review program in 2027-28.
Description	Photo monitoring of the beach and foredune can provide a valuable record of beach condition over time. Consistent monitoring will allow for assessment of coastal processes in the future and will assist in identifying ongoing issues. The Department of Transport created a guide which explains how to photo monitor beaches (DoT, 2012). City staff may effectively undertake photo monitoring. It is recommended that a coastal engineering consultant is engaged to prepare a fit for purpose photo monitoring program and resources, and then City staff take 6-monthly photos at the same time as planned beach and foreshore survey for 3 years. This plan may also include identification of future locations to install "citizen science" coastal monitoring camera cradles using CoastSnap stations.

	Field photo monitoring points are recommended approximately every 400m along the ocean coast from the Mindalong Beach car park to the Cut; and priority locations along the southern end of the Leschenault Estuary from the Cut around to the Preston and Collie River mouths and along the Collie River to the Old Coast Road bridge. Locations would be determined during preparation of the monitoring plan based on previous coastal assessments and monitoring – such as the field photos collected by PNP – see Section 4.2.

7.1.4 Geotechnical Investigations

Table 7-4 Geotechnical investigations.

Recommendation	Geotechnical investigations.
Overview	Geotechnical investigations are proposed to identify the potential presence and depths of local bedrock strata below the beach. When bedrock is located relatively near the surface, it can provide some natural resistance to erosion and help inform the refinement and design of coastal management options.
Location	CHRMAP MU's 5 and 6.
Cost	$102,000 (excl. GST).
Timing	2025-26.
Description	Collecting this data will assist in providing greater confidence of the need for, and suitability of, preferred protection options identified in the CHRMAP. Geotechnical investigations are proposed along the foreshore reserve to determine the location and level of hard subsurface limestone, which could provide coastal protection in the event of loss of overlying beach and dune material. When bedrock is located relatively near the surface, it can provide some natural protection to erosion and reduce the scope of works. However, in low-lying areas, the presence of bedrock may not significantly mitigate the coastal hazards. If the area is inundated the hard surface will not provide the expected protection to erosion. Geotechnical investigation is recommended to include: 1. Transects of Multi-Channel Analysis of Surface Waves (MASW) 2. Transects of seismic refraction tomography (SRT) 3. Cone Penetrometer Testing (CPT) for ground truthing of geophysical data, and 4. Differential topographic survey Ten days of field work have been allowed for in the budgeting estimate. The sections of coast confirmed to have buried seawalls following the Coastal Protection Structure Audit could be excluded to reduce the scope if necessary. It is recommended this action is undertaken after the Coastal Protection Structure Audit so that the locations, design, condition, and remaining design life of existing coastal protection structures can be confirmed when scoping the field work locations for geotechnical investigation.

7.1.5 Bathymetric Survey

Table 7-5 Bathymetric survey.

Recommendation	Collect bathymetry data.

Overview	Collect additional nearshore bathymetry data (water depths) at Bunbury back beach and Koombana Bay for future coastal processes investigations and structural option development.
Location	CHRMAP MU5 and parts of MU 4 (south to in line with Westwood St.) and MU 6 (to the Cut.
Cost	$43,000 (excl. GST)
Timing	2027-28.
Description	The survey area would be from wave zone out to approximately -8mAHD for the back beach coast and -5mAHD for Koombana Bay. The survey would be collected by boat using a multibeam echosounder to capture bathymetry data from the wave zone to the target depth. The multibeam echosounder emits multiple sonar beams simultaneously, enabling rapid data acquisition and providing high-resolution point cloud data for precise water depth measurement and seafloor topography analysis. The resulting point cloud will be accurate to 0.1m, high density, and corrected for pitch, roll and heave, and cover the whole survey area with 3D data. An alternative methodology using a single beam echosounder to capture bathymetry data could also be considered to reduce costs. The single beam methodology means points will only be surveyed along 18 transect lines for back beach coast and 12 transect lines for Koombana bay only, to a depth of -8m AHD and -5m AHD respectively. The resulting points will be accurate to 0.1m, high density, and corrected for pitch, roll and heave. Approximate Pricing $13,000 (excl. GST) per survey. Given the significant cost of this data collection it is recommended the City liaise closely with DoT and Southern Ports as the relevant partners within this area to investigate cost-sharing for these works. Historically DoT has also been able to provide similar bathymetric survey as in-kind work by their survey team, and occasionally the state government organise regional bathymetry data collection such as the 2009 LiDAR collection for the South West region.

7.1.6 Metocean Data Collection

Table 7-6 Metocean data collection.

Recommendation	Collect wave, current, and water level data.
Overview	Collect additional nearshore data (ocean waves, currents, and water levels) for structural option development for 12 months at Bunbury back beach in approximately 10m water depth.
Location	Approximately 10m water depth in line with Hayward St. South Bunbury.
Cost	$130,000 (excl. GST).
Timing	2028-29.

Description	This will enable calibration of numerical models, especially if a storm is captured during the deployment. The data can be used to get a better understanding of event probabilities and to confirm the relationship with data collected by Southern Ports further north. The recommended data collection includes: 1. Deployment and recovery of one suitable instrument 2. Three maintenance trips (roughly every 3 months) and one contingency trip 3. Data Analysis, QA/QC, and data provision 4. Data Report.

7.1.7 Beach and Foreshore Topographic Survey data – Provisional

Table 7-7 Beach and foreshore topographic survey.

Recommendation	Collect beach and foreshore topographic survey data.
Overview	This a provisional task which would only be required subject to review of planned data collection by PNP – see Section 4.2. If the drone data photography and conversion to a DEM does not go ahead or is it not accurate this data collection should be undertaken by the City. It is recommended to prepare an RFQ to engage a certified professional surveyor for a long-term beach and foreshore topographic survey data collection program (assumed as three years) at Bunbury back beach and Koombana Bay.
Location	CHRMAP MU's 5, 6, 7.
Cost	$120,000 (excl. GST). Assumes 6-monthly survey for 3 years: 6 surveys at $20,000 (excl. GST).
Timing	Provisional – from 2024-25 if needed.
Description	The program will efficiently use surveyor resources and generate a consistent baseline of repetitive surveys will allow for future sediment process investigations and structural option development. These data will allow analysis of beach volumes, scarp location and dune evolution. It is recommended to capture the site with fixed wing LiDAR to achieve an accurate 3D surface over the beach and foreshore area down to the water line. LiDAR will be to a minimum 10 points per square metre density, and +/-50mm accuracy. The capture undertaken on a day and time of low tide. The LiDAR will be processed to a classified point cloud, and a 3D surface / DEM model. The survey datasets should be centralised into a database, which includes previous historical beach profiles and quality control information such as survey date, datum, survey mark, beach material encountered (rock vs sand) and method used. Given the significant cost of this data collection it is recommended the City liaise closely with DoT and Southern Ports as the relevant partners within this area and PNP to investigate potential cost-sharing arrangements for these works. Historically DoT has also been able to provide similar survey as in-kind work by their survey team. It is recommended the City request PNP to extend the intended drone photography area along back beach north to the spur groyne on the Bunbury outer breakwater if possible.

	An alternative methodology using a two-person survey crew (for water safety) using traditional RTK GPS will survey the 2D profile lines from vegetation line to waist deep water (approximately 0.5m to 1m depth) This will be undertaken days of low tide. This methodology means points will only be surveyed along 18 profile lines for the back beach coast and 12 profile lines for Koombana Bay. Approximate Pricing $9,000 (excl. GST) per survey.

7.2 Investigation and Analysis

7.2.1 Sand Source Feasibility Study

Table 7-8 Sand source feasibility study.

Recommendation	Undertake a sand source feasibility study.
Overview	The City should prepare an RFQ and engage a consultant to investigate potential sand sources to use for coastal protection works.
Location	CHRMAP MU's 4, 5, 6, 7, 8 and regional sand sources both on land and offshore.
Cost	$75,000 (excl. GST).
Timing	2024-25.
Description	The CHRMAP recommended several MU's consider Options which require sand nourishment, both for erosion management (such as beach groynes including sand nourishment) and inundation management (such as raising beach levels to improve coastal drainage). The CHRMAP assumed that a reliable source of sand would be available in reasonable proximity. The availability, suitability, and viability of local sand sources for beach nourishment works is currently not well understood in the study area. It is recommended that a sand source feasibility study is undertaken to determine the capacity and cost of local sand supplies. The study should: 1. Review available information held by PNP, DoT and the City (Taylor and DALA 2001). 2. Undertake desktop investigations into the potential quantities of sand available from potential sand source locations. This should consider both land-based and marine sand sources. 3. Collect and analyse sediment samples for the existing beaches at the CHRMAP MU's and all potential sources. The purpose of this analysis is to determine the compatibility of potential sand sources with the local beach sediments. This should include: a. Particle size distribution and composition b. Sediment contamination and presence coastal acid sulphate soils 4. Evaluate potential environmental impacts and approvals required. 5. Prepare overview methodologies and cost estimates for the use of different indicative volumes of sand from each source. 6. Confirm availability and suitability of sand from Southern Ports maintenance dredging works at the outer breakwater. The budget has allowed for one day of land-based field work and one day of boat-based field work as well as analysis of approximately 40 sediment samples.

7.2.2 Coastal Protection Structure Audit

Table 7-9 Coastal protection structure audit.

Recommendation	Undertake a coastal protection structure audit.
Overview	The City should prepare an RFQ and engage a consultant to undertake an audit of the coastal protection structures the City is responsible for the care, control and maintenance of, for including – buried seawalls at Hungry Hollow and Hayward St on Ocean Drive, and exposed seawalls at the Bunbury Surf Life Saving Club and car park at Back Beach and Marlston Waterfront seawalls. Leschenault Inlet channel training walls and structures and Koombana Bay beach groynes status should be considered but it is likely that their assessment can largely rely on Seashore Engineering's 2024 design report for these.
Location	CHRMAP MU's 5, 6, 7, 8.
Cost	$48,000 (excl. GST).
Timing	2024-25.
Description	Given the current condition of many structures along the City's coastline, a program of regular monitoring of the coastal management structures (seawalls, groynes, breakwaters training walls and storm surge barrier) is required to assess structural condition and performance and identify maintenance and management requirements. Condition inspections should be undertaken with consistent methodology to allow for comparison between inspections. The initial assessment would identify an appropriate review schedule (anticipated to be every 1 to 5 years for exposed structures) for each structure, or if there is an issue with an asset. Initial condition inspection by registered and accredited coastal 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. The project should: 1. Confirm all the coastal protection structures that the City has care, control and maintenance for including – buried seawalls at Hungry Hollow and Hayward St on Ocean Drive, and exposed seawalls at the Bunbury Surf Life Saving Club and car park at Back Beach, Marlston Waterfront seawalls, Koombana Bay beach groynes, seawalls along Collie River. 2. Identify structures for which the City's coastal partners are responsible for, including–- Outer Harbour breakwater and spur groynes; Casuarina Harbour breakwaters and causeway; Dolphin Discovery Centre buried seawall; Point Busaco seawall; Port Breakwaters for Inner Harbour; structures at The Cut. 3. Desktop study (and excavation in the field if uncertainty remains) should be used to document the location and design features of buried seawalls along Back Beach and to consider any available condition inspection reports for other structures. 4. Undertake condition inspections of the City's exposed structures on the ocean coast to identify: – Current condition rating from visual inspection working to a defined methodology and rating scale. – Characterisation of features via accurate field survey, with outputs as a suitable GIS file – Maintenance works required and their cost. – Remaining expected life and replacement cost.

	– Any other recommendations regarding the structures and their ongoing monitoring – Information should be added to City asset database(s) as appropriate. Given the potential synergies of this action it is recommended the City liaise closely with DoT and Southern Ports as the relevant partners within this area who also own local coastal structures to investigate any potential cost-sharing for these works. It is recommended the City also liaise with DoT to make final desktop attempts to locate relevant records for the structures immediately north of, and beneath the Bunbury Back Beach Café and Surf Club buildings. If these efforts are unsuccessful field work using the test excavation pits and/or opportunistic survey observations following beach erosion events may be required.

7.2.3 Rock Source Feasibility Study

Table 7-10 Rock source feasibility study.

Recommendation	Undertake a rock source feasibility study.
Overview	The City should prepare an RFQ and engage a consultant to investigate potential rock sources to use for coastal protection works.
Location	CHRMAP MU's 5, 6, 7, 8 and regional potential sources.
Cost	$49,000 (excl. GST).
Timing	2026-27.
Description	The CHRMAP recommended several MU's consider Options which require structures which could be built from core and armour rock which needs to be fit for purpose. The CHRMAP assumed that a reliable source of rock would be available within an economically feasible proximity to the study area. The availability of suitable rock for coastal protection works is unfortunately not well understood in the study area. It is recommended that a rock source feasibility is undertaken to determine the capacity and cost of local rock supplies. The study should: 1. Review available information held by the City and its coastal partners including the information presented in Department of Planning (2012) and liaison with the City of Busselton as they have previously considered this issue. 2. Analyse the availability of such rock that is considered suitable for marine environments. 3. Analysis of suitable density, quarry yields, and costs associated with procurement and transport should be undertaken. 4. Potential environmental impacts should be considered as well as any approvals required. 5. Prepare overview methodologies and cost estimates for the use of different indicative volumes from each source. It is recommended this action is undertaken after the Coastal Protection Structure Audit so more detailed information is available regarding the sizing, physical characteristics, and quantities of rock required for structure maintenance works is understood prior to commencing the study.

7.3 Management Plans

7.3.1 Foreshore Asset Audit

Table 7-11 Foreshore Asset Audit.

Recommendation	Undertake a Foreshore Asset Audit in response to coastal hazard projections.
Overview	Undertake a Foreshore Asset Audit in response to coastal hazard projections to 2035. The City should prepare an RFQ and engage a consultant to undertake an audit to identify existing infrastructure and recreational facilities in the coastal erosion and inundation hazard zone.
Location	CHRMAP MU's 5 and 8.
Cost	$71,000 (excl. GST).
Timing	2024-25.
Description	Undertake a Foreshore Asset Audit: 1. Survey, and physical inspection, of the City's foreshore assets projected to be impacted by the 2035 CHRMAP project timeframe. This task could be undertaken internally by City staff. 2. Compile a record of the condition, estimated remaining life, and potential replacement cost for the City's assets. This could be a series of simple lists, or GIS-based asset information as part of a comprehensive database system. This task could be undertaken internally by City staff. 3. Identify non-critical City assets to progressively relocate away from the coastal hazard zone once they reach the end of asset life or replace assets with suitably durable and/or sacrificial infrastructure. This may include vulnerable recreational car parks; recreational amenities such as public ablutions; barbeque/picnic/shade areas; playground and other recreational equipment; and access structures such as ramps, stairs and paths and fences. 4. Identify the City's critical service infrastructure (primarily roads but may include other utilities). Plan for the relocation of the City's critical service infrastructure outside of the coastal hazard zone once they reach the end of asset life, or at a minimum, modify the service infrastructure asset so that it does not run parallel to the coastline where possible and can be progressively removed when exposed to intolerable risk levels. This may include public safety infrastructure. 5. Summarise any critical service infrastructure that the City does not have responsibility for (including utilities such as water supply, power supply, communications, wastewater networks, and roads). Share this information with the responsible organisations and advocate for the relocation of critical service infrastructure outside of the coastal hazard zone once they reach the end of asset life, or at a minimum, modify the service infrastructure asset so that it does not run parallel to the coastline where possible and can be progressively removed when exposed to intolerable risk levels. This may include public safety infrastructure. 6. Provide summary information for use in updated foreshore management plans to cover the period from 2025-2035

7.3.2 Develop Foreshore Management Plans

Table 7-12 Develop Foreshore Management Plans

Recommendation	Develop Foreshore Management Plans.
Overview	The City should prepare an RFQ and engage a consultant to prepare Foreshore Management Plans. These can increase the protective capacity of the natural dune system and provide an avenue for increased awareness and education for stakeholders and the community about coastal processes and management.
Location	CHRMAP MU's 4, 5, 6, 7 and 8.
Cost	$145,000 (excl. GST).
Timing	2025-26 (CHRMAP MU's 4, 5, 6) and 2026-27 (CHRMAP MU's 7 and 8).
Description	Updated foreshore management plans should address: 1. The requirements of SPP2.6 and its supporting documentation 2. The findings of the CHRMAP 3. Potential environmental issues such as biodiversity and environmental impacts, and detail a weed management strategy for the coastline 4. Incorporate findings of Asset Management Plans as appropriate 5. Include recommendations for assessing the suitability of fencing, rationalising excess beach access points, ensuring appropriately fenced and signed paths, signage for dune repair and clear signage for 4-wheel drive access and permissibility 6. Develop a community education strategy for coastal and environmental management. The strategy should work to inform the community about the CHRMAP and FMP and their findings and use suitable engagement methods such as infographics, FAQ's. The education strategy should also include appropriate on-ground signage and information. 7. Beach access review – consideration of the need to modify, upgrade or close on beach accessways. 8. Monitor impacts of pedestrian beach access and 4WD vehicles (where applicable) on nesting habitats and migratory bird species in dune areas. 9. Determine the need for a bush fire management plan for the dune and coastal areas. It is anticipated at least two (2) foreshore management plans would be prepared – One for the ocean coast including CHRMAP MU's 4, 5 and the ocean coastlines of MU 6 and 7 and one for the estuary coast including the estuary coast of MU6 and MU7 and tidal sections of MU 8. Alternatively the ocean coast could be split into two sections – one covering MU4 and the western part of MU5 and one covering the Koombana Bay coastline through to The Cut. This action is recommended to follow the foreshore asset audit as it will be informed by the results of that investigation.

7.3.3 Emergency Evacuation Plan

Table 7-13 Emergency evacuation plan.

Recommendation	Develop an Emergency Evacuation Plan in response to coastal hazard projections.
Overview	The City should prepare an RFQ and engage a consultant to ensure that a preliminary emergency evacuation and response plan is prepared, maintained, and implemented to ensure the safe evacuation of occupants within the City during a severe coastal inundation event and/or severe erosion event.
Location	CHRMAP MU's 5 and 8.
Cost	$55,000 (excl. GST) Excludes updates to existing reports.
Timing	2025-26.
Description	A review of CHRMAP hazard projections should be undertaken to assess the need for evacuation plans to respond to an occurrence of the projected coastal hazards. Existing documents may need to be updated or revised as required. The scope should include liaison with the Department of Fire and Emergency Services and Bunbury State Emergency Service. Plans should detail emergency response to coastal erosion and flooding impacts, as well as storm damage causing infrastructure to collapse into the public foreshore or coastal environment. Evacuation planning for inundation should clearly detail likely flood behaviour; identify appropriate evacuation triggers, evacuation routes and an assessment of their suitability; warning systems, communications and alert levels; and plan for upgrades required to meet future City developments. Future work required should be identified. The outputs should be suitable for consideration in the preparation of updates to existing local emergency plans. Scenario planning could also be undertaken to test the plans in training scenarios.

7.3.4 Review of Short-term Coastal Action Plan

Table 7-14 Review of short-term coastal action plan.

Recommendation	Review of Short-term Coastal Action Plan.
Overview	The City should prepare an RFQ and engage a consultant to undertake a review of this Short-term Coastal Action Plan and identify the next five years of priority actions.
Location	CHRMAP MU's 4, 5, 6, 7, 8.
Cost	$25,000 (excl. GST).
Timing	2028-29.
Description	A review of this Short-term Coastal Action Plan should be undertaken at the end of the 5 year delivery period, in order to: ▪ Undertake an audit of implementation ▪ Assess the performance of actions against their objectives ▪ Identify any barriers to implementation, in order to enhance delivery going forward. The review should assess the work undertaken, review the medium-term actions identified in this plan for 2028-29 to 2038-39 and scope the next priority coastal

	actions. A proposed timeframe for undertaking a revision of the CHRMAP project should also be identified.

7.4 Coastal Management Training for City Staff

Table 7-15 Coastal management training for City staff.

Recommendation	Undertake coastal management training for City staff.
Overview	The City should develop an internal coastal management training program for relevant staff.
Location	N/A.
Cost	Less than $5000 (excl. GST).
Timing	2024-25 and ongoing.
Description	Develop an internal training program for City staff working on coastal management projects including consideration of the following: 1. Informal training utilising freely available information online such as: – Educational materials available at https://coastadapt.com.au/ – The CoastWA Training Series: CoastWA Training Series (www.wa.gov.au) 2. Targeted networking activities with the City's coastal partners identified in Section 4.2. 3. Formal training courses such as the Coastal Resilience Short Course offered by Griffith University: https://www.griffith.edu.au/coastal-marine-research-centre/learning-opportunities/coastal-resilience

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APPENDIX A
COASTAL MANAGEMENT REGISTER

Coastal Management Register

Location:

Date	Action description	Further information	Entered by
22/03/2024	Coastal asset management register put into use	-	KI
23/11/2024	Excavation of outer breakwater sand trap. Material placed on beach in front of playground. Approx. 150 m^3 total. Photographs and local survey data collected. Works took 1 day.	Photos and survey data on City maintenance drive	
2/12/2024	Biannual field photos, and 3D beach survey monitoring conducted.	Data on City maintenance drive	

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Apendix 10.5.1-C

CITY OF BUNBURY

Coastal Hazard Risk Management and Adaptation Plan

March 2024 [draft]

Acknowledgement of Country

The City of Bunbury acknowledges the traditional owners of the land, the Noongar Wardandi people and their continuing connection to the land, waters and community. We pay our respects to all members of the Aboriginal communities and their cultures; and to Elders past, present and emerging.

Disclaimer

This Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) has been completed by Water Technology Pty Ltd, commissioned by the Peron Naturaliste Partnership and the City of Bunbury. All information presented in this document is a reproduction of the findings from the City of Bunbury CHRMAP document finalised on 4 December 2023.

Peron Naturaliste Partnership

CITY OF BUNBURY

Mayor's Message

On behalf of Bunbury City Council, City of Bunbury and our community, I am pleased to present to City's Coastal Hazard Risk Management and Adaptation Plan (CHRMAP).

Bunbury is renowned as a city surrounded by three waters so the importance of having a coastal management plan in place is obvious.

But more than that, we know that sustainability and climate change are one of our community's highest priorities and it is internationally recognised that rising sea levels are an element of this.

So, while we have a long way to go and further investigations and assessments to complete, I am pleased we now have a plan to help us prioritise those studies and to move forward with our coastal planning.

Our CHRMAP has been developed following extensive community consultation to help understand our community's goals and aspirations, and to provide the opportunity for direct input. Thank you to everyone who has already contributed to this important project.

Implementing this plan now requires a coordinated approach and ongoing community and stakeholder engagement to action the recommendations identified and to ensure the City is ready to respond to coastal hazard challenges moving forward.

I encourage everyone to have a read through the CHRMAP and to stay involved.
If anyone in our community needs help reading, reviewing or understanding the information in this plan, please reach out to City staff.

We look forward to working with our community towards protecting the beautiful and unique coastline we are so lucky to enjoy in Bunbury.

Jaysen de San Miguel

Mayor of Bunbury
City of Bunbury
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Frequently Asked Questions

What is a CHRMAP?

CHRMAP is the acronym for a 'Coastal Hazard Risk Management and Adaptation Plan'. It is a study developed to communicate information about future coastal planning. It includes a technical assessment to understand the existing and predicted coastal processes, includes a social assessment to understand the community values associated with the coastline being studied, and considers financial and environmental implications.

What does a CHRMAP do?

The CHRMAP estimates where the coastline is likely to 'move to' in the short, medium and long-term future. By understanding where the coastline is likely to be in the future and which areas of land may become flooded, it allows us to understand what infrastructure may be impacted by coastal processes and investigate which options for managing these impacts might be appropriate in particular areas.

Why do we need a CHRMAP?

It is important to understand areas that may be impacted so we don't place people or assets in harms way, if we can avoid it.

The WA State Government's Coastal Hazard Risk Management and Adaptation Planning Guidelines, established under the Western Australian Planning Commission's *State Planning Policy No. 2.6 - State Coastal Planning Policy*, provides guidance for decision makers to develop and implement effective CHRMAPs, based on internationally recognised science.

EROSION

INUNDATION

What are coastal hazards?

The two main coastal processes that are considered coastal hazards are:

- **Erosion** – the loss of beach and vegetation
- **Inundation** – flood from sea water

A CHRMAP identifies areas that could potentially be impacted by these hazards over the next 100 years, relative to storm events and projected sea level rise. CHRMAP uses 'vulnerability' as a way of identifying impact, which includes an analysis of how likely the impact is to occur, the consequence of the impact, and how easy it is to adapt before or after the impact.

What will the outcomes of the CHRMAP be?

The CHRMAP outlines a plan to address future risks identified across the coastal areas, on the basis of current and future use, existing or planned protection and current technology and knowledge. The components of a CHRMAP include:

- Coastal hazard risk identification and assessment;
- Coastal risk evaluation based on community and stakeholder engagement and an assessment of community safety;
- Identification of adaptation options to mitigate coastal hazard risk; and
- Assessment of adaptation options to identify preferred options.

The CHRMAP process takes into account the uncertainty associated with predictions of coastal change and provides a flexible decision-making pathway that decision makers can use as coastal hazards become more apparent or new hazards emerge.

What are the options for adapting to coastal hazards?

The WA State Government's State Planning Policy 2.6 – State Coastal Planning Policy (SPP 2.6) identifies a hierarchy of four pathways for adapting to coastal hazards:

Avoid

Identify future 'no build' areas and use planning controls to prevent new development in areas at risk now or in the future

Retreat

Withdraw, relocate or abandon assets that are at risk; ecosystems are allowed to retreat landward as sea levels rise

Accommodate

Continue to use the land but accommodate changes by building on piles, converting land uses or growing flood or salt-tolerant plants

Protect

Use hard structures (e.g. seawalls) or soft solutions (e.g. dunes and vegetation) to protect land from the sea. May be prohibitively expensive, especially in the long term

Please refer to Section 5 to learn more about these pathways and the additional pathways of 'No Regrets' and 'Do Nothing' that have been considered in the risk treatment assessment.

Who will pay for adaptation?

Financial support for coastal hazards management will need to be tailored, with funding found through existing rates and City financial reserves, or sought through advocacy.

The CHRMAP itself is an advocacy tool, essentially functioning as a business case for future investment decisions and presenting viable options to be considered by decision makers.

The endorsement of the CHRMAP is an important first step to achieve funding.

In WA, grants are managed by the Department of Planning, Lands and Heritage and the Department of Transport. Some other minor grants are available for actions such as planting and redeveloping coastal infrastructure.

Commonwealth grants are available from time to time, but not committed over longer term cycles.

Knowing that any type of coastal adaptation will be expensive, the CHRMAP recommendations should be used to commence advocacy with the relevant organisations that will likely be party to any funding.

How will this affect me?

Coastal hazards will affect different people in different ways depending on where they live and how they access, use and enjoy the coastline. Please refer to the table for a summary of information.

I AM A...	I MAY BE AFFECTED BY...
Private property owner in the coastal hazard zone	*Land Use Planning* - The land use planning framework provides for continuation of existing development or land uses until the coastal hazard risk or impacts become unacceptable. The land use planning framework then provides opportunities to introduce less vulnerable forms of use or development. *Notifications on Titles* - A notification on the property's certificate of title indicates to current and future owners that an asset is at risk, to help them make informed decisions about the level of risk they are willing to accept, and that risk management and adaptation is likely to be required. If a planning or development application is submitted for a lot located in a coastal hazard area then SPP 2.6 requires a notification to be placed on the certificate of title as a condition of approval, identifying that the lot may be vulnerable to coastal hazards.
User of the coastline	Some areas of the City of Bunbury coastlines will become vulnerable over the next 100 years. This includes beaches, access ways, footpaths, carparks, foreshore areas, toilets, roads and public open space areas. Section *7.1 Recommended Actions by Priority* provides a summary of the recommended management actions to be undertaken. These are largely focused on 'behind the scenes' actions such as monitoring, planning controls, and emergency management plans to better prepare decision makers for future coastal hazard management . Long term, adaptation strategies such as protection or managed retreat will be required when coastal hazards are realised, as explained in Section *7.2 Recommended Short Term Options, 7.2 Recommended Medium to Long Term Pathways* and the Implementation Plan. In areas identified for potential future protection, the construction of structures such as groynes, levees and storm surge barriers will mean that the natural sandy beach may eventually be lost in these locations and that access to those stretches of coastline might be affected. In areas identified for future managed retreat, existing infrastructure may gradually be removed or relocated if coastal hazards cause damage during storm events. In those cases the natural sandy beach and dunes will be given room to move, and thus the natural foreshore be retained.

Am I responsible if my property is affected?

This is complex, but the short answer is yes, you are responsible for management of your own property.

There is no legal obligation on the State or local governments to protect private assets within coastal hazard areas, or to compensate for any losses incurred due to coastal hazards. Should damaged assets pose a risk to public safety, removal may be required.

State or local Government are also not obliged to protect public assets, although they would need to ensure public safety. This might result in the need to remove assets that would be of danger to the community, if maintaining the asset is not an option.

SPP 2.6 requires that local governments prepare a CHRMAP to identify coastal hazard areas, outline potential adaptation pathways and share this information with the community, so we can all plan together.

Groups of landowners may be willing and have the capacity to fund protection works privately that the City cannot afford or seek funding for via other means. In this case, detailed planning and engineering works will still be required and funding for both capital and maintenance expenses will need to be committed by the landowners.

Engineering design would need to prove that the works would not have a negative impact on adjacent coastlines, areas or valued natural assets. Financially, the City would need to be certain that the landowners had the financial resources to continue maintenance, and may require guarantees or bonds to that effect.

Abbreviation List

AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARI	Annual Recurrence Interval
BDA	Benefit Distribution Analysis
CBA	Cost Benefit Analysis
CHRMAP	Coastal Hazard Risk Management and Adaptation Plan
CSEP	Community and Stakeholder Engagement Plan
DPLH	WA State Government Department of Planning, Lands and Heritage
DoT	WA State Government Department of Transport
FAQs	Frequently Asked Questions
GSC	Geotextile sand container
HSD	Horizontal Shoreline Datum (See SPP 2.6)
IPCC	International Panel on Climate Change
LAT	Lowest Astronomic Tide
LGA	Local Government Area
MCA	Multi Criteria Analysis
MHHW	Mean High High Water
MHLW	Mean High Low Water
MLHW	Mean Low High Water
MLLW	Mean Low Low Water
MSL	Mean Sea Level
MU	Management Unit
MWL	Mean Water Level
P&D Act	*Planning and Development Act 2005 (WA)*
PNP	Peron Naturaliste Partnership
SLR	Sea Level Rise
SPP 2.6	*State Planning Policy 2.6 – State Coastal Planning Policy*
The City	City of Bunbury
WAPC	Western Australian Planning Commission

Common Definitions

The following definitions apply to these words and phrases through the report:

Acceptable Risk

These are risks that do not need further treatment. The term 'acceptable risk' refers to the level at which it is decided that controls (further restrictions or otherwise altering the activity) is not worthwhile, as the current risk does not warrant further action.

Adaptation

Changes made in response to the likely threats and opportunities arising from climate variability and climate change.

Adaptation Pathway

Adaptation planning is about being ready to manage the risks and impacts of coastal processes a location experiences, by planning for the most appropriate decisions and options to implement over time.

A flexible adaptation pathway approach enables the establishment of a decision-making strategy that is made up of a sequence of decision points over time, preventing a decisionmaker from being locked into a risk treatment option (and associated risk management measures), which may not be appropriate for dealing with the long-term problem. The intent is for decision-making to be responsive to changing circumstances over time.

Annual Recurrence Interval (ARI)

An annual recurrence interval is the average number of years that it is predicted will pass before an event of a given magnitude occurs. For example, a 50 year ARI event would happen every 50 years on average.

Assets

Something that has value to the decision-maker, community and stakeholders – this can be tangible or intangible, includes consideration of risk and liabilities, and can be positive or negative at different stages of the assets life.

Assets may be natural or man-made and include:

- Beach
- Foreshore reserve (including dunes, flora and fauna)
- Foreshore reserve amenity (including things like car parks, paths, public ablutions, barbeque/picnic/shade areas, playgrounds, infrastructure for public safety and pedestrian access structures such as ramps, stairs and paths)
- Marinas
- Recreational boating facilities
- Facilities to benefit the broader public (such as cafés and restaurants)
- Surf life-saving facilities
- Commercial and residential land
- Protection structures such as groynes, seawalls and sand nourishment.

CHRMAP (Coastal Hazard Risk Management and Adaptation Plan)

A study that identifies the key hazards and assesses the risk to assets of coastal erosion and inundation.

Coastal Processes

Any action of natural forces on the coastal environment (and for the purposes of a CHRMAP, natural forces that affect land areas).

Coastal Zone

Area of water and land that may be influenced by coastal processes. This includes tidal areas of the lagoon or inland water bodies.

Erosion

Refers to shoreline movement where the shoreline shifts landward as a result of sediment being transported away by waves, winds and currents, reducing the size (width) of a coastal foreshore reserve and the distance to an asset on the adjoining land.

Habitat

The areas in which an organism and/or assemblage of organisms lives. It includes the abiotic factors (e.g. substrate and topography), and the biotic factors.

Horizontal Shoreline Datum (HSD)

The active limit of the shoreline under storm activity. It is the line from which the erosion hazard allowance will be applied from.

Inundation

The flow of water onto previously dry land. It may either be permanent (for example due to sea level rise) or a temporary occurrence during a storm event.

In the context of CHRMAP, inundation does not include circumstances where groundwater or stormwater runoff may sit at the surface of land and be unable to infiltrate back into the soil.

Intolerable Risk

Risk that is unacceptable in any circumstances or at any level.

Longshore

Parallel to the shoreline.

Multi-Criteria Analysis

A decision-making tool that supports the prioritisation of risk management options using multiple criteria as reviewed by the community and government stakeholders.

Mean Sea Level (MSL)

The average surface level of coastal bodies of water (from which elevation may be measured).

Rehabilitation

The re-establishment of vegetation and other ecological attributes, acknowledging that the area and the environmental asset will remain modified.

S1

The current risk of storm erosion (based on historical storms).

S2

Historic shoreline movement trends determined by reviewing available monitoring information and historical coastline photographs.

S3

The allowance which is required by State Planning Policy to allow for predicted sea level rise.

S4

The allowance for the current risk of storm surge inundation.

Sand Nourishment

Sand nourishment is one possible protection adaptation option to coastal hazards. It may be a standalone measure for protection, or be used to improve the beach amenity when used in combination with other adaptation measures such as a seawall.

It is considered to be a ‘soft’ management option and usually mimics natural beach and dune systems.

Sandy Coast

Comprises unlithified and/or unconsolidated sediments, rock is either not present or not dominant. They typically feature gently to moderately sloping shores and are often backed by dunes or beach ridges, which may contain dune blowouts. The shoreline can quickly alternate between accretion and erosion but is likely to retreat as a result of sea level rise.

Sediment Cell

A length of shoreline in which interruptions to the movement of sediment along the beaches or near shore sea bed do not significantly affect beaches in the adjacent lengths of coastline. Within a sediment cell the sediments sources, transport pathways and sinks should be clearly definable.

Storm Surge

The increase in water level at the shoreline due to the forcing of winds (wind-setup) and atmospheric pressure.

Trigger

A pre-determined point that is set to ‘trigger’ the commencement of planning and /or implementation actions; a catalyst for decision making.

Unacceptable Risk

These are risks that require action or treatment, as the current risk is intolerable to the community, the economy or the environment.

Vulnerability

The underlying properties of an ‘asset’ which result in susceptibility to a risk source that can lead to an event with a consequence.

Wave Overtopping

Water carried over the top of a structure or landform due to wave run-up or surge action exceeding the crest.

Contents

Refer website (CoB)

Appendices listed at back of report with hyperlink to the web page intended. Hyperlink could also be here

1 Introduction

It is internationally recognised that the mean sea level has been rising globally since the nineteenth century and is predicted to rise at an increasing rate in the future (IPCC, 2021).

The City of Bunbury is a highly populated coastal settlement that is facing the increased risks from sea level rise and intensifying storm activities.

Management of risks to the land areas adjacent to the ocean coast, estuaries and rivers is very important for the social, environmental, infrastructure and economic assets and values of the local communities.

1.1 Background

Some work on coastal hazards has been undertaken in the past. A coordinated approach which identifies areas likely to be affected by erosion and/or inundation and requiring management and adaptation to mitigate the risks, will provide increased resilience to the coastal communities.

The Western Australian Planning Commission's (WAPC) State Planning Policy No. 2.6: State Coastal Planning Policy (SPP 2.6) recommends that management authorities develop a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP), in accordance to a specific guideline for the **CHRMAP process** (*Figure 1*).

The purpose of the CHRMAP is to provide strategic guidance for coordinated, integrated, and sustainable decision making for future coastal land use planning, including management of, and adaptation to, coastal hazard risks (coastal erosion and inundation).

SPP2.6 requires adequate risk management planning is undertaken where the existing or proposed development is in an area at risk of being affected by coastal hazards over the **100-years planning timeframe**.

SPP2.6 and the CHRMAP Guidelines provide the risk assessment framework to be applied to identify risks that are intolerable to the community, and other stakeholders such as local governments, indigenous and cultural interests, and private enterprise. Risk management measures are then developed according to the adaptation hierarchy outlined in SPP2.6.

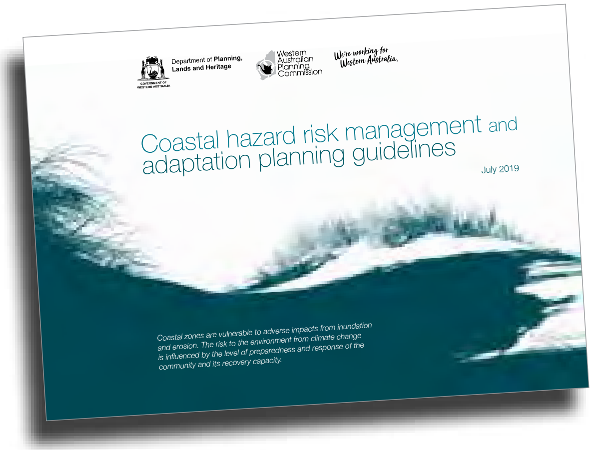


Figure 1: CHRMAP stages per the CHRMAP Guidelines (Source: WAPC 2019)

Stage 1 – Establish the Context

- Project inception
- Stakeholder and Community Engagement Plan
- Confirm the purpose, objectives, scope, study area

Stage 2 – Risk Identification

- Coastal hazard assessment
- Coastal hazard mapping
- Identify coastal assets and values – community engagement and survey

Stage 3 – Vulnerability Assessment

- Prepare likelihood and consequences scales
- Develop level of risk matrix and risk tolerance scale
- Risk assessment for coastal assets against erosion and inundation to determine the vulnerability ratings

Stage 4 – Risk Evaluation

- Identify existing controls and mitigation measures
- Priorities for risk treatment
- Identify risk treatment options
- Multi-Criteria Analysis (MCA)

Stage 5 – Risk Treatment

- Cost Benefit Analysis (CBA)
- Benefit Distribution Analysis (BDA)
- Adaptation options and pathways including identifying triggers and planning horizons

Stage 6 – Implementation

- Identify long-term pathways
- Produce a short-term implementation plan to 2035
- Land use planning instruments considered
- Funding options

Stage 7 – Monitor and Review

- Develop monitoring plan, detailing any monitoring or review that may be required.

Peron Naturaliste Partnership

Project Partners

The Peron Naturaliste Partnership (PNP) comprises membership of nine local government authorities. The PNP's Coastal Adaptation Pathways Project identified the coastal areas of Capel, Leschenault and Greater Bunbury as being particularly exposed to coastal hazards and climate change, which triggered the need for this CHRMAP. Therefore, the present study aims to investigate the nature and severity of coastal hazards that are likely to affect these regions over future planning horizons.

The PNP worked with the Steering Group and a consultant team to develop a CHRMAP for the coastal, river and inlet environments of Capel, Bunbury, Dardanup and Harvey (Leschenault), with the support and technical advice of the State Government departments.

This studyproduced four separate CHRMAPs with substantial information available in technical documents for those wishing to view detailed analysis.

The Steering Group:

- City of Bunbury
- Shire of Capel
- Shire of Dardanup
- Shire of Harvey
- Department of Biodiversity, Conservation and Attractions (DBCA)
- Southern Ports Authority (SPA)

Support and technical advice:

- Department of Water Environment and Regulation (DWER)
- Department of Planning Lands and Heritage (DPLH)
- Department of Transport (DoT)

This report summarises all findings related to the land areas within the City of Bunbury.

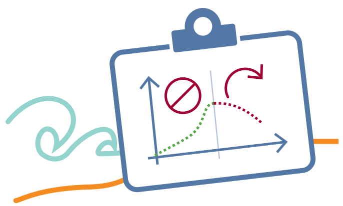
1.2 Objectives

This report is a summary document outlining the CHRMAP process and presenting content from the technical reports. **It has been prepared to provide an overview that is more accessible to a wider audience**.

This report should be considered in combination with the more detailed technical reports which are provided as appendices. References are provided throughout this document and refer to the documents listed in the reference section of the relevant technical reports.

The overall objectives of the CHRMAP were to:

- Summarise the existing policies and planning controls, existing physical controls, and jurisdiction boundaries
- Improve understanding of existing coastal processes, features, and hazards within the study domain
- Identify coastal assets and values through stakeholder and community engagement
- Identify coastal hazard risks in terms of both coastal erosion and inundation, as well as potential vulnerability trigger points
- Improve understanding of asset risk and vulnerability to coastal hazards
- Determine the consequence, likelihood, and tolerance of assets to the identified risks
- Identify effective risk management measures through Multicriteria Analysis and Cost Benefit Analysis
- Identify short, medium, and long-term risk management actions
- Engage with stakeholders and the community to inform local values, adaptation pathway selection, and the implementation plan



Scope

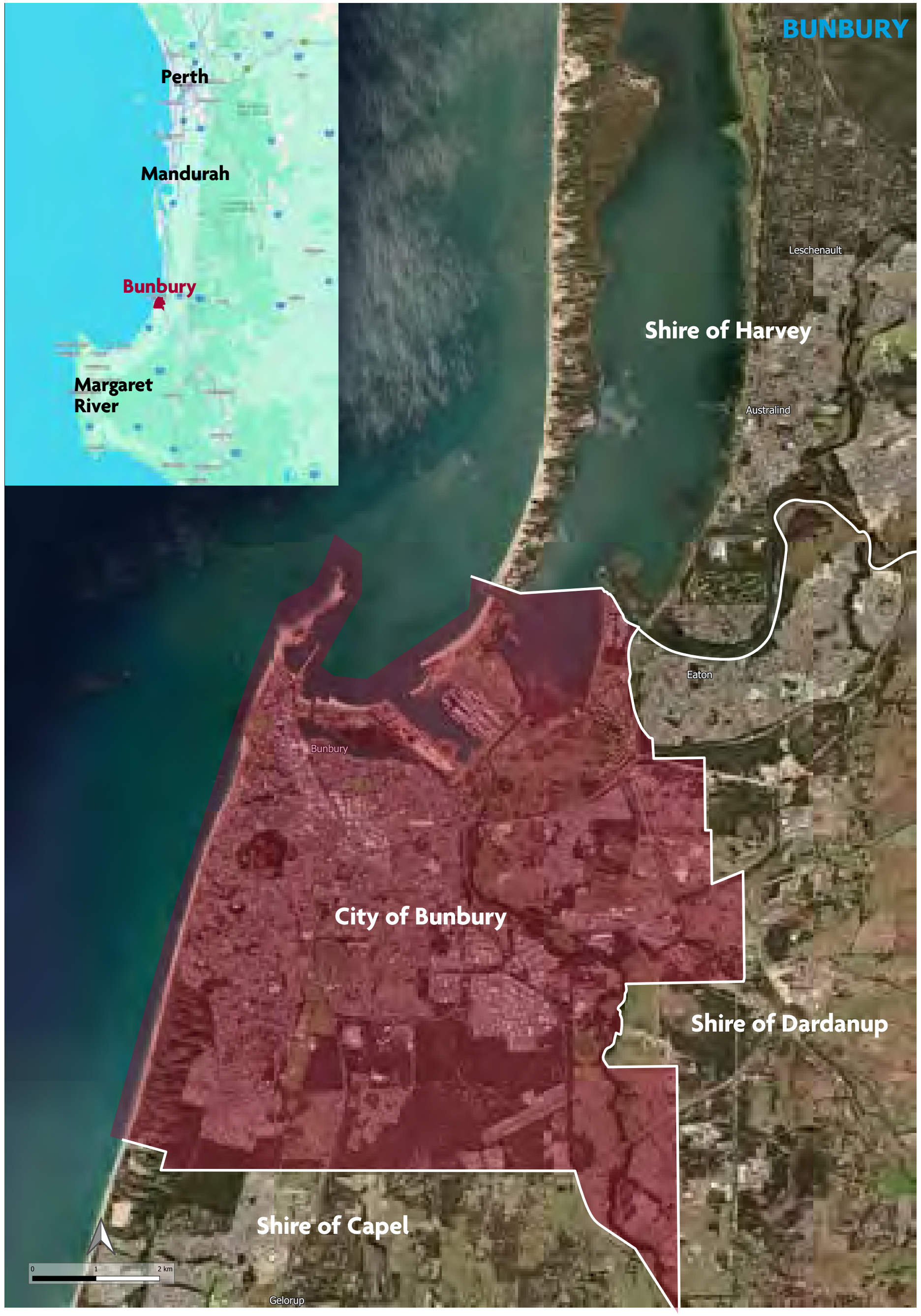
The CHRMAP identifies values and assets that are vulnerable to coastal erosion and inundation hazards within the study area.

Risk management measures are then considered that reduce risk to levels that would be considered tolerable to the community (which is tested through engagement).

Detailed information is provided for short-term (less than 25 years) management measures.

Strategic guidance on medium and longer-term risk management is also included.

The CHRMAP focusses on preserving assets and values which provide benefit to all members of the community, noting that private at-risk assets are also acknowledged and considered.



1.3 Study Area

The broader study area covers four Local Government Areas (LGAs) namely Shire of Harvey, City of Bunbury, Shire of Dardanup, and Shire of Capel. This report addresses coastal hazard vulnerabilities for the City of Bunbury.

Goomburrup (Bunbury) is located in the Gnarla Karla Boodja region of WA and the traditional owner of this land is the Wardandi people of the Noongar nation.

The City is located approximately 180 km south of Perth covering about 65 km area (*Figure 2*). The area was first established as the Municipality of Bunbury in 1871.

In 1961, it became the Town of Bunbury under the Local Government Act 1960. It assumed its current name in Oct 1979. The 2016 census figures indicate the City has an established population of almost 32,000. The City is a regional hub and has numerous developments along its coast.

Near coast infrastructure and assets located within the study area includes shops, restaurants, foreshore areas and playgrounds, houses, natural vegetation, community facilities, arts precincts, civic buildings, roads, car parks, paths, breakwaters, jetties, groynes, seawalls, bridges, the storm surge barrier, as well as the surf club, sailing club, Dolphin Discovery Centre, Casuarina Harbour and the Bunbury Port.

Coastal considerations

The study area within the City comprises many different sections of coastline with variable shore types and degrees of development (*Figure 3*).

Low-lying land is present along Five Mile Brook (e.g., the Big Swamp Wetland), surrounding the Leschenault Inlet (East Bunbury), and along the Collie and Preston Rivers.

These areas are susceptible to coastal inundation.

Areas likely to experience coastal erosion are located along the Indian Ocean frontage, Koombana Bay, Vittoria Bay and the Leschenault estuary.

Collectively, inundation and erosion are likely to impact large parts of the City's local Government area. Consideration of coastal hazards and adaptation constraints of assets will be crucial for successful risk management and implementation plans across the City.

Figure 2: City of Bunbury location (source: Google Maps, Esri Satellite Imagery)

Management Units

To facilitate the coastal hazard assessment and development of adaptation options, the study area was delineated into several management units which are determined according to a set of factors:

- Jurisdiction boundaries
- Presence of coastal assets and relevant stakeholders
- Coastal processes and relevant hazard types.

The City shoreline can be divided into **five primary management units**:

- MU4 - Bunbury South
- MU5 - Bunbury (including Five Mile Brook district, Koombana Bay, Leschenault Inlet)
- MU6 - Bunbury Port (Inner Harbour)
- MU7 - The Cut
- MU8 - Bunbury East

NB: the numbering of these management units recognise the broader technical CHRMAPs developed for the Capel to Leschenault area, comprising the local Government areas of Bunbury, Capel, Dardanup and Harvey.

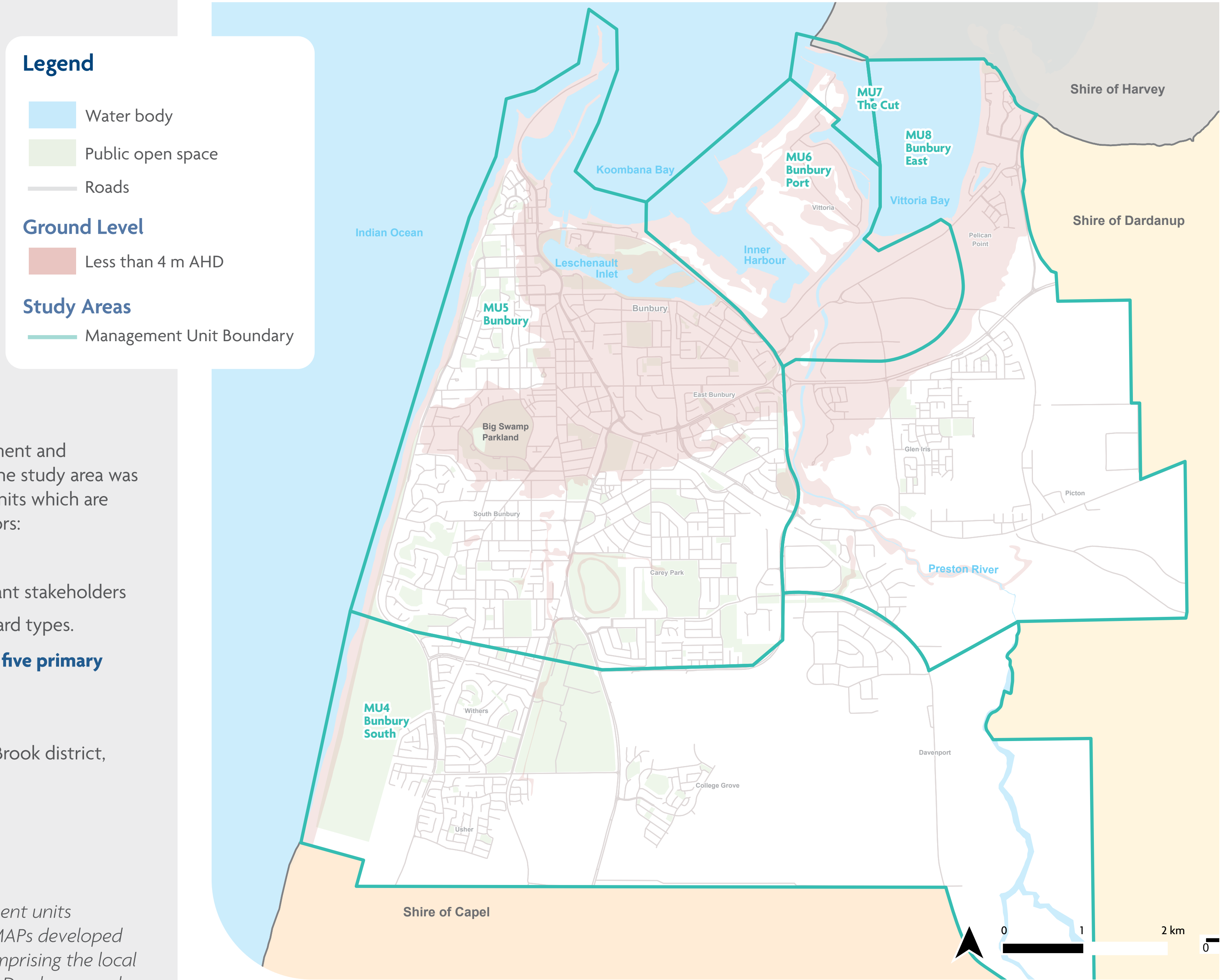


Figure 3: Bunbury CHRMAP study areas (overlaid are suburbs and roads)

2 Existing Environment

Figure 4: City of Bunbury Shoreline Type (contains Esri Satellite Imagery)

Table 1: Shoreline Characteristics

Assessment Zones			Shoreline Type	Description
MU4	1	• Mindalong Beach	Sandy	• Straight open coast, sandy beach backed by coastal reserve (Maidens Reserve) • Populated town site with public assets such as playground, lookout, car parks etc.
MU5	2	• Hungry Hollow Beach • Back Beach	Sandy	• Populated coast at Bunbury • Straight open coast, sandy beach
MU5	3	• Five Mile Brook & Big Swamp Wetland	Drainage Channel	• Inland area with a low elevation.
MU5	4	• Point Casuarina	Mixed	• Low rock (basalt) outcrops • Presence of numerous assets
MU5	5	• Casuarina Drive (South of the Spur Groyne)	Sandy	• Backed by Casuarina Drive, sandy beach
MU5	6	• Casuarina Drive (outer Harbour breakwater, Casuarina Harbour)	Physical Control	• Bunbury Outer Harbour Berths, breakwater and Casuarina Harbour • Key protection for Koombana Bay • Casuarina Harbour is currently under development
MU5	7	• Jetty Baths Beach • Ski Beach • Koombana Beach	Sandy	• Protected beach backed by Casuarina Drive • Small sandy beach under protection of the Plug storm surge barrier and breakwater/ groynes • Key public space and assets; significant developments and recreational facilities
MU5	8	• Marlston Waterfront	Seawall	• Key public space and assets
MU5	9	• Koombana Bay Sailing Club • Storm surge barrier	Sandy	• Small sandy beach under protection of the storm surge barrier & Koombana Beach breakwater/groyne • Potential breakwater protection

Assessment Zones			Shoreline Type	Description
MU5	10	• Leschenault Inlet	Foreshore protection Mangrove habitats	• Enclosed water • Storm surge barrier • Protection on southern side • Shallow water
MU6	11	• Port area on eastern Koombana Beach	Seawall	• Presence of seawall control • Port land
MU6	12	• Inner Port Berths	Seawall	• Erosion allowances are not directly relevant.
MU6	13	• Point Hamilla	Sandy	• Short stretch of sandy beach between two groynes
MU6	14	• Port area at south of the Cut	Sandy	• Short stretch of sandy beach
MU6	15	• Lower Preston River	Riverbank	• North of Australind Bypass • River flood plain
MU7	16	• Turkey Point	Sandy	• Unprotected on both the seaside and estuary side
MU7	17	• The Cut	Seawall	• Some segments are not built to required design standard
MU8	18	• Vittoria Bay	River delta	
MU8	19	• Pelican Point	Sandy, Man-made canal	• Sandy shoreline on western side • Houses connected by canal with physical protection
MU8	20	• Upper Preston Point	Sandy, Tidal flat	• River flood plain

2.1 Shoreline Type

The current shoreline of Bunbury is a result of combined effects of coastal processes and human intervention.

The City is subject to coastal erosion and inundation, despite the numerous physical controls that have been implemented.

Figure 4 shows the natural and man-made shoreline type in the City of Bunbury study area. *Table 1* describes the shoreline characteristics of each assessment zones. The following information describes the key man-made infrastructure and natural physical controls that exist along the shoreline.

A **Koombana Beach** has experienced westwards movement and progressive erosion on the eastern end. The issue has been studied previously to develop a feasible adaptation option. A seawall structure has been constructed to prevent further erosion. Koombana Beach has been identified as an erosion hotspot (DoT 2019).

B A breach of the northern training wall occurred at **the Cut** channel into **Leschenault Estuary** in 2012 causing erosion of a sand bar along the northern bank. Emergency remedial work such as minor excavation of the sand bar and landward extension of the northern breakwater ('training wall'), was undertaken in 2014, however it was not built to specification due to erosion of the site access point. This area has also been identified as an erosion hotspot (DoT 2019).

(source: Apple maps)

C **Ocean Drive** includes rock outcrops north of Wellington St along Bunbury Ocean Drive and Baudin Terrace. These rocks in general have a low elevation backed by sandy soil. The shoreline further north is protected by the **Outer Harbour breakwater** and **spur groyne**. Ocean Drive is on the watchlist of coastal erosion (DoT 2019).

D Shorelines within **Koombana Bay** are either modified by engineering controls e.g., breakwaters and seawall, or within the scope of large-scale developments (such as the Port).

All beaches in Koombana Bay are heavily modified due to the construction of the Port's inner harbour and river diversion. Sandy beaches are also present inside the bay, e.g., within **Casuarina Harbour**, **Koombana Beach**, and near **Turkey Point**.

E **Leschenault Inlet** and surroundings have a low-lying nature and are vulnerable to present and future inundation hazards. A **tidal gate** (Bunbury storm surge barrier, or 'the Plug') was installed near the entrance to prevent coastal flooding.

F **Five Mile Brook** is one of the main drainage paths of the City. The surrounding areas, including the **Big Swamp Reserve**, have a low ground elevation. There are one-way valves at the outfall location.

G **Preston River** flood plain. Riverbank protections were built to restrict the spreading of river flood.

2.2 Metocean Conditions

Key documents and datasets have been reviewed to provide context for this CHRMAP, including data on metocean (meteorological and oceanographical) processes, coastal processes and existing coastal hazard information. Sources of information identified as directly relevant to inform this CHRMAP have been utilised and referenced and reported in *Appendix AB* Chapter Report: Coastal Hazard Assessment.

This significant detail can be summarised as follows:

2.2.1 Water Levels

Ocean water levels over the project region comprise variations from astronomical tide, wind and wave setup, atmospheric pressure, seasonal and interannual anomalies, riverine discharge, and periodic impacts of tropical cyclones, coastal trapped waves and tsunamis.

Tidal Planes - tidal motion of the region can be characterised by one high tide and one low tide per day. Tidal range is approximately 0.8 m during spring tide and can be much smaller during the neap phase.

Non-tidal Water Level Variability - oceanographic processes have a substantial influence on variability in coastal sea levels, related to the El Nino Southern Oscillation (ENSO) cycle. Impacts may be enhanced in the future due to the increased risk of extreme La Nina events under a warmer climate.

Storm Surge - storm surges arise in relation to strong winter storms moving out of the Southern Ocean, as well as tropical cyclones travelling from the tropics.

Tsunami - although usually occurring at a lower frequency than storm surge and river flood events, inundation levels are likely to be similar to that of the 500 years ARI storm surge levels; with a predicted wave height of 1.6-1.8m.

Seal Level Rise (SLR) - recommended SLR for 2120 is at +0.9 m above current levels, per the requirements of SPP2.6.

Wind Climate - average wind speeds are around 18 km/h, peaking at 36 km/h. The strongest storm winds can reach about 71 km/h for a 1-year event and over 94 km/h for a 100-year event, especially from the west.

Tropical/Extra-tropical Cyclones - most likley from December to April, the southwest region seldom experiences cyclones. However, when they do occur such as Tropical Cyclone Alby or Tropical Cyclone Bianca, tropical cyclones can pose greater coastal hazards than winter storms due to extreme winds often surpassing 108 km/h, extreme waves, severe storm surges and intense rainfall, particularly affecting low-lying areas like the Leschenault Inlet and Estuary (Bunbury, East Bunbury, Picton, South Bunbury and Pelican Point / the Grand Canals).

2.2.2 Wave Climate

Wave climate is largely influenced by deep-water swell waves from the Indian and Southern Oceans, with significant seasonal variations. Four main wave sources occur in Bunbury:

- offshore swells, larger during winter
- storm waves from winter storms
- local wind seas from sea breezes
- tropical/extra-tropical cyclones

Extreme Wave Conditions -

Offshore: wave height predictions varied from 6.7 m to 11 m.

Koombana Bay: wave height predictions varied from 0.9 m to 3.4 m with a reduction in heights attributed to the Outer Harbor breakwater.

Casuarina Harbour: wave height predictions varied from 0.2 m to 0.6 m with a reduction in heights attributed to the Casuarina breakwater and Jetty Road Causeway. The proposed new breakwater in this location is expected to keep this wave energy low.

Leschenault Estuary: wave height predictions suggest a maximum of 0.6 m in this low wave energy environment, with significant winds required to generate more substantial wave height.

Leschenault Inlet: wave height information was not available for this water body, although as a small and confined water body, it is expected to be low energy.

2.3 Coastal Processes

2.3.1 Geomorphological Setting

Landforms and shorelines are formed over many thousands of years. Over 6,000 years, significant shoreline changes have occurred, influenced by geological factors like rock formations and mobile sand ridges.

The foreshore features simple seabed contours, parallel sand dunes, and wetlands or lakes between dunes. While limestone rock is sometimes found, it's rarely above sea level. Outcropping basalt rock is present between Rocky Point and Casuarina Point at Bunbury.

Over the next 10 years, the majority of change is expected to be the result of storms and seasonal shoreline variability. Over the 100 year timescale of the CHRMAP, change is expected to be the result of local landform changes and metocean climate and weather events

2.3.2 Sediment Cell

Sediment (predominantly sand) cells are areas of the coast within which marine and terrestrial landforms are likely to be connected. Sediment cells are used to assist coastal planning, management, engineering, science, and governance along the coast.

2.3.3 Sediment Transport

Sediment transport within the project predominantly flows in a northwards direction, driven by the dominant westerly/south-westerly swells throughout the year.

2.3.4 Local Processes

Ocean Drive, Casuarina Breakwater and the Outer Harbour

Although sediment moves predominantly northwards, basalt outcrops have stabilised the shoreline at Point Casuarina, leading to a wider beach at Bunbury Back Beach on the southern side of Wyalup Rocky Point. Sand drift has caused sand accumulation against the Spur groyne north of Rocky Point and then again at the Casuarina Breakwater near McKenna Point. This sand build up can be mobilised by a southerly storm around the head of the breakwater.

Seawalls along this coast, especially at Bunbury Back Beach, offer extra protection to crucial foreshore areas.

Jetty Baths Beach & Ski Beach

The Jetty Baths and Ski Beach have remained stable, likely influenced by a lower wave energy compared to more exposed beaches like Koombana and Back Beach. Physical barriers, such as Jetty Road and the storm surge barrier training wall, have created isolated, stable sediment cells at these beaches, supported by larger sand grain sizes (that 'move' less readily).

Koombana Beach

Sand transport along Koombana Beach predominantly moves westward. There's been significant sand buildup on the western part and minor erosion, while the eastern side continuously erodes. Studies suggests potential for 6-20 m of erosion during severe storms.

Koombana Beach has undergone extensive engineering with groynes, revetments, and edge treatments affecting its shape. These structures, including those protecting the Dolphin Discovery Centre influence the beach's future morphology.

Sand is trapped between groynes most of the year, though sand may be lost during storms.

Leschenault Inlet

The shoreline is protected by rock revetments and mangrove habitats, with minimal landscape changes observed, and sediment movement is low due to the area's low wave energy. The City undertakes minor maintenance of the Sykes Foreshore beaches through sand replenishment.

Leschenault Estuary

The estuary was altered by the construction of the Cut entrance in the 1950s, division into Leschenault Inlet and Estuary in the 1970s, and various industrial and dredging activities.

Overall, the Leschenault Estuary has seen little change since the early 2000s, with low sediment transport rates except near river mouths and The Cut entrance.

Riverbank Erosion

The various riverbanks are generally stable. Historically, the Preston River has been realigned with flood levees extending to the Forrest Highway.

The Collie River and catchment have moderately degraded banks, but few engineered responses. Satellite images show that the location of riparian zone did not change significantly in past 20 years.

Coastal Management

Coastal management currently includes activities such as monitoring, revegetation, repairs and maintenance of the storm surge barrier, sand nourishment (bringing in sand) and management and maintenance of coastal structures (breakwaters, groynes, seawalls).

2.4 Historic Shoreline Changes

2.4.1 Development in Koombana Bay

Koombana Bay has experienced **significant development since the 1900s** (see *Figure 5*).

- The outer harbour breakwater was constructed in the early 1900s which formed the current layout of Koombana Bay.
- Since then, numerous coastal infrastructure projects have been implemented, including the construction of the Inner Harbour and various groynes, breakwaters, and jetties to stabilise the shoreline, including:
  - » the storm surge barrier in the 1970s
  - » Inner Harbour in the 1970s
  - » the Cut in the 1950s-1970s
  - » Northern Breakwater Arm in the 1980s

Investment in Bunbury's coastline has increased in recent years, including:

- Planned, yet to be implemented, **Inner Harbour expansion** (*Figure 6*) by Southern Ports Authority (SPA).
  - » The expansion of the inner harbour has been in discussion for at least three decades.
  - » In 2009, Bunbury Port drafted a structure plan as a policy document to guide the development and decision making of the Inner Harbour.
  - » More recently, a draft master plan has been prepared.

Figure 5: Historic Developments in Koombana Bay (until 1990s) (Taken from Water Technology 2023)

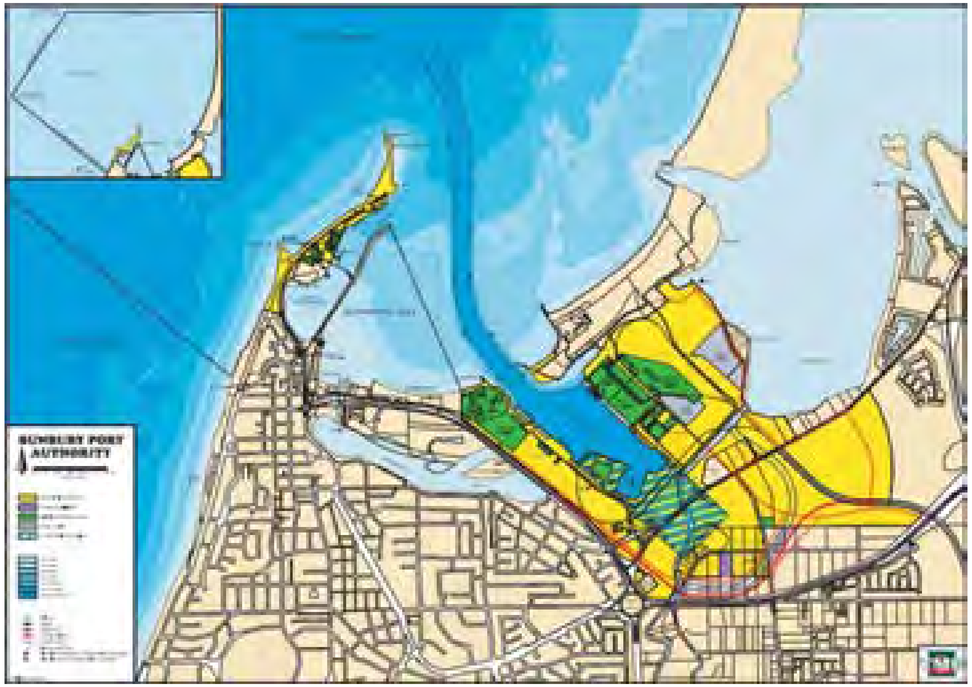


Figure 6: Expansion of the Inner Harbour (taken from 2009 Inner Harbour Structure Plan)

- **Transforming Bunbury's Waterfront** (*Figure 7*) by the Department of Transport and South West Development Commission. This development includes multiple stages:
  - » Koombana Foreshore Revitalisation and Dolphin Discovery Centre Redevelopment (completed)
  - » Jetty Road Causeway upgrade (completed)
  - » Casuarina Drive Redevelopment (underway)
  - » Construction of new breakwaters for Casuarina Harbour (funding announced, planning in progress subject to approvals, including environmental approvals)
  - » Koombana Sailing Club Marina, (planning in progress - subject to approvals, including environmental approvals)

2.4.2 Developments in Leschenault Inlet

Leschenault Inlet is a remnant of the lower section of the Leschenault Estuary, which was separated from the main water body by the construction of the Inner Harbour in the 1970s. The inlet has an area of approximately 70 hectares and is now one of Bunbury's most important recreational waterfronts. Since the 1980s, the inlet has undergone significant development including construction of foreshore protection (seawalls), boat ramps, jetties, boat clubs, discovery park, car parks, foreshore reserves, and boardwalks.

In 2013, the City prepared a **Leschenault Inlet Master Plan** to guide future development and planning for the area (*Figure 8*). The plan prioritised management of the inlet for the future.

Currently, the inlet comprises a mangrove reserve, and segments of engineered shoreline protecting the foreshore area. The foreshore is backed by paved roads and urban development and has limited setback for shoreline management. The Bunbury storm surge barrier (the Plug) limits high ocean water levels impacting the inlet and surrounding lands.

Figure 7: Bunbury Waterfront transformation - Marina Structures (Taken from RPS 2015)

Figure 8: Leschenault Inlet Master Plan (City of Bunbury, 2013)

2.5 Existing Physical Controls

Physical controls have been implemented primarily along Casuarina Drive, inside Koombana Bay (including the inner Harbour) and Leschenault Inlet.

Table 2 lists some major physical controls in Bunbury region and may not provide a complete list of physical controls over the entire study domain.

The influence of existing physical controls has been considered throughout the CHRMAP.

Table 2: Physical Controls

LOCATION	PHYSICAL CONTROL	STRUCTURE TYPE	MATERIAL	JURISDICTION
Leschenault Inlet	Pat Usher Foreshore	Seawall	Limestone Block and Mortar	CoB
	Rowing Club	Seawall	Basalt and Concrete	CoB
	Queens Gardens	Seawall	Basalt and Concrete	CoB
	Stirling Street	Seawall	Limestone Block and Mortar	CoB
	Frank Buswell Foreshore	Seawall	Limestone Block and Mortar	CoB
	Richmond Reserve	Seawall	Coffee Rock and Concrete	CoB
	Koombana Boardwalk	Seawall	Sheet Piling and Rock Armour	CoB
	Sykes Foreshore	Seawall	Rock Armour	CoB
	Power Boat Club	Seawall	Limestone Block	CoB
	The Plug – Les D Vorak	Seawall	Rock and Mortar	CoB
	The Plug – Youth Precinct	Seawall	Rock Armour	CoB
Ocean Drive	Five Mile Brook outfall	Unclear		TBC
	Ocean Drive Spur	Groyne	Rock	SPA
	Casuarina Drive Outer Harbour Breakwater	Breakwater	Rock	SPA
	Ocean Drive – Hungry Hollow	Revetment Wall	Unknown	CoB
	Ocean Drive – Hayward Street	Revetment Wall	Unknown	CoB
Koombana Bay	Koombana Bay Jetty Road	Breakwater	Rock	DoT
	Marlston Waterfront	Seawall	Rock Armour	CoB
	Ski Beach Groyne	Groyne	Rock	TBC
	Storm Surge Barrier	Storm Surge Barrier		DoT
	Koombana Bay Sailing Club Groyne	Groyne	Rock	TBC
	Koombana Foreshore – Sailing Club	Revetment	Unknown	CoB
	Koombana Foreshore – Dolphin Discovery	Revetment	Unknown	CoB
	Koombana Beach Eastern Seawall	Seawall	Rock Armour	SPA
	Point Busaco Groyne	Groyne	Rock	SPA
	Point Hamilla Groynes	Groyne	Rock	SPA
Pelican Point	Pelican Point – Taylor Foreshore	Seawall	Limestone Block and Mortar	CoB
Turkey Point	the Cut	Seawall	Rock Armour	CoB
Inner Harbour	Inner Harbour Berth	Berth	Rock	SPA
Rivers	Weirs/gates/riverbank protection			TBC

CoB = City of Bunbury DoT = Department of Transport SPA = Southern Port Authority

2.6 Existing Planning Controls

Planning in Western Australia is guided and regulated by the State Planning Framework, which sits within the *Planning and Development Act 2005*. The framework includes overarching strategic planning strategies and specific planning policies and supportive guidelines at the state, regional, and local levels.

Figure 9 illustrates this framework. It demonstrates how strategic planning is implemented through statutory planning controls (e.g., local planning schemes) and local planning policies. The planning documents within this Framework were reviewed to determine which are relevant to coastal hazard planning in the project area.

This review helped to:

- assess the adequacy of the existing planning documents for addressing coastal hazards;
- identify gaps that needed to be addressed through the CHRMAP process (such as planning controls that are required, or need amending to enable implementation of CHRMAP recommendations);
- identify any potential planning issues that may constrain the CHRMAP process; and
- ensure that the adaptation plan aligns with state, regional and local planning frameworks.

A large array of regional and local planning documents were also reviewed for study area and discussed further in *Appendix A* Chapter Report: Establish the Context.

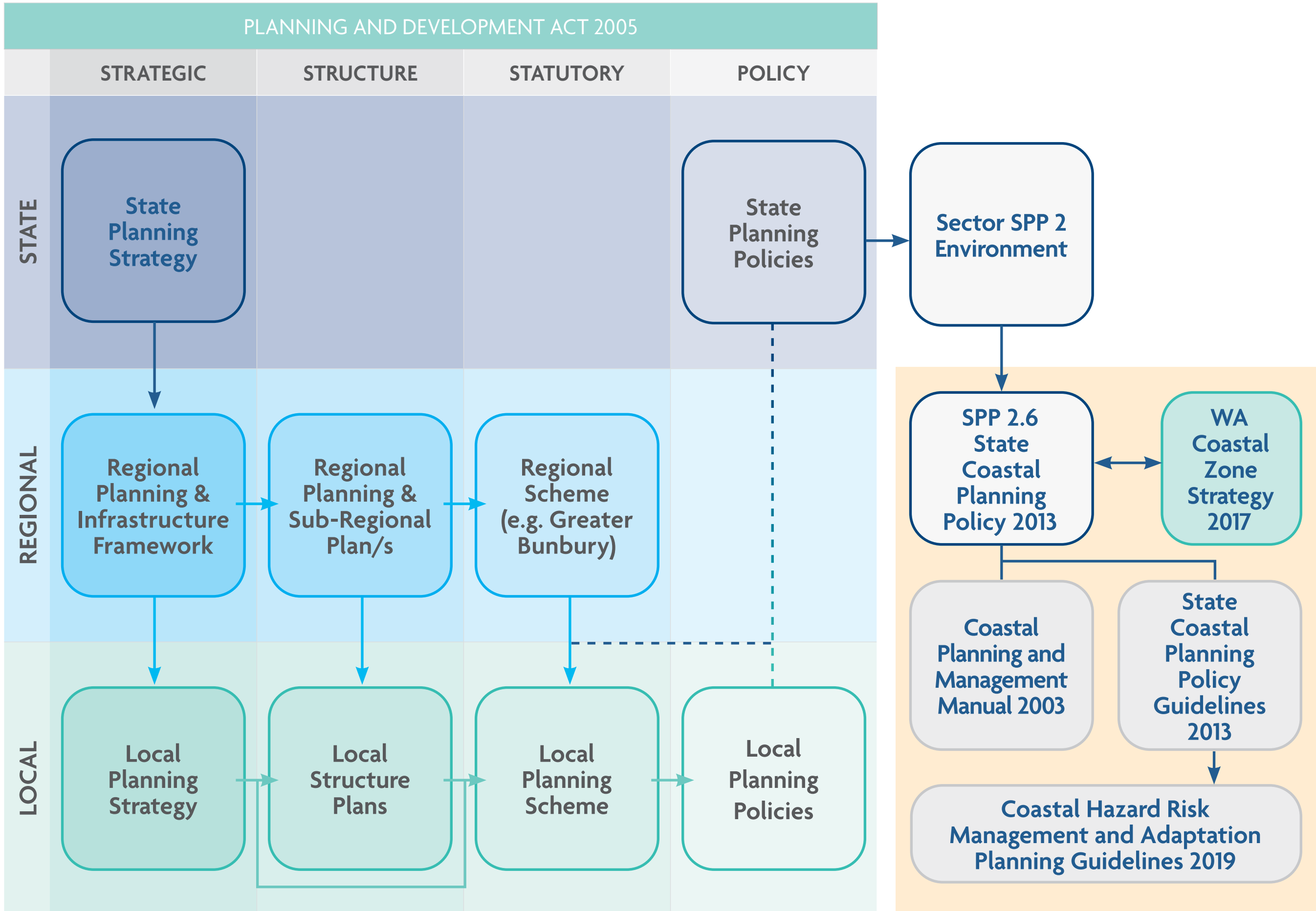


Figure 9: WA State Planning Framework and policy relationship to coastal planning

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2.7 Asset Identification

Coastal assets (both natural and built) were identified in the following ways:

1. Asset information was provided for use in this study by the City and included in a GIS database.
2. Landgate was accessed to identify assets, including roads.
3. The coastal values survey(s) and other engagement activities identified additional assets of importance and value to the community.
4. Site visits investigated locations where information required greater detail or clarity.
5. Further assets were idenfied manually from aerial photography (e.g., developed areas of foreshore reserve).

2.7.1 Asset Categories

One of the main challenges of this CHRMAP is the numerous assets and management zones. This asset classification was developed to address the main coastal adaptation issues and key locations and enable a simple yet effective method for adaptation planning.

At the time of identification, each asset was categorised into a classification. This streamlines the adaptation planning process in subsequent phases of the project. The study team grouped assets as follows:

1. **Roads.**
2. **Residential Properties**, including both occupied and vacant land.
3. **Commercial Land and Assets** e.g., Bars, shops, markets etc.
4. **Public and Community Assets** not located in the foreshore reserve e.g., car parks, recreational facilities.
5. **Developed Foreshore Reserve**, including coastal, estuary and river foreshore areas containing public assets, e.g., car parks, public ablutions, playgrounds, walkways, access structures.
6. **Undeveloped Foreshore Reserve**, including coastal, estuary and river foreshore areas.
7. **Environmental Assets**
    - Contaminated sites
    - Matters of National Environmental Significance (such as Carnaby's Cockatoo's and Western Ringtail Possums),.
    - Threatened and Priority Ecological Communities.
    - Known locations of threatened flora.
8. **Agricultural/rural Lots**
9. **Aboriginal Heritage**

3 Community and Stakeholder Engagement

3.1 Why We Consult

Key to the success of the CHRMAP project was to ensure that the plan is underpinned by community and stakeholder values and knowledge.

To this end, a Community and Stakeholder Engagement Plan was developed in order to identify relevant stakeholders and determine the structure and pathways for their engagement throughout the CHRMAP process. The plan intended to be tailored to identified stakeholders, open to any other interested stakeholder, and be commensurate with the size and scope of the CHRMAP.

This plan was prepared in accordance with the requirements of, and for consistency with, the following documents:

- Capel to Leschenault Communications Framework (PNP, 2020).
- The International Association of Public Participation (IAP2).

Engagement Objectives

The overarching objectives of the community and stakeholder engagement plan for the CHRMAP were to:

1. Establish strong working relationships with community networks and stakeholders.
2. Ensure all stakeholders have up to date information about the CHRMAP.
3. Provide the community and relevant stakeholders the opportunity to have direct input into the development and delivery of the CHRMAP.
4. Understand community goals and aspirations for the coastal zone and community views on values, assets, opportunities and priorities.
5. Aid in identifying key issues and selecting site-specific CHRMAP management actions to address them, based on knowledge of the area developed over years of interaction.
6. Increase community and stakeholder understanding of, and support for, actions and priorities in the CHRMAP.

3.2 How We Engaged

The engagement activities for the initial stage of the project included:

- Use of an **interactive mapping** tool to gather feedback on values, use of the coastal and riverine environment and other comments.
- **A survey** mirroring the online task.
- **A community workshop** held in September 2021 to discuss coastal processes, map community values and understand issues and concerns of the community for the study area.
- **Direct engagement** with Traditional Owners and Indigenous representatives.
- **Key stakeholder meetings.**

This initial stage was available from July to September 2021.

Briefings to key City staff members and regular meetings with the Steering Group comprising administrative staff from PNP, the Department of Planning, Lands and Heritage, the Department of Water, Environment and Regulation, the Southern Ports Authority and the Department of Transport were also included in initial engagement, to ensure technical rigour.

Following this early engagement, a second engagement phase was undertaken to present the draft adaptation options. This phase comprised the convening of a Coastal Community Advisory Group in September and November 2022, made up of key stakeholders within the study area who nominated to be involved via an Expression of Interest process.

The final engagement was undertaken during public advertising of the draft CHRMAP, and received limited responses from City residents and stakeholders.

Notwithstanding, the feedback received confirms the need for ongoing and detailed engagement with the community, especially those users groups with direct interface or regular use of the coastal environment.

Engagement Outcomes

The project team received a total of 181 responses and 56 additional comments provided spatially in the first phase (see example in *Figure 10).* The second phase comprised 10 members. Just five people provided feedback during the formal advertising phase. A drop-in session event was held at the surf club during formal advertising.

Overall the engagement achieved an approximate reach of more than 445 local community members and organisations., although more significant involvement throughout the CHRMAP development would have been beneficial.

Refer to *Appendix C* and *Appendix G* for detailed community and stakeholder engagement methods and outcomes.

Figure 10: Online mapping tool on Social Pinpoint (snippet)

3.3 What We Heard

The values collated from the engagement were used to **generate the success criteria** for the vulnerability and risk assessment component of the CHRMAP. These ultimately drive the selection of adaptation options. It is important to recognise that ongoing engagement is required to ensure that the CHRMAP is understood and becomes increasingly applicable to all stakeholders.

Assets and values

Key coastal, estuarine and riverine values identified by participants across the whole study area as follows:

- Beaches and estuarine areas for activities like walking, swimming, snorkelling, exercise, views, fishing, surfing, 4WDing
- Wetlands and environmental areas for their flora and fauna diversity which participants could appreciate
- Coastal views, walks and scenery
- Coastal vegetation and the natural environment generally
- Opportunities for observing wildlife at various locations and protecting habitat for these communities and species

Issues and Concerns

Key issues and concerns / risks to the coastal values:

- Beach erosion and its environmental, social and financial impacts
- Vegetation retention, revegetation and the need to do more to protect coastal areas from erosion
- Environmental protection was highly valued
- Sea level rise and climate change was also a key discussion point, with participants encouraging Local Government to actively addressing climate change impacts
- Contamination and pollution impacts on fauna and flora and the health of waterways from industrial activities along the coastline and river environment, including the Port at Bunbury
- Protection of coastal wetlands that mitigate against impacts of extreme events and that are home to birds and wildlife
- Biodiversity and habitat loss
- Human impact on the coastal and estuarine natural assets and values to the community

Success Criteria

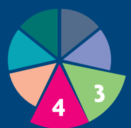
The success criteria established for the CHRMAP reflected all stakeholder views, as presented throughout the process.

1. **Conserve**, **enhance** and **maintain** the natural environment and character of the study area.
2. **Facilitate** and **promote** public usage and enjoyment of the natural environment, coast, estuaries and rivers.
3. **Protection** of the cultural values of the coastline.
4. **Manage** impacts to the existing residential areas from erosion and inundation.
5. **Maintain** critical infrastructure supporting the community (roads, utilities).
6. **Manage** and **maintain** coastal infrastructure that provides access to the water and supports the lifestyle enjoyed by people in the region.
7. **Retain** the widest possible range of risk management options for future users of the coast.

The success criteria highlight the need for continuing public access to beaches, beach amenity, and the provision of a coastal foreshore reserve, and also identify the high value placed on protecting the natural environment.

4 Coastal Hazard and Vulnerability

The study area covers a complex shoreline with various types of environments present in this region. The presence of rivers, an estuary and inlet has increased the complexity of the broader study area, in particular the assessment of inundation hazards where river flood plays an important role.



4.1 Coastal Hazard Assessment

The CHRMAP produces 'hazard maps' defining the potential extent of erosion and inundation over long term timeframes. This CHRMAP presented the timeframes of Present day (2020), 2035, 2050 and 2120.

The hazard identification component of the CHRMAP was undertaken to provide a broad understanding of the potential extent, to support government planning at a regional level based on known data and required technical inputs.

It must be acknowledged that once site-specific studies become available, particularly at the estuary/inlet and along the river courses, some of the modelling may change.. However, what is always the case, is that a CHRMAP identifies the most robust information available at any given point in time, to allow decision makers to make the best possible decisions.

More detailed risk assessments, and studies such as geotechnical assessment and analysis will be required for the development of detailed responses.

For this reason, the CHRMAP provides a number of recommendations for more research, whilst planning pathways are being modified.

Erosion Hazard Modelling

SPP 2.6 requires the following be considered to assess erosion:

1. Simulate the current risk of storm (S1).
2. Evaluate historic shoreline movement trends (S2).
3. Allow for sea level rise impacts for present day (2020), 2035, 2050 and 2120 (S3).
4. Apply corrections where shorelines comprise existing hazard controls (e.g. seawalls etc).
5. Evaluate erosion for each coastal management zone over the planning timeframes; 2020 (present day), 2035 (short term), 2050 (medium term) and 2120 (long term).

The output is mapping of erosion hazards, represented by 'lines'.

Inundation Hazard Modelling

SPP2.6 requires that modelling allow for the current risk of storm surge inundation, based on processes that have at least 0.2 percent or one-in-five hundred years probablility of occurring or being exceeded (S4).

The predicted extent of sea level rise is also required to be modelled.

For Bunbury, the inundation level is modelled through the simulation of a representative cyclone based on the existing Tropical Cyclone Alby track, with adjustments to locate the cyclone eye near the Bunbury region.

The output is mapping of inundation areas.

Refer to *Appendix B* for the erosion and inundation study approach, including the modelling tools, considerations and limitations.

A quick reminder:

Erosion

When sediment (sand) is transported away by waves, winds and currents, reducing the size (width) of a coastal foreshore reserve and/or the distance to an asset on the adjoining land.

Inundation

The flooding of a portion of previously dry land with ocean water. It may be a temporary occurrence during a storm event or high tide, or permanent due to sea level rise.

The next four sections provide a summary of the erosion hazard lines and inundation extents that have been modelled in this CHRMAP for each of the City's Management Units.

4.1.1 MU4 – Bunbury South

The Bunbury South Management Unit (MU4) is the City's least affected management unit, with a predicted loss of the natural environment from a wide and flexible foreshore reserve.

- Erosion is predicted to impact natural assets within this management unit with adequate foreshore allowing for natural processes over time.
- Inundation is not anticipated to in this management unit, with adequate foreshore allowing for natural processes over time.

Assets at Risk (MU4)

from Present Day (from erosion)

- Developed and undeveloped foreshore

by 2120 (from erosion)

- Public and community assets
- Environmental assets

by 2120 (by inundation)

- Environmental assets

Figure 11: Hazard mapping focusing on MU4 - Bunbury South

Figure 12: Hazard mapping focusing on MU5 - Bunbury)

4.1.2 MU5 – Bunbury

The Bunbury Management Unit (MU5) is particularly at risk.

- Erosion is a significant risk for buildings and natural assets along the western coast of the City.
- Koombana Bay and Leschenault Inlet are heavily engineered. Erosion may still occur along shorelines not protected by structures. Access to the outer harbour (Casuarina Drive) is at risk from 2035.
- Inundation is a significant risk across much of this management unit, and predicted to increase from present day to 2120. By 2120, the 100-year ARI is predicted to inundate a significant residential and commercial area.
- The storm surge barrier (the Plug) plays a key role in inundation control. Risk will increase if the barrier is not in operation.
- Much of the CBD is predicted to be under water during a 100-year and 500-year ARI storm by 2120. The crest of the current storm surge barrier is about 2.1 m AHD, which and may require modifcation to withstand these storms in 2120.

Assets at Risk (MU5)

from Present Day (both erosion and inundation)

- Aboriginal Heritage assets, developed and undeveloped foreshore, public and community assets

by 2120 (from erosion)

- Substantial extent of roads
- Significant numbers of environmental assets
- More than 200 residential properties
- Several commercial assets

by 2120 (by inundation)

- Extensive road networks
- Extensive environmental assets
- More than 2,000 residential properties
- Hundreds of commercial assets

4.1.3 MU6 – Bunbury Port

Largely developed with port infrastructure design to withstand and work with the coastal environment, MU6 is at risk over longer timeframes.

- By 2120, the land near the entrance to the inner Port will be at risk from erosion. Reinforcement may be required for shoreline segments not protected.
- The area is at risk from inundation at the port and other lower ground areas, although main port facilities are not affected.

4.1.4 MU7 – the Cut

The man-made 'Cut' is at risk over the long term.

- The Cut entrance is vulnerable to erosion by 2120. Seawater may erode the sand dune behind the seawall if not upgraded to higher standards. Overtopping and breaching of the sand dune behind the seawall may occur.
- MU7 is not vulnerable to Inundation in any substantial way.

Assets at Risk (MU6 & MU7)

from Present Day (both erosion and inundation)

- Public and community, developed and undeveloped foreshore

by 2120 (from erosion)

- Several roads (MU6)
- Significant numbers of environmental assets (MU6 & MU7)
- A small number of agricultural/rural lots (MU6)
- Several commercial assets (MU6)

by 2120 (by inundation)

- Several roads (MU6)
- Extensive environmental assets (MU6 & MU7)
- A small number of agricultural/rural lots (MU6)
- Several commercial assets (MU6)

Figure 13: Hazard mapping focusing on MU6 - Bunbury Port and MU7 - the Cut

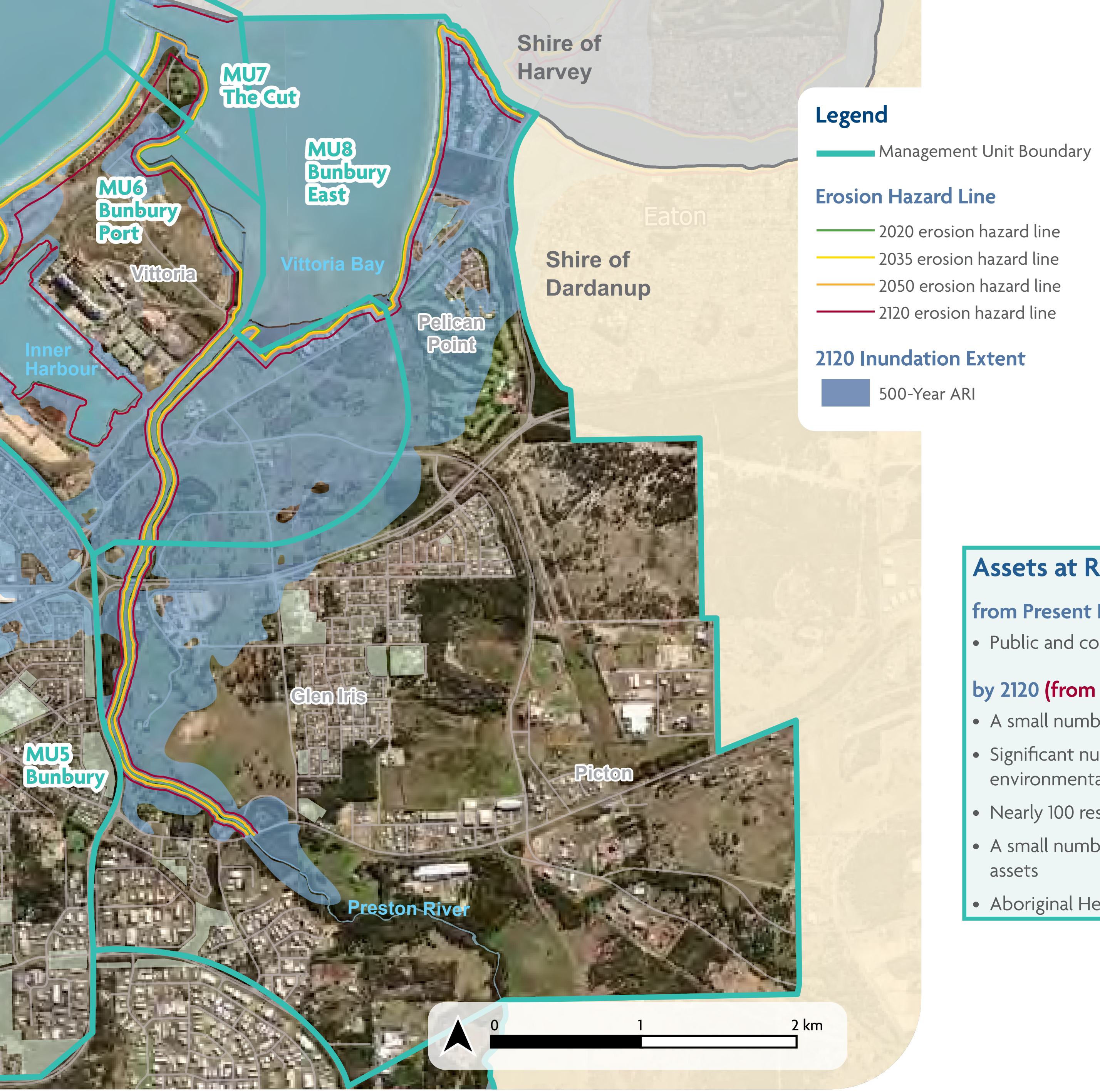


Figure 14: Hazard mapping focusing on MU8 - Bunbury East

4.1.5 MU8 – Bunbury East

The Bunbury East Management Unit (MU8) is particularly at risk.

- The areas surrounding Preston River and the Estuary are at risk from, and experiencing, inundation. Pelican Point, including the Grand Canals, are included in this assessment.
- Foreshore assets and the commercial properties on Estuary Drive are predicted to be at risk from coastal erosion by 2120.
- It is assumed the canal infrastructure will be maintained; however, the canal properties are at risk from erosion along the river and estuary fronts by 2120. Should canals not be maintained, further analysis will become increasingly necessary.

Assets at Risk (MU8)

from Present Day (both erosion and inundation)

- Public and community, developed and undeveloped foreshore

by 2120 (from erosion)

- A small number of roads
- Significant numbers of environmental assets
- Nearly 100 residential properties
- A small number of commercial assets
- Aboriginal Heritage assets

by 2120 (by inundation)

- Substantial extent of roads
- Significant numbers of environmental assets
- More than 400 residential properties
- Several commercial assets
- Aboriginal Heritage assets

4.2 Vulnerability Assessment

Vulnerability analysis constitutes the second stage of the risk identification process. A vulnerability assessment defines the degree of impact coastal hazards are likely to have on coastal assets over the planning timeframe.

The **vulnerability** of coastal assets to coastal hazards is related to its **exposure** to the hazard, its **sensitivity** to that exposure, and the **adaptive capacity** of the **asset at risk** (modified or adapted) to manage this exposure. This is displayed diagrammatically in *Figure 15*.

The vulnerability results are presented in full in the Vulnerability Analysis Chapter Report in *Appendix D*. A summary is presented in the following pages by management unit and asset category, for the planning horizons of 2020 (present day), 2035, 2050 and 2120.

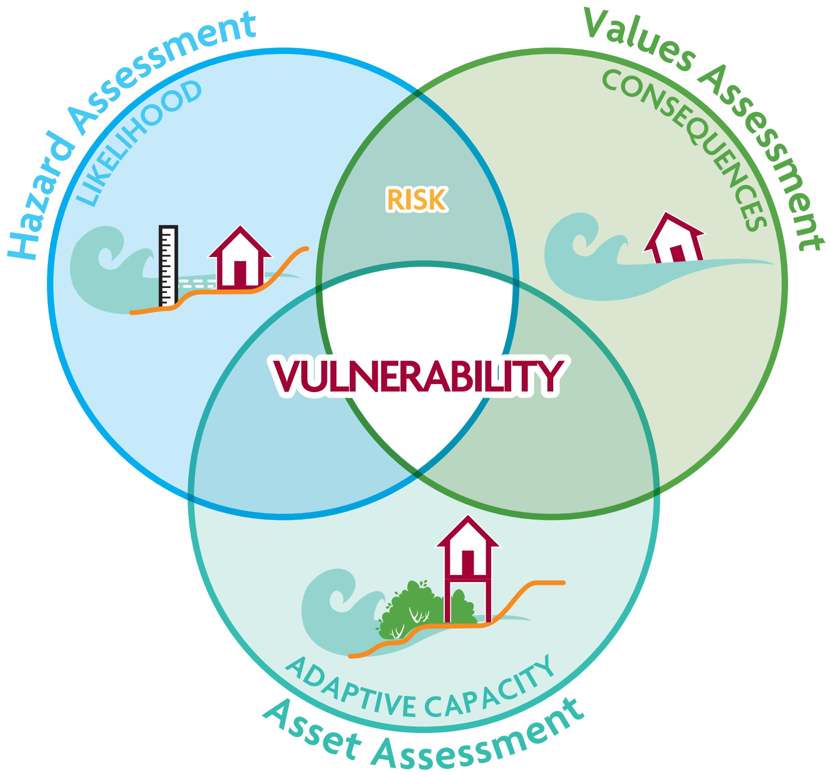


Figure 15: Vulnerability assessment, adapted from CHRMAP Guidelines (WAPC, 2019)

Glossary

Sensitivity/Consequence is an asset's responsiveness to a coastal hazard. Each asset category is assigned a sensitivity/consequence rating, for erosion and inundation respectively. The consequence ranking presented in *Table 3* constitutes the physical impact of the event to the asset, as well as that of the values attributed to it by the success criteria defined earlier in the CHRMAP.

Exposure/Likelihood of identified assets represents the likelihood of coastal hazards impacting on an asset – the chance of erosion or inundation impacting on existing and future assets and their values. The likelihood scale adopted for this study is presented in *Table 4*. Ratings have been allocated to asset categories for each hazard at each timeframe based on hazard assessment results.

Risk Level/Potential Impact is calculated as the product of exposure and sensitivity (see *Figure 16 and Table 5*).

It provides a classification of the potential impact (risk level) of coastal hazards on identified assets, which was determined for each project timeframe. Definitions are provided in *Table 6*.

Adaptive Capacity is the asset's ability to adjust/adapt to the identified hazard. It is determined based on the potential for modification of the asset to cope with the impacts from coastal hazards. The scale of adaptive capacity is provided in *Table 7*. Rating of adaptive capacity was determined by assets/asset groups as well as feedback from stakeholders and community.

Vulnerability is calculated as the product of potential impact (risk level) and adaptive capacity (*Figure 16 and Table 8*).

As per WAPC (2019), four levels of vulnerability are considered in this study for each of the planning timeframes considered by this CHRMAP.

Vulnerability ratings are Very High, High, Medium and Low.

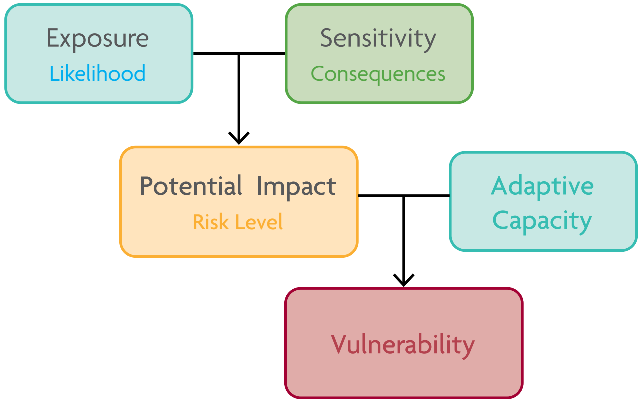


Figure 16: Vulnerability relationship

Table 3: Sensitivity/Consequence rating

CRITERIA	SENSITIVITY/CONSEQUENCE RATING				
	Insignificant	Minor	Moderate	Major	Catastrophic
Physical	• No or minimal damage, perhaps requiring increased maintenance	• Minor damage to assets resulting in restrictions in capability.	• Damage to assets resulting in isolated loss of capability.	• Significant damage to many assets resulting in capability constraints.	• Significant damage to most assets resulting in loss of capability.
Financial	• Financial loss less than $20,000	• Financial loss of $20,000 to $200,000	• Financial loss of $200,000 to $2 million	• Financial loss of $2 million to $5 million	• Financial loss of over $5 million
Environment	• Negligible to no impact to the environment	• Short-term damage to environment. • Recovery will be strong. • Local or regional alternate habitat exists	• Medium-term loss of environmental assets. • Recovery is likely. • Local or regional alternate habitats exist	• Long-term damage to environmental assets. • Limited chance of recovery. • No local alternate habitat(s) exist. Regional habitats exist	• Permanent damage to environmental assets. • No chance of recovery. • No alternate habitat(s) exist.
Community/ Social & Cultural	• Minimal short-term inconvenience to the asset, services and function, <5% of community affected • Many alternatives exist	• Isolated but noticeable (short term) decline or disruption to asset, services and function, <10% of community affected. • Alternative sites exist	• Moderate (short to medium term) decline or disruption to assets, services and function, <25% of community affected. • No convenient alternative exists	• Severe (medium-term) decline or disruption to asset, services and function, <50% of community affected. • No convenient alternative exists	• Long-term or permanent loss of asset, services and function >75% of community affected. • No alternative exists

Table 4: Exposure/Likelihood rating

EXPOSURE/LIKELIHOOD RATING	
Rare	May occur in exceptional circumstances
Unlikely	Impact to asset for a given planning timeframe is unlikely
Possible	Impact to asset for a given planning timeframe is possible
Likely	Impact to asset for a given planning timeframe is likely
Almost Certain	Expected to occur in most circumstances

Table 5: Risk level matrix as product of Sensitivity/Consequence and Exposure/Likelihood

LIKELIHOOD	CONSEQUENCE				
	Insignificant	Minor	Moderate	Major	Catastrophic
Rare	Low	Low	Low	Medium	Medium
Unlikely	Low	Low	Medium	Medium	High
Possible	Low	Low	Medium	High	Extreme
Likely	Low	Medium	High	Extreme	Extreme
Almost Certain	Low	Medium	High	Extreme	Extreme

Table 6: Risk Level/Potential Impact rating

RISK LEVEL/POTENTIAL IMPACT RATING	
Low	Tolerable risk. A level of risk that is low and manageable without intervention outside routine asset maintenance.
Medium	A level of risk that may require intervention to mitigate, such as changes to design standards or asset maintenance. Short to medium term action required.
High	A level of risk requiring significant intervention to mitigate in the immediate to short term.
Extreme	Immediate action required to reduce risk to acceptable levels

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Table 7: Adaptive Capacity rating

ADAPTIVE CAPACITY RATING				
No adaptation required	Very High (Very Good)	High	Moderate	Low (Very Poor)
Potential impact has insignificant effect on asset. Controls are re-established naturally or with ease before more damage would likely occur.	Good adaptive capacity. Functionality restored easily. Adaptive systems restored at a relatively low cost or naturally over time.	Decent adaptive capacity. Functionality can be restored, although additional adaptive measures should still be considered. Natural adaptive capacity restored slowly over time under average conditions	Small amount of adaptive capacity. Difficult but possible to restore functionality through repair and redesign.	Little or no adaptive capacity. Potential impact would destroy all functionality. Redesign required.

Table 8: Vulnerability matrix (as a combined product of Risk Level and Adaptive Capacity, where Extreme Risk and Low Adaptive Capacity combine as the least-best scenario)

RISK LEVEL (POTENTIAL IMPACT)	ADAPTIVE CAPACITY			
	Very High	High	Moderate	Low
Low	Low	Low	Medium	Medium
Medium	Low	Medium	Medium	High
High	Medium	Medium	High	Very High
Extreme	Medium	High	Very High	Very High

4.2.1 Vulnerability Ratings

Vulnerability ratings for each category within each management unit at each planning horizon is presented in *Table 9* for erosion and inundation respectively.

There is a substantive number of at-risk assets, a total of approximately 48,000 across the broader study area.

The vulnerability ratings are assessed based on the grouping of **nine asset categories** as detailed in *2.7.1 Asset Categories*.

Asset Categories

1. **Roads**
2. **Residential**
3. **Commercial**
4. **Public and Community**
5. **Foreshore - Developed**
6. **Foreshore - Undeveloped**
7. **Environmental**
8. **Agricultural/Rural**
9. **Aboriginal Heritage**

Note: Asset categories with Not Applicable results for both erosion and inundation are omitted from these tables.

Table 9: Vulnerability Rating for asset categories of all Management Units in Bunbury

ASSET CATEGORIES	VULNERABILITY RATINGS 2020	2035	2050	2120	SUMMARY
MU4 Bunbury South					**4 categories** are vulnerable to **Erosion** from Medium to Very High levels. Adaptation in some form is required from the present day. **3 categories** are vulnerable to **Inundation** at a Medium level. Adaptation in some form may be required from the present day.
Public and Community	High / Not Applicable	High / Not Applicable	High / Not Applicable	Very High / Not Applicable	
Foreshore - Developed	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	
Foreshore - Undeveloped	High / Medium	Very High / Medium	Very High / Medium	Very High / Medium	
Environmental	Very High / Medium	Very High / Medium	Very High / Medium	Very High / Medium	
MU5 Bunbury					**8 categories** are vulnerable to **Erosion** from Medium to Very High levels. Adaptation in some form is required from the present day. **6 categories** are vulnerable to **Inundation** at Medium to High levels. Adaptation in some form may be required from the present day. **Residential and commercial assets** are vulnerable to **Inundation** at a Very High level. For these categories, adaptation in some form is required from the present day.
Roads	Very High / Medium	Very High / Medium	Very High / Medium	Very High / Medium	
Residential	4x Very High, High / Very High	Very High / Very High	Very High / Very High	Very High / Very High	
Commercial	3x Very High, High / Very High	Very High / Very High	Very High / Very High	Very High / Very High	
Public and Community	5x Very High, High / High	5x Very High, High / High	Very High / High	Very High / High	
Foreshore - Developed	Medium / Medium	Medium / Medium	Medium / Medium	Medium / Medium	
Foreshore - Undeveloped	High / Medium	Very High / Medium	Very High / Medium	Very High / Medium	
Environmental	Very High / Medium	Very High / Medium	Very High / Medium	Very High / Medium	
Aboriginal Heritage	Very High / High	Very High / High	Very High / High	Very High / High	

Legend

- Not Applicable (for erosion or inundation respectively)
- 4x Where a smaller number of assets have a higher vulnerability rating (the number of assets is noted)

Erosion Vulnerability: Low, Medium, High, Very High

Inundation Vulnerability: Low, Medium, High, Very High

Table 9: Vulnerability Rating for asset categories of all Management Units in Bunbury (continued)

ASSET CATEGORIES	VULNERABILITY RATINGS				SUMMARY
	2020	2035	2050	2120	
MU6 Bunbury Port					6 categories are vulnerable to Erosion from Medium to Very High levels. Adaptation in some form is required from the present day. 5 categories are vulnerable to Inundation at Medium to High levels. Adaptation in some form may be required from the present day. Commercial assets are vulnerable to Inundation at a Very High level. For these categories, adaptation in some form is required from the present day.
Roads					
Commercial					
Public and Community					
Foreshore - Undeveloped					
Environmental					
Agricultural/Rural					
MU7 The Cut					2 categories are vulnerable to Erosion from High to Very High levels. Adaptation in some form is required from the present day. 2 categories are vulnerable to Inundation at Medium to levels. Adaptation in some form may be required from the present day.
Foreshore - Undeveloped					
Environmental					
MU8 Bunbury East					8 categories are vulnerable to Erosion from Medium to Very High levels. Adaptation in some form is required from the present day. 7 categories are vulnerable to Inundation at Medium to High levels. Adaptation in some form may be required from the present day. Residential and commercial assets are vulnerable to Inundation at a Very High level. For these categories, adaptation in some form is required from the present day.
Roads					
Residential	3x				
Commercial					
Public and Community					
Foreshore - Developed					
Foreshore - Undeveloped					
Environmental					
Agricultural/Rural					
Aboriginal Heritage					

Risk Treatment Needed for All MUs

'Very High' vulnerability has been identified from the present day (2020) onwards. Most of this is predicted to be from erosion, with the exception of residential and commercial, which is vulnerable to inundation.

All MUs at all planning horizons have unacceptable levels of vulnerability for both erosion and inundation (medium or above) for one or more asset categories.

5 Management Options

SPP2.6 provides a hierarchy of adaptation pathways to guide decision-making in coastal areas to be used by planning authorities and development proponents when considering adaptation options to minimise coastal hazard risks at the local level.

Avoid

Identify future 'no-build areas', use planning tools to prevent new development, and enhance the natural environment in areas at risk now or in the future.

Retreat

Withdraw, relocate or abandon built assets that are at risk; enhance the natural environment and allow natural ecosystems to retreat landward as sea levels rise.

Accommodate

Continue to use the land but implement changes such as building on piles, converting agriculture to fish farming or growing flood or salt-tolerant crops.

Protect

Use hard structures (e.g., seawalls, levees) or soft solutions (e.g. vegetation) to protect built assets. May result in loss of natural environment and be prohibitively expensive, especially in the long term.

Figure 17: Adaptation hierarchy (adapted from WAPC, 2019)

5.1 Adaptation Hierarchy

The hierarchy, presented in *Figure 17* describes a clear preference against the adoption of 'protect' as a long-term adaptation pathway.

This preference is re-emphasised in SPP2.6, the policy guidelines, the CHRMAP Guidelines and the WA Coastal Zone Strategy.

The objectives of SPP 2.6 are to:

- Ensure that the location of coastal facilities takes into account coastal processes, hazards and climate change projections.
- Ensure the identification of appropriate areas for the sustainable use of the coast.
- Provide for public coastal foreshore reserves and access to them on the coast.
- Protect, conserve and enhance coastal zone values, particularly in areas of landscape, biodiversity and ecosystem integrity and cultural significance.

It is important to note that no law requires public authorities to protect private property from environmental hazards nor provide compensation when property or assets are damaged due to coastal hazards.

Adaptation Considerations for Decision Makers

The CHRMAP process aims to minimise coastal hazard risks and maximise the beneficial use of the coast. The following summarises the considerations for adaptation actions.

- Adaptation options should **minimise coastal process interference and legacy issues**
- Coastal **development must be sustainable** in the long term, and must balance the community, economic, environmental and cultural needs
- **Local Governments are responsible for managing risks to public assets and any assets they manage**. They should also:
  - » **Develop local policies and regulations** consistent with state legislation and policy
  - » **Facilitate building resilience and adaptive capacity** within the local community
  - » **Work in partnership with the community** to identity and manage risks / impacts
- Management strategies that **preserve the natural coastline** and **move development away from the active coastal zone** in an orderly manner are considered ideal. Of particular relevance to the CHRMAP process is the **user pays principle**, whereby those who benefit most from protection must provide the greatest financial contribution.
- Adaptation options should **maintain future flexibility**, in order to build resilient coastal communities.
- A key adaptation option will be the use of **planning instruments**, including managed retreat.

5.2 Risk Treatment Options

There are 17 risk treatment options identified to address coastal erosion and inundation hazards.

These options may be suitable for both immediate and long-term adaptation. These options are briefly discussed regarding their potential applicability to Bunbury, likely benefits, and potential impacts.

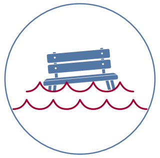
While the risks and their respective treatment options are evaluated independently, the need for adaptation can occur at any time from either erosion or inundation.

Avoid

AV – Avoid locating assets in areas that will be vulnerable to coastal hazards

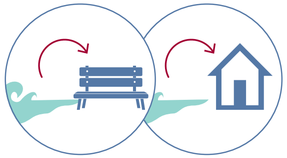
Assets will not be vulnerable to risk arising from coastal hazards.

Planned or Managed Retreat



PMR1 – Leaving assets unprotected

For low values assets, accept loss following event. Only implement repairs to maintain public safety. Allow for retreat that allows natural recession of the shoreline over the long-term.



PMR2 – Demolition/removal/relocation of asset from inside hazard area.

Relevant for assets of low value where it is impractical both technically and financially to design the asset to withstand the impact of the coastal hazards instead of relocating it.

PMR3 – Prevention of further development/prohibit expansion of existing use rights

For all assets, this risk treatment option would enable existing development and use rights to continue without increasing them, until such time that risk arising from coastal hazards becomes intolerable. Would be specified in the local planning scheme.

PMR4 – Voluntary acquisition

For private property assets, this risk treatment option would proposes the acquisition of affected properties, on a voluntary basis.

Accommodate

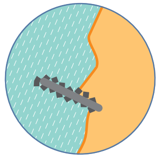
AC1 – Design assets to withstand impacts

Where avoiding or relocating an asset is not an option, design of assets to withstand the impact of inundation.

Protect

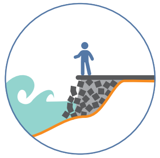
PR1 – Sand nourishment

Placement of sand within the beach profile and/or dunes to activate beach coastal processes and provide a sediment supply.



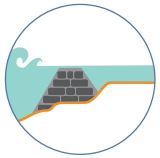
PR2 – Groyne

Construction of groynes to stop or restrict the movement of sand around the end of the structure, to provide protection to assets behind the beach/foreshore reserve. They are primarily effective where there is longshore sand movement or when partnered with PR1 sand nourishment.



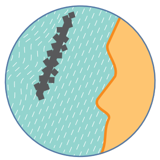
PR3 – Seawall

Construction of a seawall usually along an entire section of shoreline. Where a beach is to be retained, this risk treatment option should generally be accompanied with PR1 beach nourishment or replenishment.



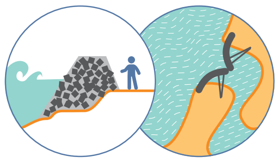
PR4 – Artificial reef

Construction of a submerged artificial reef offshore, to dissipate wave energy impacting the shore by causing waves to break on their seaward side and reducing wave energy on the leeward side. Artificial reefs do not block waves and during storm events water depths over the reef may be sufficient to allow waves to pass over the reef without breaking, reducing their effectiveness in protecting the beach from erosion.



PR5 – Offshore breakwater

Construction of an emergent offshore barrier (often referred to as an offshore breakwater). Offshore breakwaters block wave energy by absorbing wave impact on their seaward side. They create a lower wave energy section of beach immediately in its lee, which is characterised by sand accreting in the low energy environment, when designed appropriately.



PR6 – Levee/weir/storm surge barrier

Inundation protection to minimise inundation on low-lying land. This could be a levee on the banks of a river, a storm surge barrier at the entrance to an inlet/estuary etc. Details would be specific to the relevant conditions of each MU.

No Regrets

NR1 – Monitoring

Involves long-term baseline monitoring and event-based monitoring following storm erosion events.

NR2 – Protection structure audit

Involves undertaking an audit of existing protection structures, to determine their current condition, effectiveness and future protection potential.

NR3 – Notification on Certificates of Title

Indicates to current and future landowners that an asset is likely to be affected by coastal erosion and/or inundation over the planning timeframe. Helps current and future owners make informed decisions about level of risk they are/may be willing to accept, and that risk management is likely to be required at some stage within the planning timeframe.

NR4 – Emergency evacuation plans

Where existing assets may be affected by inundation and are not already identified in an existing emergency evacuation management plan. Such plans are important in managing the safety of community and stakeholders.

Do Nothing

DN1 – Do nothing

Assumes all levels of risk are accepted and that there is no change in existing planning controls, and no actions are implemented (i.e., no controls are implemented to treat known coastal risks).

All risk treatment options were assessed using a **Multi-Criteria Analysis**.

5.3 Multi Criteria Analysis (MCA)

Successful risk management and adaptation planning requires identification and diligent assessment of suitable options to ensure selection of the best strategy. The chosen option should mitigate risk to an acceptable level whilst maximising the values important to the stakeholders and community.

For this CHRMAP the MCA criteria were:

MCA CRITERIA	CONSIDERATIONS
Effectiveness	• Ability for the option to mitigate the coastal hazard risk
Environmental Impact	• Impact on existing native vegetation / dunes / coastal processes • Includes consideration of: » Any construction / clearing impacts » Impact of maintenance on the environment
Social Impact	• This considers stakeholder and community impacts from previous CHRMAP chapters • Potential impacts on Aboriginal and European heritage sites and values are considered in this criterion.
Aesthetic Impact	• The visual appeal of the option • Consideration of option aesthetics tying into the wider town / Management Unit vision
Cost	• Upfront capital costs • Ongoing maintenance costs • Economic affects – such as loss of businesses, income, value
Future Adaptability	• Whether the option is easily adaptable in future, such as for updated sea level rise actuals or predictions • If the option limits the feasibility of selecting other options in future

MCA Process and results

An initial assessment of options against the criteria was carried out by the project team.

While ratings are somewhat subjective, the initial MCA results were reviewed by the Steering Group to ensure the ratings reflected stakeholder knowledge and community feedback.

A Coastal Community Advisory Group (CCAG) was subsequently formed, comprising community members from across the study area. Members attended a workshop to further review and to calibrate the MCA scoring, focusing on the **Environmental**, **Social** and **Aesthetic Impact** categories. Several component category scores changed during this review process, but only one overall score substantively changed:

- **MU8 Bunbury East** – **PR5 – Offshore Breakwater** – changed from 'Suitability Unclear' to 'Not Recommended'.

In most cases it is necessary to implement more than one option, and the options selected through the MCA may vary between management units and with implementation timeframes.

Table 10 summarises the MCA score of each option for each management unit. Options receiving a positive score are considered suitable until detailed investigations are complete.

The MCA methods and results are presented in full in the Risk Evaluation and Treatment Chapter Report in *Appendix E*.

Table 10: Multi-Criteria Analysis summary by Management Unit

RISK TREATMENT OPTIONS			MU4	MU5	MU6	MU7	MU8
Avoid	AV	Locating assets in areas that will not be vulnerable to coastal hazards	11	11	11	11	11
Planned or Managed Retreat	PMR1	Leaving assets unprotected	2	2	2	2	2
	PMR2	Demolition/removal/relocation of asset from inside hazard area	7	7	7	7	7
	PMR3	Prevention of further development/prohibit expansion of existing use rights	10	6	6	N/A	6
	PMR4	Voluntary acquisition	N/A	5	5	N/A	5
Accommodate	AC1	Design assets to withstand impacts	10	9	10	12	9
Protect	PR1	Beach nourishment or replenishment	-7	3	4	4	2
	PR2	Groynes	-11	1	3	3	0
	PR3	Seawalls	-12	-2	0	0	0
	PR4	Artificial reef	-10	-3	-4	-4	-5
	PR5	Offshore breakwater	-12	0	-3	-4	-1
	PR6	Levee/Weir/Storm Surge Barrier	N/A	4	3	N/A	1
No Regrets	NR1	Monitoring	7	7	7	7	7
	NR2	Protection Structure Audit	N/A	6	6	6	6
	NR3	Notification on Certificates of Title	7	7	7	7	6
	NR4	Emergency evacuation plans	N/A	6	6	N/A	7
Do Nothing	DN1	Do nothing	-8	-8	-8	-8	-8

Green = Recommended for further investigation; Orange = Unclear; Red and NR = Not Recommended; N/A = Not Applicable.

Key Observations:

Avoid / Accommodate: Very High Positive Scores (all MUs)

AV – Avoid locating assets in areas that will be vulnerable to coastal hazards

All MUs 11

This option applies to undeveloped land. Community will benefit by appropriate foreshore reserve width and access throughout the planning timeframe.

- Most undeveloped land is already zoned as reserve.
- Any undeveloped land should be subject to this option.

AC1 – Design assets to withstand impacts

MU4 & MU6 10 **MU5 & MU8** 9 **and MU7** 12

For inundation hazard. Early design considerations mean implementation can occur as assets are routinely upgraded/renewed/redeveloped. This option affects very few assets in MU4 and MU7.

Do Nothing: Very High Negative Scores (all MUs)

Do Nothing 1 – Do nothing

All MUs -8

Not an effective adaptation option and may not be popular with the community.

Planned & Managed Retreat

All options in this category are positively scored.

PMR1 – Leaving assets unprotected

All MUs 2

Suitable for low-value public assets such as foreshore recreational amenities.

PMR2 – Demolition/removal/relocation of asset from inside hazard area.

All MUs 7

Suitable for low-value public assets such as foreshore recreational amenities. Potentially costly if triggers met before asset due for replacement.

PMR3 – Prevention of further development/prohibit expansion of existing use rights

MU4 10 **MU5, MU6 & MU8** 6

Allows for continued use of the land whilst viable, without creating legacy issues. May be unpopular with landholders. Nature of environmental reserve can be maintained effectively with this approach.

MU7 N/A

No developed land parcels.

PMR4 – Voluntary acquisition

MU5, MU6 & MU8 5

For private property. Effective but costly option. Ensures foreshore reserve retained. May be unpopular with landholders, depending on implementation strategy and timeframes. Likely to cost less than protection.

MU4 & MU7 N/A

No developed land parcels.

Protect

Protect options had divergent scoring results across Management Units.

Positively Scored

PR6 – Levee/weir/storm surge barrier

MU5 4

The storm surge barrier is effective at reducing inundation, but the present design is predicted to be breached by the present day (2020) 500-year ARI event, and more frequent future events. Upgrades would be effective at reducing the inundation impact.

MU6 3 **and MU8** 1

A storm surge barrier at the Cut may be effective at reducing inundation, potentially combined with additional protection along Preston River. This would be costly; impacts would need to be investigated. Future adaptability scored neutral because it creates reliance on protection but can be modified for increasing SLR if required.

MU4 & MU7 N/A

Inundation is not a high risk in MU4 and not necessarily required in MU7.

Mixed Scored/Unclear

PR1 – Beach nourishment or replenishment

MU5 3 **and MU8** 2

Potentially very expensive if no nearby suitable and sustainable sand source available. Could create legacy issues for future.

MU6 & MU7 4

Small ocean frontage and structure-controlled beaches make it a potentially effective option.

MU4 -7

Not feasible over large section of coastline. Does not complement environmental focus of MU4.

PR2 – Groyne

MU5 1 **MU6 & MU7** 3 **and MU8** 0

A groyne field may assist in stabilising the shoreline. Groynes can lead to downdrift erosion issues if not designed and constructed appropriately.

It would require sand nourishment as part of the work, which can help provide a sandy beach. Existing structures already in use in MU5.

MU4 -11

Not feasible over large section of coastline. Groynes can be effective at stabilising shorelines but can also lead to downdrift erosion issues if not designed and constructed appropriately. Does not complement the natural environment of MU4.

Negatively Scored

PR3 – Seawall

Expensive option. Likely to lead to reduction or loss of usable sandy beach.

MU4 -12 **MU5** -3

Does not complement the natural environment of MU4.

Already in use in MU5. Likely more acceptable because familiar and MU5 is more developed than others.

MU6, MU7 & MU8 0

May be acceptable at the industrialised area of MU6, especially because there are existing seawalls.

MU7 already has seawall for much of coastline.

For MU8, it is likely more acceptable because nature of MU8 allows smaller structures.

PR4 – Artificial reef

Difficult to design submerged structures to work effectively, and costly to build and maintain.

MU5 -3 **MU6 & MU7** -4 **and MU8** -5

Did not progress through MCA for any MUs (not suitable for CBA).

MU4 -10

Expensive option, not realistic due to the length of MU4, and nature of impacted assets. Does not complement the natural environment of MU4.

PR5 – Offshore breakwater

Costly to build and maintain but can be designed to work effectively and provide usable sandy beach.

MU6 -3 **MU7** -4

- MU7 location indicates unlikely to very effective.

MU4 -12 **MU5** 0 **and MU8** -1

- Social concerns about ocean views likely. Concerns and some costs could be offset by designing shore-attached structures.
- Not realistic due to the length of MU4, and number of impacted assets (and hence low funding potential). Does not complement environmental focus of MU4.

No Regrets

All No Regrets options are positively scored.

NR1 – Monitoring

All MUs 7

Low-cost action which causes no problems. Resulting data is required for most management approaches. Also a source of data for identifying triggers for other management options.

NR2 – Protection structure audit

MU5, MU6, MU7 & MU8 7

An audit should be undertaken of all existing coastal protection structures

MU4 N/A

No existing protection structure in MU4.

NR3 – Notifications on Certificates of Title

All MUs 7 **except MU8** 6

For private property. Effective low-cost option. May be unpopular with affected landholders, but appreciated by potential purchasers, depending on implementation strategy.

NR4 – Emergency evacuation plans

MU5 & MU6 6 **and MU8** 7

For inundation hazard. Doesn't directly address vulnerabilities of assets but low cost to plan for keeping people safe. Important for considering inundation of access roads to parts of MU.

MU4 and MU7 N/A

Suitable for inundation hazards that may affect people, but given the few affected assets in this MU and their nature, this is not applicable.

5.4 Cost Benefit Analysis (CBA)

Cost Benefit Analysis (CBA) is a tool used to assist decision-making for selecting coastal adaptation options.

The CBA aims to examine the selection of coastal adaptation options through economic analysis, allowing consideration of coastal adaptation options which are economically more defendable than other options.

While the CBA process assists in contrasting options, it is not the panacea for decision-making. For instance, changing scientific, environmental and macro-economic considerations can alter cost estimates in the future.

The cost-benefit of each coastal adaptation option is presented in **net present value** (NPV) terms. NPV is a standard economic analysis to compare options with time-variable costs and benefits. It allows for the adjustment of all future economic considerations to present-day dollars for a more direct comparison.

Refer *Appendix F* for the CBA in detail.

CBA Method

The steps taken to complete the CBA are summarised below:

1. Re-analyse to extract asset category data by area.
2. Finalise quantities of assets at risk
3. Determine value for each category for both loss to erosion or damage by inundation
4. Value the loss of existing assets and values
5. Scope and design the adaptation options
6. Price the adaptation options
7. Reduce all costs to NPV
8. Recommendation of options to proceed to for further consideration.

CBA Outcome

5.4.1 MU4 – Bunbury South

No options in the Bunbury South Management Unit (MU4) required further consideration through an economic analysis.

5.4.2 MU5 – Bunbury

The CBA identified PR2 - Groynes, PMR4 - Voluntary Acquisition, PR1 - Beach Nourishment and PR6 - Storm Surge Barrier as suitable for further consideration based on the economic analysis.

5.4.3 MU6 – Bunbury Port

The CBA identified PR2 - Groynes, PR1 - Beach Nourishment and PR6 - Levee as suitable for further consideration based on the economic analysis.

A storm surge barrier option at the Cut did not perform better than the base case and requires more detailed investigation of costs and benefits.

5.4.4 MU7 – the Cut

The CBA identified PR1 - Beach Nourishment as suitable for further consideration based on the economic analysis.

5.4.5 MU8 – Bunbury East

The CBA identified PR2 - Groynes and PR1 - Beach Nourishment as suitable for further consideration based on the economic analysis.

A storm surge barrier option at the Cut did not perform better than the base case and requires more detailed investigation of costs and benefits.

Recommended options for further consideration

The review of the CBA results shows that the ranking of options for each MU changes based on the assumptions used, making few options clearly preferable to others.

5.5 Benefit Distribution Analysis (BDA)

BDA is a tool used to understand who should be expected to pay when a 'protect' option is selected to be implemented.

A BDA is undertaken to allocate the derived benefits from the options identified to the relevant stakeholder. The relevant stakeholders are all those who are expected to benefit from the protection of the identified area.

Key beneficiaries include:

- Private landholders directly affected
- Local community (direct users of the area under threat)
- Broader community (indirect users, such as occasional beachgoers)

Identifying the beneficiaries and accurately evaluating their individual share of benefits is important. This paves the way for the next step in the BDA: identifying funding options and a funding model.

The CHRMAP guidelines require consideration of a "beneficiary pay principle"; that is, that the beneficiaries of a coastal adpatation option should contribute a proportion of the cost.

Refer *Appendix F* for BDA in detail, noting that a BDA was only completed for MU5.

BDA Outcome

In general, the BDA finds that various beneficiaries should contribute to the cost of adaptation options.

The amount ranges from 1% of the cost of the option to 45%, and varies from private property owners through to the State Government.

Generally, the BDA suggests that private land owners should contribute where their assets are vulnerable and being protected, and that the Local Government through rates or the State Government through whole-of-WA taxes should contribute where the assets have a shared value, such as the environment, public and community assets and Aboriginal Heritage.

The BDA has found that allocating beneficiaries when forecasting coastal management is a complicated process. The process provides information to assist decision-makers with information about the approximate proportion of beneficiaries between private and public parties.

Howevere, while indicative funds appear to be relatively small compared to the value delivered and the overall cost, the costs are not insignificant and further work remains to detail each intervention (ie risk treatment option selected in the CHRMAP), their extents, design standard, program and costs through additional detailed technical studies.

6 Implementation

6.1 Land-Use Planning Instruments

This section explores the relevant state and local planning instruments that can be used to increase coastal resilience.

There is a direct relationship between coastal hazard exposure and development. How buildings and assets are designed and located determines their exposure, ultimately impacting risk to people and property. Therefore, the policy instruments that govern development are an important tool to reduce risk exposure.

The City and its partners have acknowledged coastal based hazard for many decades since the flooding experienced from Cyclone Alby in 1978. Planning conditions have been used to support an 'accommodate' option in the suburb of East Bunbury since that time, with flood-prone land noted via planning instruments in the Greater Bunbury Region Scheme and the City's Local Planning Scheme No. 8.

A recent CHRMAP has also been prepared for Koombana Bay. The Koombana Bay, Casuarina Drive and Leschenault Inlet Master Plans refer to flooding and coastal vulnerability, as well as the importance of the waterfront environment.

Notwithstanding, few provisions exist within the City's planning instruments to directly respond to the broader coastal hazard challenge and there is a need to establish a response within the town planning legislative framework to best manage the challenge and make the associated risks more apparent / visible.

This section describes changes to the land use planning framework and other property related matters that may be suitable. These tools align with risk treatment options 'Avoid', 'Planned or Managed Retreat' 'Accommodate' and 'No Regrets'. They can also support implementation of 'Protect' options indirectly.

Refer *Appendix G* for more detailed background discussion and specific detail on the recommendations.

Local Planning Scheme Amendment - Special Control Area

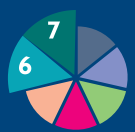
A Local Government Authority (LGA) may declare a Special Control Area (SCA) over areas that are regarded as significant and where special provisions may need to apply.

An SCA overlay typically includes a mapped area that special development conditions apply to. The requirements of a SCA apply in addition to the underlying planning controls dictated by the planning scheme and state framework, such as zoning, building requirements and matters of significance.

The effect of the SCA includes further development regulation, which can then be assessed on a case-by-case basis to control the intensification of land where coastal risks are prominent.

For the City, there may be some merit in consolidating the existing SCA for Flood Prone Areas with the SCA for Coastal Hazard Planning. This will need to be investigated as the Flood Prone Areas SCA also sits within the Greater Bunbury Region Scheme.

AV PMR AC NR



Reservation of Land

Subject to remaining consistent with the Greater Bunbury Region Scheme and associated Floodplain Management Policy, land within the local planning scheme may be reserved as 'Foreshore'. This is particularly the case for public assets, where such a reservation would give rise to improved asset management and planning of the foreshore, including information about when and how to relocate public assets such as public amenities, seating, shelter, playground etc when they reach end of life.

AV PMR AC

Local Planning Policy (LPP)

An LPP can provide more detail and guidance on what sort of development would be acceptable and will assist the City in making planning decisions on coastal development requiring the exercise of discretion (e.g., it might specify appropriate design responses for individual development proposals; relocatable dwellings; prescribed setbacks; finished floor levels). The policy would further identify the City's intention to require notifications on certificates of title as a condition of development approval.

AV PMR AC

Notifications on Titles

Supported by a suitable SCA, there is an opportunity to require the provision of a Section 70A Notification on the Certificate of Title of land as a condition of any planning approval to alert prospective purchasers of the potential coastal hazard impacts on the lot, as required by SPP2.6.

AV AC NR

Structure Planning

Structure Plans are prepared and approved prior to the subdivision or development of land in development areas identified within the Local Council Planning Scheme, or where required by WAPC.

In areas where further development or redevelopment of land is possible or anticipated, structure plans should incorporate the requirements of the CHRMAP. This would allow the formation of a coastal foreshore reserve to manage coastal erosion and to infill low-lying areas to manage coastal inundation.

AV AC

Advice to Real Estate and Settlement Agents

Real estate agents and settlement agents are usually the first people that a prospective landowner will meet on their journey to buying into a town or region. Real estate agents have an obligation to provide information to prospective purchasers, whilst settlement agents are often in touch with the local government during settlement to ascertain the current monies owed or conditions applying to land. Although not a catch-all, providing information about the CHRMAP to these parties may help to alert prospective purchasers of the potential coastal hazard impacts on the lot, where a notification of the Certificate of Title has not yet been included.

NR

Compulsory Acquisition

Compulsory acquisition is an option where no other planning instrument has been able to suitably set aside land for coastal hazard processes, when hazards have advanced to a stage where land exceeds tolerable risk thresholds. Options include:

- Purchase of the land by the LGA if the owner is willing to sell it by ordinary sale under Section 190 of the Planning and Development Act (2005) (PD Act)
- Compulsory taking by the LGA without agreement under Section 191 of the PD Act coupled with the Land Administration Act (1997).

PMR

Other Instruments

Innovative planning instruments, such as 'leaseback of land' and 'land swaps' may be considered. While there is growing interest in these and much work interstate on these matters, these instruments have not been tested in the WA planning context and are not explicitly provided for or anticipated under the State's current planning framework.

Considerations of other instruments should be informed by research, implementation case studies from other locations, suitability to the local context, and receptiveness of decision-makers and the community.

The City may also review existing leasehold facilities located within the hazard zone and notify the lessee of the CHRMAP. Ongoing leasing of affected land should be reviewed at renewal timeframes to determine the suitability and/or length of future leases.

AV PMR AC NR

6.2 Funding Options

This section identifies all revenue-raising mechanisms available for obtaining funds to assist implementation.

City of Bunbury Operating Budget and General Rates

The City and other dindividual land managers within the study area should consider establishing a coastal management fund that includes specific allowance for managing and adapting to the risk posed by coastal erosion and inundation. The purpose of this fund includes:

- To allocate a percentage of the organisation's operating budget for coastal management.
- Retention of funds so that management actions can be implemented efficiently when required.

Levies

It is recommended the City investigate the feasibility of establishing a particular levy for coastal management that would be a transparent source of the coastal management fund discussed above.

Specified Area Rate

Where adaptation options are designed to protect specific sections of coastal land and assets, such as private property, it is recommended that the City progress the establishment of a specified area rate. It is recommended that the City consider the need and suitability of a Specified Area Rate in conjunction with further detailed investigations and design.

Lease Land Management

Coastal land leased to third parties represents a unique scenario whereby implementation of some Options may require specific lease clauses. During considerations of lease renewal, coastal managers should consider the land use, vulnerability of the land, projected timeframe of unacceptable vulnerability, length of lease, recommended implementation options and need for any specific clause for implementation by the lessee.

Beneficiary Pays

'User Pays' principles essentially dictate that the beneficiaries of adaptation Options should pay for them. Mechanisms for fund raising may include:

- **Specified Area Rates**
- **Mechanisms for visitors** to the town, as users of the coastline, to contribute. This could be in the form of a levy applied to their accommodation, or paid parking at key tourist sites.
- **Developer contributions** where specific developments benefit from their coastal location

State Grants

A number of grants programs exist in WA that may support implementation.

Department of Transport grants:

- **Coastal Adaptation and Protection (CAP)** grants, which fund up to 50% of project costs.
- **Hotspot Coastal Adaptation and Protection (H-CAP) Major Project Fund**, invitations to apply are sent directly to eligible coastal managers (completed CHRMAP and an identified erosion hotspot)

Department of Planning, Lands and Heritage grants:

- **Coastwest grants** support eligible coastal land managers and community organisations to undertake projects such as rehabilitation and restoration of the natural environment
- **Coastal Management Plan Assistance Program (CMPAP)** grants support eligible coastal land managers to develop adaptation and management plans and strategies

Other WA grant programs which may provide funding for coastal projects include Royalties for Regions and Local Government Financial Assistance Grants.

- **Royalties for Regions** is facilitated by Department of Primary Industries and Regional Development
- **Local Government Financial Assistance Grants** are administered by the Department of Local Government, Sport and Cultural Industries.

Federal Grants

Federal grants are variable and often unpredictable, but it is important for coastal managers to stay aware of any funding and grant programs available.

- **Disaster Ready Fund** aims to decrease impacts of natural hazards, and eligible projects include direct investment in flood levees, seawalls, constructed wetlands and reefs.

6.3 Options and Triggers

The CHRMAP uses triggers to suggest when adaptation responses (options) should be implemented rather than focusing directly on a specific date or time. Triggers help decision making to occur and when relevant, rather than focusing on predicted timescales.

In this way, implementation of a CHRMAP recommendation can be relevant and timely.

The CHRMAP identifies four types of triggers, as follows:

Proximity trigger: Where the storm erosion allowance (S1) is close to a public asset of interest or private property lot boundary.

Access trigger: Where a public road is considered no longer available or able to provide legal access to nearby property.

Utilities trigger: When water, sewerage, communications or electricity to the nearby property is no longer available as they have been removed/decommissioned by the relevant authority due to coastal hazards.

Damage trigger: Where any property is damaged by a coastal hazard.

An asset at the end of it's design life might also constitute a trigger, if monitoring suggests that in-situ replacement is not suitable.

The preference is that triggers are sequential. That is, a "**proximity trigger**" is recommended over a "**damage trigger**".

Figure 18 illustrates how these triggers might be occur over time, reflecting the likely order in which the trigger will result in action being required. Note that many of the triggers will occur when monitoring indicates the need (see *Section 6.4*).

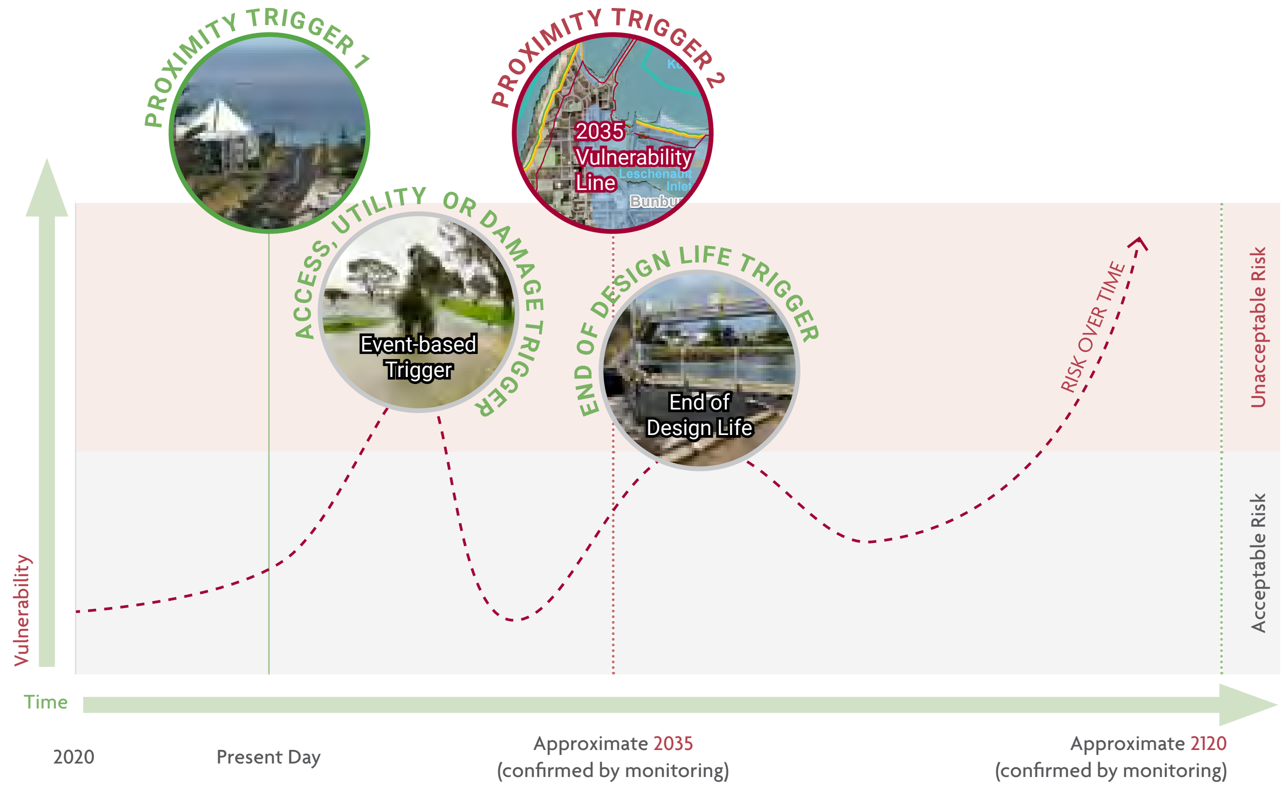
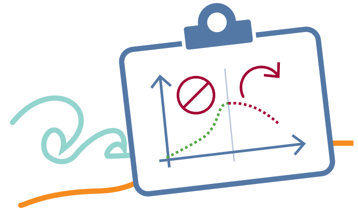


Figure 18: Triggers and How they apply



6.4 Monitoring and Review

Monitoring activities are designed to identify the actual effect of coastal hazards, monitoring and recording the evolution of coastal hazards to help inform timely decision making and improved coastal hazard predictions.

Recommended coastal monitoring activities

1. **Routine beach and dune surveys**.
2. **Corresponding monitoring photos should be taken at the same time** as beach surveys
3. **Regular monitoring of the coastal management structures**
4. **Geotechnical investigations**

CHRMAP Review

The CHRMAP should be updated at least every 10 years to maintain its currency and ensure it remains a "living document". The CHRMAP should be revisited when triggers are reached to ensure it includes an up-to-date and accurate coastal hazard assessment.

As described in *6.3 Options and Triggers*, physical triggers provide clear pathways, but provide limited flexibility, rely on monitoring, and assume that conflicting interests have been resolved.

It is essential to also recognise that environmental and societal considerations significantly affect the implementation of management actions. These external triggers would include:

Environmental Triggers

- Substantial storm events generating severe coastal hazards approaching or exceeding the CHRMAP projections
- Environmental Impacts

Societal Triggers

- Change to governance, planning and/or laws, such as a significant change to State land-use planning or a major change in a Local Planning Scheme or the Greater Bunbury Region Scheme
- New information becomes available that substantially affects the understanding of local community values
- Major societal events such as macro-economic, public protests, etc

Such unplanned external triggers will also guide implementation of the CHRMAP. An earlier review of the CHRMAP may be considered necessary when such an external trigger occurs.

Therefore, it is essential to support coastal zone managers to be opportunistic and reactive to such external triggers rather than only follow the CHRMAP recommendations.

To prepare a coherent CHRMAP update it may be necessary to update the hazard modelling/assessment to include:

- Recent monitoring data
- Planning changes and changes to the CHRMAP success criteria and stakeholder feedback
- Updates in climate change science, specifically local sea level rise projections
- Updated coastal engineering science and methodologies, and emerging adaptation options

6.5 Short-term Implementation

The coastal adaptation pathway includes short-term, medium-term and long-term actions. Short-term actions are anticipated to be implemented by 2035, corresponding to a 10-15 year planning horizon; medium-term actions implementation would occur before 2050 (15-30); while long-term actions would be implemented beyond 2050, towards 2120.

Key assumptions

The timeframes envisaged in the coastal adaptation pathways are not absolute, as noted in *6.3 Options and Triggers*. Other options may be envisaged, particularly if land planning practices, new coastal information or climate projections change the current understanding. Therefore, the implementation pathway will evolve overtime.

Options have been selected based on information gathered through the CHRMAP process, however, the preparation of the MCA and CBA required interpretation and approximations, particularly regarding the criteria and cost quantifications.

Further investigations, surveys, policy review, impact investigations (environmental, visual and social), development approval and authorities endorsement, local stakeholder and community engagement, preliminary design, detailed design, costing and any other applicable preparation work are all required prior to being implemented.

Further Investigations and Legislative Change

Information gaps identified in the CHRMAP should be gathered early. Some of these gaps can be closed by the collection of data, as indicated in *Section 6.4*. Other information gaps can be closed during the preliminary and/or detailed design phase when specific or detailed analysis of available data, information, modelling, and projections are carried out. Options should be optimised and modified following such additional investigations.

Some interim management options may also be progressed, such as the development of emergency evacuation procedures and systems, until inundation protection measures can be fully implemented.

The following investigations and legislative changes are recommended for Short Term implementation:

Sand source feasibility study

Several MU's have recommended options which require sand nourishment, both for erosion management (such as beach groynes including sand nourishment) and inundation management (such as raising beach levels). The availability of suitable sand for beach nourishment works is unfortunately not well understood in the study area. It is recommended that a sand source feasibility is undertaken to determine the capacity and cost of local sand supplies.

Rock source feasibility study

Similar to the above but for armour rock suitable for building coastal management structures. Several MU's have recommended options requiring armour rock which needs to be fit for purpose. An analysis of the availability of such rock suitable for marine works, with suitable density, quarry yields, close location and tolerable costs should be undertaken.

Foreshore Management Plans (FMPs)

Updated foreshore management plans for the study areas may provide more conscious management of foreshore areas and increase the protective capacity of the natural dune system. Foreshore management plans should address the findings of this CHRMAP, and:

- Potential environmental impacts and benefits, and monitoring of flora and fauna species
- Asset management
- Closure or consolidation of beach access points
- Management and monitoring of 4-wheel drive access and permissibility
- Educational program, signage etc
- Bush fire management requirements

Asset Management Plan

Prepare an Asset Management Plan, which identifies existing infrastructure and recreational facilities in the coastal erosion and inundation hazard zone and provides direction to:

- Progressively relocate non-critical assets away from the coastal hazard zone, which may include car parks; public ablutions; barbeque/picnic/shade areas; playgrounds, ramps, stairs and paths and fences, etc.
- Plan for the relocation of critical service infrastructure outside of the coastal hazard zone once they reach the end of asset life.

Monitoring

See *Section 6.4*.

Planning Scheme Amendment

Prepare an amendment to the Local Planning Scheme No. 8 to include provisions relating to the coastal erosion and inundation hazard zones to 2120 as identified in this study. The amendment shall be inserted into Schedule 7, and shall read: *Coastal Hazard Risk Area Special Control Area*.

Notifications on Titles

Supported by a suitable SCA, require the provision of a Section 70A notification on the Title of land as a condition of any planning approval to alert landowners of the potential coastal hazard impacts on the lot, as required by SPP2.6. These notifications can only be applied where triggered by a subdivision (under Section 165 of the Planning and Development Act 2005) or development application (Section 70A of the Transfer of Land Act 1893).

Local Planning Policy (LPP)

Prepare a Local Planning Policy (LPP) to be linked to the SCA. The policy may include recommended finished floor levels where impacted by inundation or siting of development to the least vulnerable portion of a lot for both erosion and inundation where possible.

Leaseback of land and land swaps

Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat. Seek legal advice regarding the basis of agreements with landholders and whether opt-ins can be time constrained.

Emergency evacuation planning

Review emergency evacuation plans in the study area to assess if the evacuation plans are suitable for managing the projected coastal hazards. Existing documents may need to be updated or revised as required.

Reservation of Land

Prepare an amendment to the Local Planning Scheme No. 8 to include a 'Foreshore Reserve' encompassing public land within the coastal erosion and inundation hazard zones to 2120 as identified in this study. The amendment shall be inserted at Part II – Reserves, Clause 14 (3).

Structure Planning

Review existing and proposed structure plans to ensure they adhere to SPP2.6 and account for the risks identified in the CHRMAP.

Advice to Real Estate and Settlement Agents

Notify landholders, real estate agents and settlement agents and prospective purchasers through direct email to affected properties and stakeholders and by implementing a procedure through the 'orders and requisitions' process with information relating to land that may be affected by coastal hazards by 2120.

Compulsory Acquisition

Investigate compulsory acquisition where no other planning instrument has been able to suitably set aside land for coastal hazard processes, when hazards have advanced to a stage where land exceeds tolerable risk thresholds.

Other Instruments

Review existing leasehold facilities located within the hazard zone and notify the lessee of the CHRMAP. Leases should be reviewed at renewal timeframes to determine the suitability and/or length of future leases.

Coastal Hazard Mapping Study

Establish an advocacy program with the support of organisations such as the Western Australian Local Government Association (WALGA) and Local Government Planners Association (LGPA) to achieve a state-wide coastal mapping database similar to the Fire and Emergency Services (FESA) mapping of bushfire prone areas.

6.6 Medium and Long-term Implementation

Medium (15-30 years) and long-term (30-100 years) implementation provide strategic consideration of how the City of Bunbury will adapt to long-term climate change impacts. Therefore, medium- and long-term implementation are not described in detail in the CHRMAP.

Longer-term responses include:

- Actioning the revised planning instruments
- Managing coastal retreat
- Exhausting the SPP2.6 hierarchy of actions, where high value assets may be protected if sustainable impacts and funding are identified/prioritised
- Providing temporary/interim hazard protection until too costly or a change in adaptation pathway is required. For example, as sea level rise progresses, it is likely that options using sand or rock resources to protect assets near the coast may become unsustainable.

For erosion

The two primary coastal management actions mitigating erosion hazards are:

Planned or Managed Retreat 4 – Voluntary acquisition

Use the planning instruments and long-term plan to systematically move assets with low adaptive capacity out of the hazard zone

Protect Options – e.g. Groynes

Undertake design and construction of final protect options endorsed.

For inundation

The three coastal management actions mitigating inundation hazards are:

Planned or Managed Retreat 4 – Voluntary acquisition

Use the planning instruments and long-term plan to systematically move assets with low adaptive capacity out of the hazard zone

Accommodate 1 – Design assets to withstand impacts

Limit damage from inundation events through planning and building requirements

Protect Options – e.g. Levees

Undertake works as necessary to prevent or limit inundation of assets exposed along the coast

7 Recommendations

The CHRMAP recommendations are based on currently available information, and made based on a number of assumptions recognising the gaps in information that still need to be resolved.

Future investigations are required to confirm they are suitable, including further consultation with stakeholders and the community. The next step, following finalisation of the CHRMAP, is to develop a program of investigative works over the short to medium term, to help inform the timing and scope of future investigations.

A likely outcome is that a combination of options may be the preferred approach in some locations. Additional considerations may be incorporated into future analyses.

All recommendations still need further research. The CHRMAP provides the basis for which for the City may access grant funding to undertake this work and how recommendations may be updated, improved, or confirmed. This process requires ongoing engagement with affected communities.

Refer *Appendix G* for all recommendations in detail.

How to read the recommendations

Table 11 lists the recommended management actions by priority including short term recommendations to address erosion and inundation for each specific management unit are summarised.

In addition, long-term adaptation strategies/pathways have been recommended for erosion and inundation that will allow for the continuous function of local communities whilst accommodating the increasing burden of coastal hazards.

The long-term strategy informs future planning instruments, supports monitoring, recommends planning reviews and underpins collaboration between coastal land managers, stakeholders and the community.

The medium and long term adaptation strategies/pathways are summarised in *Table 12*.

All recommendation tables are presented with the following elements for easy reference.

Legend

- **Management Unit** - relevant management unit
- **Responsibility** - responsible authority
- **Funding** - related funding options
- **$$ Cost** - estimated funding and cost requirement
- **Timeframe** - when the action should be taken
- **Trigger** - factors to inform decision-making

7.1 Recommended Actions by Priority

Table 11: Recommended management actions to address coastal hazards

	RECOMMENDATION	RESPONSIBILITY	FUNDING AND COST	TIMEFRAME AND TRIGGER
1	**INVESTIGATION 1 – Detailed action plan* followed by investigations to confirm assumptions used in the CHRMAP** MU5 MU6 MU7 MU8 Undertake detailed investigations to confirm assumptions used in the CHRMAP; and consider protect options (e.g. rock groynes) *A detailed action plan has been prepared as part of the CHRMAP and can be found in *Section 8*.	City of Bunbury	Operational $$ up to $1 million	2023-2030 Completed CHRMAP
2	**INVESTIGATION 2 – Update Foreshore Management Plans (FMPs)** ALL Prepare an updated Foreshore Management Plan MU6 - Incorporate appropriate clauses into operational and strategic planning and lease conditions (Southern Ports). MU7 - Joint approach with Southern Ports.	City of Bunbury • MU4, MU5, MU6, MU7, MU8 Southern Ports • MU6, MU7	Operational Grants $$ up to $500k	2025-2120 Completed CHRMAP
3	**INVESTIGATION 3 – Audit of assets within 2035 Erosion hazard zone** ALL Audit of assets within 2035 erosion hazard zone and identification of assets where damage would be unacceptable Investigation to determine acceptable foreshore amenity within hazard zone (MU4) Further investigation, feasibility analysis and further civil and maritime design considerations (MU8)	City of Bunbury Neighbouring LGAs State Government	Operational Grants Specified Area Rate Levies User Pays $$ up to $200k	2023-2035 Completed CHRMAP Monitoring Confirmation of Design/Cost/Funding Confirmation of 2035 SLR

Legend: Management Unit Responsibility Funding $$ Cost Timeframe Trigger

Table 11: Recommended management actions to address coastal hazards (continued)

	RECOMMENDATION	RESPONSIBILITY	FUNDING AND COST	TIMEFRAME AND TRIGGER
4	**INVESTIGATION 4 – Sand Source Feasibility Study** ALL Determine the capacity and cost of local sand supplies, including both land-based and marine sources MU4 - For ad hoc sand nourishment MU5 - For ocean coast sand nourishment, and potentially to raise the height of land in the inundation hazard zone MU6 - For Southern Ports ocean and estuary frontage sand nourishment, and potentially to raise the height of land in the inundation hazard zone MU7 - For ocean and estuary frontage sand nourishment, and potentially to raise the height of land in the inundation hazard zone MU8 - For estuary coast sand nourishment, and potentially to raise the height of land in the inundation hazard zonee	City of Bunbury • MU4, MU5, MU8 - Seek support from neighbouring LGA's, PNP, State Southern Ports • MU6 - Seek support from neighbouring LGA's, PNP, Southern Ports, State To be confirmed • MU7 - between LGA's, DoT, DBCA and Southern Ports, Bunbury	Operational Grants $ up to $500k	2023-2030 2035-2050 Completed CHRMAP
5	**INVESTIGATION 5 – Rock Source Feasibility Study** MU5 MU6 MU7 MU8 Analyse availability of rock MU5, MU6 & MU7 - Focus for armour and core rock of all sizes MU8 - Focus for small to medium armour rock	City of Bunbury • MU5, MU8 - Seek support from neighbouring LGA's, PNP, Southern Ports, State • MU6 - Seek support from neighbouring LGA's, PNP, State To be confirmed • MU7 - between LGA's, DoT, DBCA and Southern Ports	Operational Grants $$ up to $500k	2023-2030 2035-2050 Completed CHRMAP
6	**Avoid – Avoid locating assets in areas that will be vulnerable to coastal hazards**	City of Bunbury • MU4, MU5, MU7, MU8 Southern Ports • MU6	Operational $$ up to $500k	2023-2030 Completed CHRMAP

Legend: Management Unit Responsibility Funding $$ Cost Timeframe Trigger

Table 11: Recommended management actions to address coastal hazards (continued)

	RECOMMENDATION	RESPONSIBILITY	FUNDING AND COST	TIMEFRAME AND TRIGGER
7	**Accommodate 1 – Design assets to withstand impacts** MU5 MU6 MU7 MU8	City of Bunbury • MU5, MU7, MU8 Southern Ports • MU6	Operational Grants Levies (MU7) $$$ up to $1 million	2023-2030 • MU4, MU5, MU6, MU8 2023-2035 • MU7 Completed CHRMAP
8	**No Regrets 4 – Emergency evacuation plans** MU5 MU6 MU8	City of Bunbury • MU5, MU8 Southern Ports • MU6	Operational Grants $$ up to $500k	2023-2030 Completed CHRMAP
9	**No Regrets 1 – Monitoring** ALL Beach survey for storm behaviour and to track HSD and inundation MU4, MU7 - Routine beach profiles every two years in Spring MU5, MU6 - Routine beach profiles every year in Spring MU8 - Routine 6-monthly beach profiles following the summer and winter periods. Minimum every two years in Spring	City of Bunbury • MU4, MU5, MU8 - Seek support from DoT Southern Ports • MU6 - Seek support from State City of Bunbury • MU7 - Seek support and assistance from Southern Ports and DoT	Operational Grants $ up to $100k	2023-2035 Completed CHRMAP Severe storm event(s)
10	**Planned or Managed Retreat 1 – Leaving assets unprotected** ALL For low-value public assets, assumes a clean-up rate following damage/loss	City of Bunbury • MU4, MU5, MU7, MU8 Southern Ports • MU6	Operational $$$$ up to $10 million	2023-2035 Storm damage Audit of assets

Legend: Management Unit, Responsibility, Funding, $$ Cost, Timeframe, Trigger

Table 11: Recommended management actions to address coastal hazards (continued)

	RECOMMENDATION	RESPONSIBILITY	FUNDING AND COST	TIMEFRAME AND TRIGGER
11	**Planned or Managed Retreat 2 – Demolition/removal/relocation of asset from inside hazard area.** ALL Preparation of Asset Management Plan Removal / Relocation of assets as required	City of Bunbury • MU4, MU5, MU7, MU8 Southern Ports • MU6	Operational Grants $$$$ up to $10 million	2023-2035 Audit of assets • (MU4) Audit of assets within 2035 erosion hazard zone • (MU5, MU6, MU7, MU8) Audit of assets within 2035 erosion and inundation hazard zone
12	**Protect 2 – Groynes**			
	MU5 Engagement, technical analysis, detailed design and delivery	City of Bunbury	Operational Grants Specified Area Rate Levies User Pays $$$$$ up to $100 million	2023-2035 Completed CHRMAP Completed Investigation #1 Monitoring Confirmation of Design/Cost/Funding Construction likely to be staged
	MU6 Engagement, technical analysis, detailed design and delivery	City of Bunbury Southern Ports	Operational Grants $$$$ up to $10 million	
	MU7 Monitoring and confirmation of concept design	City of Bunbury	Operational Grants Levies $$$ more than $2 million	
	MU8 Engagement, technical analysis, detailed design and delivery	City of Bunbury	Operational Grants Specified Area Rate Levies User Pays $$$ more than $2 million	

Legend: Management Unit | Responsibility | Funding | $$ Cost | Timeframe | Trigger

Table 11: Recommended management actions to address coastal hazards (continued)

	RECOMMENDATION	RESPONSIBILITY	FUNDING AND COST	TIMEFRAME AND TRIGGER
13	**No Regrets 2 – Protection structure audit** MU5 MU6 MU7 MU8 Inspect asset condition, influence on sediment transport and inundation, and remaining design life on all coastal management structures MU5 - Includes seawalls, breakwaters and spur groynes, causeway MU6 - Includes Port seawall and Port Breakwaters for Inner Harbour MU7 - Includes structures at The Cut MU8 - Includes walls along Collie River.	City of Bunbury • MU5, MU8 Department of Transport • MU5 Koombana Sailing Club • MU5 Southern Ports • MU5, MU6 To be confirmed • MU7 - between LGA's, DoT, DBCA and Southern Ports	Operational Grants $$ up to $500k	2025-2035 Completed CHRMAP
14	**No Regrets 3 – Notification on title** ALL MU6 - Incorporate appropriate clauses into operational and strategic planning and lease conditions (Southern Ports)..	City of Bunbury • MU4, MU5, MU7, MU8 - Seek support and assistance from DPLH, WALGA Southern Ports • MU6 - Seek support and assistance from LGA, DPLH, WALGA	Operational Grants $$ up to $500k	2025-2035 Completed CHRMAP
15	**Planned or Managed Retreat 3 – Prevention of further development/ prohibit expansion of existing use rights** MU4 MU5 MU6 MU8 Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat. MU6 - Incorporate appropriate clauses into operational and strategic planning and lease conditions (Southern Ports).	City of Bunbury • MU4, MU5, MU8 Southern Ports • MU6	Operational Grants $$ up to $500k	2025-2035 Completed CHRMAP

Legend: Management Unit | Responsibility | Funding | $$ Cost | Timeframe | Trigger

Table 11: Recommended management actions to address coastal hazards (continued)

RECOMMENDATION		RESPONSIBILITY	FUNDING AND COST	TIMEFRAME AND TRIGGER
16	**Protect 6 – Storm surge barrier** MU5 Engagement, technical analysis, detailed design and delivery	Lead agency: State Government Department of Transport Supporting agency: City of Bunbury	Operational Grants Specified Area Rate Levies User Pays $$$$ up to $20 million	2035-2050 Completed CHRMAP Monitoring Confirmation of Design/Cost/Funding Confirmation of 2035 SLR
17	**Protect 6 – Levee** MU6 Engagement, technical analysis, detailed design and delivery	Southern Ports	Operational Grants $$ up to $2 million	2035-2050 Completed CHRMAP Monitoring Confirmation of Design/Cost/Funding Confirmation of 2035 SLR

Legend: Management Unit Responsibility Funding $$ Cost Timeframe Trigger

7.2 Recommended Medium to Long Term Pathways

Table 12: Recommended medium and long term pathways to address erosion and inundation

	RECOMMENDED MEDIUM TO LONG TERM PATHWAYS	RESPONSIBILITY	FUNDING AND COST	TIMEFRAME AND TRIGGER
	For erosion			
1	**Planned or Managed Retreat 1 –** Leaving assets unprotected **Planned or Managed Retreat 2 –** Removal of asset from inside hazard area **Planned or Managed Retreat 3 –** Prevention of Further Developmentt MU4	City of Bunbury	Operational Grants $ in other actions	2035-2120 Proximity Trigger • HSD within 11m of low value public assets, equivalent of approximately half of storm erosion allowance for this MU (21m)
2	**Protect 2 –** Groyne			2035-2120 Monitoring Updated CHRMAP
	MU5 Monitoring to determine future protection methods and refurbishment of existing treatments	City of Bunbury	Operational Grants Specified Area Rate Levies User Pays $$$ up to $1 million • Annual maintenance estimate	
	MU6 Monitoring to determine future protection methods and refurbishment of existing treatments	City of Bunbury Southern Ports	Operational Grants $$ up to $200k • Annual maintenance estimate	
	MU7 Monitoring to determine future protection methods and refurbishment of existing treatments	City of Bunbury	Operational Grants Levies $$ up to $100k • Annual maintenance estimate	
	MU8 Monitoring to determine future protection methods and refurbishment of existing treatments	City of Bunbury	Operational Grants Specified Area Rate Levies User Pays $ up to $50k • Annual maintenance estimate	

Legend: Management Unit Responsibility Funding $$ Cost Timeframe Trigger

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Table 12: Recommended medium and long term pathways to address erosion and inundation (cont'd)

	RECOMMENDED MEDIUM TO LONG TERM PATHWAYS	RESPONSIBILITY	FUNDING AND COST	TIMEFRAME AND TRIGGER
	For inundation			
1	**Protect 6 – Storm surge barrier** MU5 Monitoring to determine maintenance, design and performance reviews, additional protection methods and refurbishment of existing treatments	City of Bunbury	Operational, Grants Specified Area Rate Levies, User Pays $ up to $20k • Annual maintenance estimate	2035-2120 Monitoring Updated CHRMAP
2	**Protect 6 – Levee** MU6 Monitoring to determine maintenance, design and performance reviews, additional protection methods and refurbishment of existing treatments	Southern Ports City of Bunbury	Operational, Grants $ up to $20k • Annual maintenance estimate	2035-2120 Monitoring Updated CHRMAP
3	**Accommodate 1 – Design assets to withstand impacts** MU7 Monitoring Reviews to consider additional protection methods and refurbishment of existing treatments	City of Bunbury	Operational, Grants Levies $ in other actions • Included as part of Monitoring (NR1)	2035-2120 Monitoring Updated CHRMAP
4	**INVESTIGATION – Ongoing audit of assets within hazard zone** MU8 Further investigation, feasibility analysis and further civil and maritime design considerations.	City of Bunbury Neighbouring LGAs State Government	Operational, Grants Specified Area Rate Levies, User Pays $ unknown • To be determined following further investigations	2035-2120 Monitoring Updated CHRMAP

Legend: Management Unit, Responsibility, Funding, $$ Cost, Timeframe, Trigger

8 Detailed Coastal Action Plan

Implementing a CHRMAP requires a coordinated and orderly approach, prioritising appropriate actions to ensure the City is well placed to respond to coastal hazard challenges.

This CHRMAP provides a number of short, medium and long term actions, which are quite broad in nature and are recommended over long time periods..

Table 13 provides a Detailed Coastal Action Plan to assist the City's Staff and Elected Members in prioritising, budgeting, scoping, and implementing the various coastal management actions that are recommended in the CHRMAP *over the next 5-years* (2024 to 2028 inclusive).

The following information is provided for each action:

1. An overview of the action;
2. It's proposed location;
3. Budget cost estimates; and
4. Suggested timing

Table 13: Coastal monitoring, investigation and adaptation actions recommended for the next 5 years, listed by recommended year of implementation

ACTION	OVERVIEW	LOCATION	COST	TIMING
Storm impact monitoring	Prepare for, and undertake, storm impact monitoring during and immediately after severe ocean storm events	CHRMAP MU's 4, 5, 6, 7, 8	$10,000. (Only required if an external surveyor needs to be used after a severe storm.)	2024 and ongoing
Coastal management register	Implement and maintain a coastal management register for monitoring and management actions	CHRMAP MU's 4, 5, 6, 7, 8	N/A. Internal City resourcing only (in kind).	2024 and ongoing
Field photos	Collect beach and foredune monitoring photos at the same time as PNP's planned drone photography (or the provisional beach and foreshore topographic survey if undertaken by the City)	CHRMAP MU's 4, 5, 6, 7, 8 Note this covers a larger area than PNP's planned drone photography	$15,000 (excl. GST) for consultant to prepare a monitoring program and then internal City resourcing to collect photos.	2024, 2025, 2026. Review program in 2027
Coastal management training for City staff	The City should develop an internal coastal management training program for relevant staff	N/A.	Less than $5000.	2024 and ongoing

Table 13: Coastal monitoring, investigation and adaptation actions recommended for the next 5 years, listed by recommended year of implementation (cont'd)

ACTION	OVERVIEW	LOCATION	COST	TIMING
Sand source feasibility study	The City should prepare an RFQ and engage a consultant to investigate potential sand sources to use for coastal protection works	CHRMAP MU's 4, 5, 6, 7, 8 and regional sand sources both on land and offshore	$75,000.	2024
Foreshore asset audit	Undertake a Foreshore Asset Audit in response to coastal hazard projections to 2035. The City should prepare an RFQ and engage a consultant to undertake an audit to identify existing infrastructure and recreational facilities in the coastal erosion and inundation hazard zone	CHRMAP MU's 5 and 8	$71,000	2024
Beach and foreshore topographic survey – provisional	This a provisional task which would only be required subject to review of planned data collection by PNP – see Section 4.2. If the drone data photography and conversion to a DEM does not go ahead or is it not accurate this data collection should be undertaken by the City It is recommended to prepare an RFQ to engage a certified professional surveyor for a long-term beach and foreshore topographic survey data collection program (assumed as three years) at Bunbury back beach and Koombana Bay	CHRMAP MU's 5, 6, 7	$120,000. Assumes 6-monthly survey for 3 years: 6 surveys at $20,000.	Provisional – from 2024 if needed
Emergency evacuation plan	The City should prepare an RFQ and engage a consultant to ensure that a preliminary emergency evacuation and response plan is prepared, maintained, and implemented to ensure the safe evacuation of occupants within the City during a severe coastal inundation event and/or severe erosion event	CHRMAP MU's 5 and 8	$55,000	2025
Coastal protection structure audit	The City should prepare an RFQ and engage a consultant to undertake an audit of the coastal protection structures the City is responsible for the care, control and maintenance of, for including – buried seawalls at Hungry Hollow and Hayward St on Ocean Drive, and exposed seawalls at the Bunbury Surf Life Saving Club and car park at Back Beach, Marlston Waterfront seawalls, and Koombana Bay beach groynes	CHRMAP MU's 5, 6, 7, 8	$48,000	2025

Table 13: Coastal monitoring, investigation and adaptation actions recommended for the next 5 years, listed by recommended year of implementation (cont'd)

ACTION	OVERVIEW	LOCATION	COST	TIMING
Update Foreshore Management Plans	The City should prepare an RFQ and engage a consultant to prepare updated Foreshore Management Plans. These can increase the protective capacity of the natural dune system and provide an avenue for increased awareness and education for stakeholders and the community about coastal processes and management	CHRMAP MU's 4, 5, 6, 7 and 8	$145,000	2025 (CHRMAP MU's 4, 5, 6) and 2026 (CHRMAP MU's 7 and 8)
Geotechnical investigations	Geotechnical investigations are proposed to identify the potential presence and depths of local bedrock strata below the beach. When bedrock is located relatively near the surface, it can provide some natural resistance to erosion and help inform the refinement and design of coastal management options	CHRMAP MU's 5 and 6	$102,000	2026
Rock source feasibility study	The City should prepare an RFQ and engage a consultant to investigate potential rock sources to use for coastal protection works	CHRMAP MU's 5, 6, 7, 8 and regional potential sources	$49,000	2026
Bathymetric survey	Collect additional nearshore bathymetry data (water depths) at Bunbury back beach and Koombana Bay for future coastal processes investigations and structural option development	CHRMAP MU5 and parts of MU 4 (south to in line with Westwood St.) and MU 6 (to the Cut)	$43,000	2027
Metocean data collection	Collect additional nearshore data (ocean waves, currents, and water levels) for structural option development for 12 months at Bunbury back beach in approximately 10m water depth	Approximately 10m water depth in line with Hayward St. South Bunbury	$130,000	2028

Appendices

For the City:

These should all be hyperlink reports once they have found a 'home' on the website

CITY OF
BUNBURY

How to Get Involved

Want to help build a better, brighter Bunbury?

Please reach out to your Elected Member or the responsible officer at the City of Bunbury to share your thoughts and ideas.

A: 4 Stephen Street, Bunbury, WA, 6230
T: 08 9792 7000
E: mayor@bunbury.wa.gov.au
info@bunbury.wa.gov.au

www.bunbury.wa.gov.au

10.5.2 Prinsep Streetscape Concept Design

File Ref:	DOC/1282976
Applicant/Proponent:	Internal report
Responsible Officer:	Carol Marter – Landscape Architect, Cameron Scott – Coordinator Engineering Design
Responsible Manager:	Stacey Meredith – A/Manager Projects and Asset Management
Executive:	Gavin Harris, Director Infrastructure
Authority/Discretion	☐ Advocacy ☐ Review ☒ Executive/Strategic ☐ Quasi-Judicial ☐ Legislative ☐ Information Purposes
Attachments:	Appendix 10.5.2-A Prinsep Streetscape Concept Plan Option A Appendix 10.5.2-B Prinsep Streetscape Concept Plan Option B Appendix 10.5.2-C Preliminary Concept Plan and Visualisations Appendix 10.5.2-D Submission Summary

Summary

Council officers have been developing a vibrant new streetscape design for Prinsep Street. This report presents two concept plans for Council consideration, named Option A (appendix 10.5.2-A) and Option B (Appendix 10.5.2-B). Both respond to the comments received from the recent stakeholder engagement round.

Executive Recommendation

That Council:

1. Adopt Option A, as presented at appendix 10.5.2-A, for the redevelopment of Prinsep Street and request officers to proceed to detailed design.

2. Consider allocating funding of $1.15 million for detailed design and construction of Prinsep Street as part of the 2024-2025 and subsequent 2025-2026 budget deliberations.

Voting Requirement: Simple Majority

Strategic Relevance

Pillar	Place
Aspiration	An integrated, vibrant, and well - planned City.
Outcome 8	A Place with attractive and welcoming community spaces where people want to live.
Objective 8.1	Create a strong and vibrant City Centre.

Regional Impact Statement

City of Bunbury is continuing work to beautify its CBD streets as part of implementing the City Centre Action Plan. The City Centre Action Plan sets out a vision to achieve a network of thriving and attractive streets and laneways that are engaging, inclusive, easily accessible, integrated in design, and celebrate our identity.

The redesign of Prinsep Streetscape will increase the appeal, safety, and function of the street and will provide benefit for our community at a local and regional scale. This project has the potential to set a template for other streets in our CBD, and to establish a precedent for high quality future works.

Background

The City's Roads Asset Management Plan identifies Prinsep Street as being in 'Poor Condition' and identifies that it is due for renewal. The road seal has deteriorated, and large structural cracks are present in the surface layer. These large cracks make the underlying pavement susceptible to water ingress and loss of strength and integrity. This loss of strength and integrity will likely see road degradation occur imminently.

Due to its poor condition, reconstruction of the carriageway and parking areas is required for this section of Prinsep Street, (between the intersection at Haley/Prinsep/Carmody and Victoria Street). Undertaking these works will result in disruption for local trade and businesses due to the extent of excavation and scale of the works. This presents an opportunity to upgrade the entire streetscape and undertake Council works in a strategic, integrated, and holistic manner.

Currently, Prinsep Street is dominated by parking, with no street trees and heavy building canopies that dominate the streetscape. Footpaths are narrow, and pedestrian movement is constrained by the placement of light poles, temporary signage boards, and permanent parking signage. The existing brick paving is dated and in need of renewal.

The current street configuration does not provide safe crossing points, with pedestrians required to traverse between parked cars when crossing the street. The existing kerbing and constrained footpath widths pose a barrier and hazard to those with physical and visual impairments.

Council officers have designed a new streetscape for Prinsep Street that continues the high-quality treatments from the Haley/Prinsep/Carmody intersection, terminating at Victoria Street. The key aim of the design is to elevate the appeal and function of the street and create a welcoming, attractive, and safe environment for local users and the wider community.

A Preliminary Concept Plan was developed to undertake a targeted engagement round with business owners and property owners in Prinsep Street, in March 2024. The Preliminary Concept Plan was presented to business owners and property owners for their comment. In general, the overall project is supported. However, concerns were raised around the loss of parking, as the Preliminary Concept Plan proposed a loss of 7 carparks from the existing parking format.

The Preliminary Concept Plan was updated to address comments received in the engagement round, presented as Option A. Option A added 2 parking spaces back into the design resulting in a loss of 5 carparks from the existing parking format. Further changes are also proposed that reflect comments received during the engagement round. The inclusion of the 2 parking spaces has had minimal impact on the key design objectives, such as footpath widths and greening.

Option B was also developed that provides for angled parking on the north side of the street, resulting in a loss of only 2 carparks from the existing parking format. However, Option B restricts the scope for implementing other beneficial and key aspects of the design, due to the depth and space required for angled parking bays.

Council Policy Compliance

N/A

Legislative Compliance

N/A

Officer Comments

The main intention of this project is to create a safe, functional, and well executed design outcome for Prinsep Street. Option A and B presented in this report both reflect the following key design elements. However, Option A presents the best outcome in translating these key elements into a workable streetscape design.

The key design elements are:

- Increased road safety by slowing vehicle movements through the street.
- Creating a designated mid-block crossing point aligned with the entrance to Central Arcade.
- Generous footpath widths with an increase of up to one metre in specific locations, to increase pedestrian comfort and allow for increased accessibility.
- The introduction of greening and shade through planting new street trees and associated amenity garden underplanting. This is in line with the City of Bunbury Greening Plan target to increase canopy cover in the City by 10 percent by 2030. The City's current canopy cover is 13.7 percent, well below the WA average of 20 percent.
- Opportunities for people to sit and stop in the streetscape in a relaxed environment, with a new central alfresco area to help attract more people into the street.
- Improved lighting for the safety and comfort of pedestrians.

The targeted stakeholder engagement round (outlined in detail below) has resulted in changes to the original Preliminary Concept Plan that was distributed to business owners and property owners for comment. Two design options, Prinsep Streetscape Concept Plan Option A and Prinsep Streetscape Concept Plan Option B have been developed for Council consideration.

Prinsep Streetscape Concept Plan Option A (Appendix 10.5.2-A)
This design presents an update to the Preliminary Concept Plan, with specific changes made to address feedback received through the engagement round. These changes are:

- 2 x additional 15-minute parking bays.
- 2 x additional parallel parking bays (total of 22 bays).
- Extension to the loading zone to better allow for truck movement.
- New arrangement of the south side alfresco zone.
- Red asphalt to delineate parking bays.

Outlined below are the pros and cons for Option A and have been developed in comparison to the existing conditions in the street.

<u>Pros of Option A</u>
Option A changes the existing parking format from angled bays to parallel bays to the north side of the Street. This ensures the following design outcomes can be achieved to the entire project area:

- **Designated pedestrian crossing** is provided at the mid-point of Prinsep Street, outside the Central Arcade, which provides a safer opportunity to cross the road than currently exists.
- **Increased pedestrian safety** is generated through providing more space in the pedestrian realm and more space for users with limited mobility. This generates a comfortable pedestrian environment.

- **Increased road safety.** The possibility of cars reversing into traffic is eliminated through the removal of all angled parking bays. MRWA Crash Map Data shows that 4 out of the 5 crashes in the last 5 years have resulted from Parking Vehicle Movements, so removal of the angled bays would work to reduce this crash risk. The risk of drivers coming from the opposite direction doing a 225 degree turn to access angled bays is also eliminated.
- **Amenity.** The inclusion of parallel parking increases visibility to shop frontages and the streetscape. It also provides more footpath space to allow for street furniture.
- **Greening.** Available space is generated for tree and garden planting, that will reduce the urban heat island effect, provide shade for pedestrians, and help to achieve targets under the Greening Bunbury Plan. 16 street trees are proposed with this option.
- **Sustainable design for the future** whereby opportunities are created for future alfresco parklets and fluid use of space, as land use changes over time.

Cons of Option A

- **Parking reduction** of 5 x carparks from the existing parking format.
- **Removal of taxi bays** from the street, to maximise opportunities for parking.
- **Relocation of motorcycle parking** from Prinsep Street to Stephen Street where there is space to accommodate that. Please refer to **Table 1** below for a comparison of parking arrangements in Prinsep Street.

Prinsep Streetscape Concept Plan Option B (Appendix 10.5.2-B)
This design incorporates the same changes as Option A to address feedback received through the engagement round. Option B also retains some angled parking on the north side of the street. The pros and cons of Option B are described below and have been developed in comparison with Option A and the existing conditions in the Street.

Pros of Option B
There will only be a loss of 2 x carparks for the street. Please refer to **Table 1** below for a comparison of parking arrangements. Option B will still deliver on the original design intents described above, although at a reduced extent to what is proposed in Option A. This option also removes the taxi bays and motorcycle parking from the street.

- **Designated pedestrian crossing** is provided at the mid-point of Prinsep Street, outside the Central Arcade. Providing a safer opportunity to cross the road than currently exists.
- **Car parking opportunities.** Leaving some of the existing angled parking bays reduces the loss of car parking opportunities through the project.
- **Amenity.** The realignment of bays does provide for some amenity benefits compared with the existing streetscape. However, these is less less available space for street furniture and garden planting, with a loss of 2 amenity garden beds and 1 seat from what is proposed in Option A.
- **Greening.** Available space is still generated for tree and garden planting, that will reduce the urban heat island effect, provide shade for pedestrians, and help to achieve targets under the Greening Bunbury Plan. 14 street trees are proposed with this option, as opposed to 16 street trees in Option A.

Cons of Option B
The depth and space required for angled parking results in a loss of key design elements. This forms a fragmented and inconsistent design outcome, particularly in regard to footpath widths and street tree/garden planting.

- **Parking reduction** of 2 x carparks from the existing parking format.
- **Removal of taxi bays** from the street, to maximise opportunities for parking.

- **Relocation of motorcycle parking** from Prinsep Street to Stephen Street where there is space to accommodate that. Please refer to **Table 1** below for a comparison of parking arrangements in Prinsep Street.
- **Pedestrian safety** is not prioritised with this design, as the existing footpath widths will need to be retained on the north side of the street to retain the angled parking. This will result in varying footpath widths across the streetscape.
- **Road safety.** Retaining angled parking bays does not eliminate the crash risk from Parking Vehicle Movements. MRWA Crash Map Data shows that 4 out of the 5 crashes in the last 5 years have resulted from Parking Vehicle Movements.

Table 1 – Comparison of parking arrangements in Prinsep Street

Bay Type	Existing Qty	Option A	Option B
Normal	23	16	19
15 Minute	3	5	5
Loading	1	1	1
Total Car Bays	**27**	**22**	**25**
Taxi	3	0	0
Motorcycle	4	0	0

The preferred option is Option A. The pros of this design align with the original key design intent of prioritising pedestrian safety, increasing greening and increasing road safety, to the maximum extent possible in the Street. Option A is in line with the aims of the City Centre Action Plan and aligns with the City of Bunbury Corporate Business Plan "Place" outcomes and objectives. Option B will still deliver on the original design intents described above, although at a reduced extent to what is proposed in Option A.

Analysis of Financial and Budget Implications

The Corporate Business Plan, under *Implement CBD Roadworks*, has $400,000.00 allocated to the 2024/2025 financial year and $750,000.00 for 2025/2026 year. The intention is for this project to be delivered across two financial years to minimise adverse construction impacts on traders.

Community Consultation

An engagement process was undertaken for the Haley/Prinsep/Carmody intersection upgrade project in 2021. A set of concept design drawings for the intersection, including Prinsep Street, was made available to the wider community to have their say on the overall design. Pop up community meetings in the street were held in September 2021 and the plans were made available on the City's community connect page. The comments received from the first round of engagement were taken into consideration and used to develop the design for Prinsep Street further.

In March 2024, a targeted stakeholder engagement round was undertaken, where feedback from business owners and property owners in Prinsep Street was sought. This targeted approach was undertaken to ensure that specific and meaningful feedback was received from those directly impacted by the design proposals.

A letter has been sent to the Taxi company who currently have the exclusive right to use 3 x existing parking bays in the street, for their feedback on the proposed change. Further information on the outcome of that engagement will be provided.

The Preliminary Concept Design and visualisations that were used for this engagement round and formed part of the engagement package are included in Appendix 10.5.2-C. The engagement package also included a cover letter, feedback form, and images of the existing works at the roundabout.

The engagement package was distributed in person to 23 business owners. 11 engagement packages were delivered by mail to property owners. Business and property owners received 2 engagement packs. A two-week turnaround time was provided to receive comments.

On site meetings and phone conversations were also conducted with business owners to assist in alleviating any concerns of the submitters.

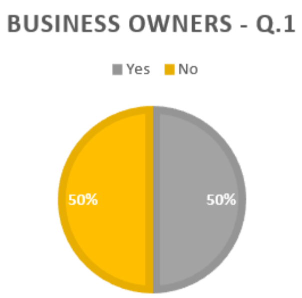
Engagement results:

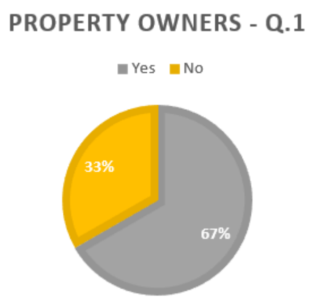
Six (6) forms were received from business owners (26% response rate), 2 forms were received from property owners (18% response rate) and 3 forms were received from stakeholders who are both business and property owners (27% response rate). Eleven (11) forms were received in total.

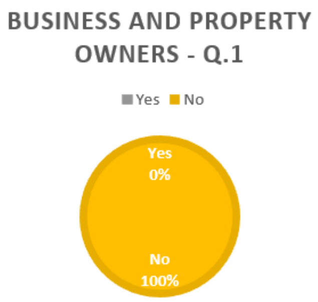
The following questions were posed to the stakeholders via the feedback form. The responses to those questions are outlined below. Appendix 10.5.2-D includes a summary of all the engagement comments as well as proposed changes to the designs based on feedback received. These changes are reflected in both Options A and B.

Question 1 – to see an improved, attractive, and safe streetscape environment for Prinsep Street including high quality brick paving, wide footpaths, new street furniture and street trees, do you agree with reducing the number of the parks in the street by 7?

Business owners - 50% Yes, 50% No.
Property owners - 67% Yes, 33% No.
Business and property owners - 100% No.

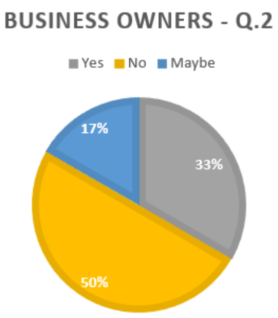


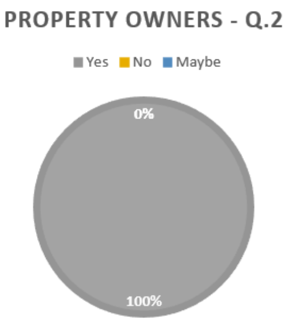


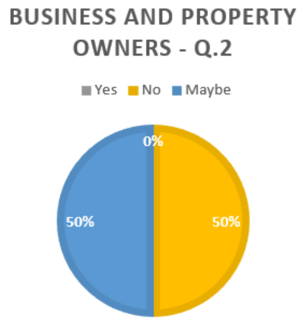


Question 2 – Should the project and detailed design be approved by Council; construction is proposed between July and November 2024. Do you support this proposed timing of works?

Business owners - 33% Yes, 50% No, 17% Maybe.
Property owners - 100% Yes.
Business and property owners - 50% Maybe, 50% No.







Should this project progress into construction phase, we will be engaging further with stakeholders around timing and access to businesses during construction.

Co-Design Access Panel (CoDAP)

A meeting was held with CoDAP on the 27th March 2023. Overall, the design is supported by CoDAP, and the existing works at the Haley/Prinsep/Carmody intersection was praised. Several items were raised that will be considered at detailed design phase. These were mainly centred around tactile pavers, and discussion was had for utilising existing bays for disability pick up and drop off. This applies to both Option A and Option B. Council Officers are investigating the possibility of shared use arrangements for parking bays proposed in the street, including the loading zone. If this project is endorsed, Council Officers will be engaging further with CoDAP at detailed design phase.

Councillor/Officer Consultation

Consultation has been undertaken with the Senior Strategic Planner – Planning and Building Department. This consultation process highlighted the need for peer review of the City's design projects. Mackay Urbandesign has therefore undertaken a peer review of the Preliminary Concept Plan, under the 10 Principles of Good Design, State Planning Policy 7.0 – Design of the Built Environment.

The report concluded that while the project was at an early phase of the design process, the improvements show promise of presenting a good design outcome and will be a significant improvement to the public realm in the CBD. The report stated there were no fundamental concerns about the design and it seeks to do all the right things from an urban design perspective. The report was supportive of the parallel parking format and the benefits that brings from an urban design perspective.

Some minor improvements were put forward which will be included at the detailed design stage of the project, where budget allows. This review is relevant for the Preliminary Concept Plan only.

Applicant Consultation

N/A

Timeline: Council Decision Implementation

If endorsed by Council, Officers will proceed to detailed design for construction to commence in the 2024/2025 financial year and be completed in the 2025/26 financial year.

N

COMPARISON OF PARKING ARRANGEMENTS:

BAY TYPE	EXISTING QUANTITY	OPTION A
Normal	23	16
15 Minute	3	5
Loading	1	1
Total Car Bays	27	22
Taxi	3	0
Motorcycle	4	0

CHANGES MADE BASED ON FEEDBACK:

- 2 X ADDITIONAL 15 MINUTE BAYS
- 2 X ADDITIONAL PARKING BAYS, ONE TO NORTH SIDE ONE TO SOUTH SIDE
- EXTENSION OF LOADING ZONE TO ALLOW FOR TRUCK MOVEMENT
- NEW ARRANGEMENT OF SOUTH SIDE ALFRESCO AREA
- RED ASPHALT TO PARKING BAYS

MOTORBIKE PARKING TO BE ACCOMODATED ON STEPHEN STREET

AMENDMENTS			
B	03/2024	ISSUED FOR DISCUSSION	CJS AND CM
A	01/2024	ISSUED FOR DISCUSSION	CJS AND CM
REV	DATE	DESCRIPTION	DRAWN

CITY OF BUNBURY

THESE PLANS ARE NOT TO BE USED FOR CONSTRUCTION UNLESS SIGNED FOR CONSTRUCTION

SIGNATURES:

DESIGNED BY: CS AND CM	APPROVED BY: AARON LINDSAY	PROJECT MANAGER: JOHN CARBONE
DATE SIGNED:	DATE SIGNED:	DATE SIGNED:

DRAWING FILENAME: N:\Assets & Design\Landscape\Prinsep Street

DATUM V: AHD71 | DATUM H: MGA94

SURVEYOR: KELLEE NUNN

BEFORE YOU DIG www.byda.com.au

DRAWING NO: COB/6218

SHEET: 1 OF 2 | SCALE: 1:200

ISSUED FOR COMMENTS

A1

PRINSEP STREET - VICTORIA STREET TO HALEY STREET OPTION A

REV. B

CM10 FOLDER: COB/6218

N

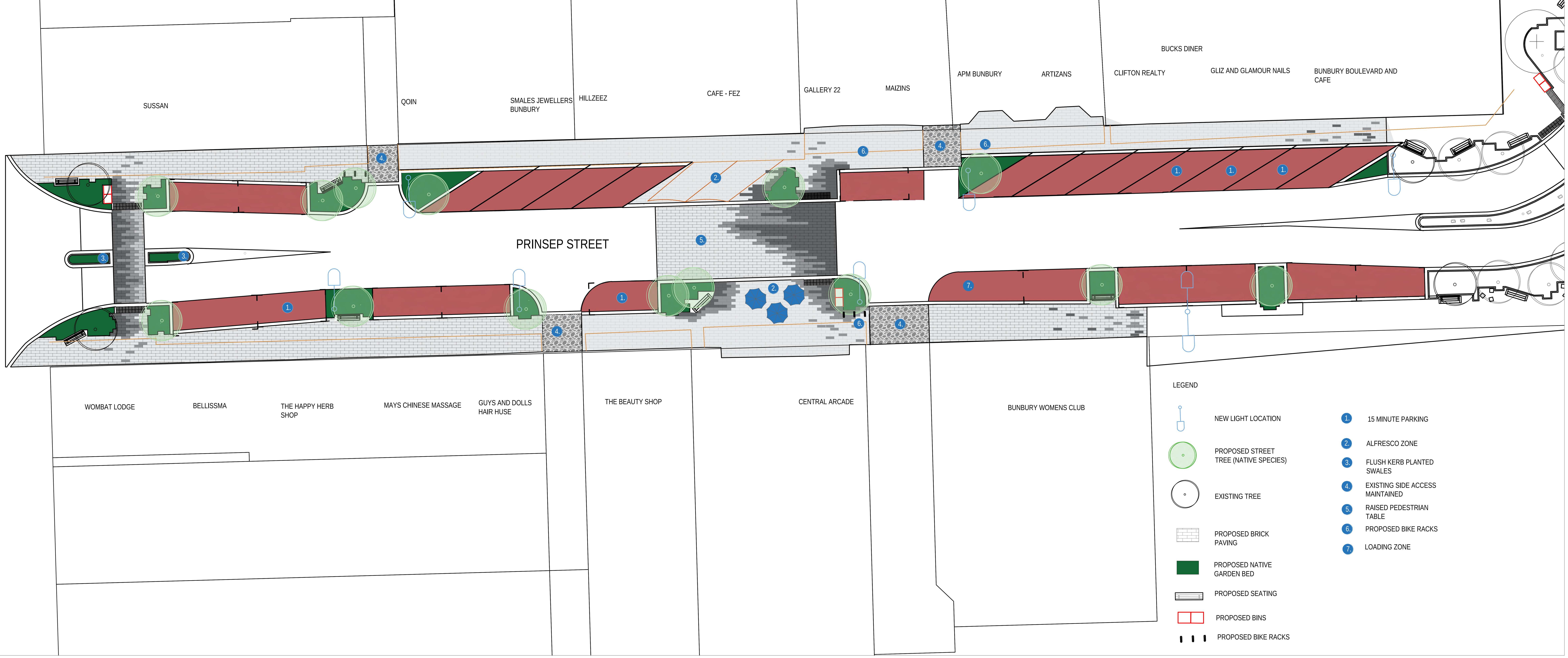
COMPARISON OF PARKING ARRANGEMENTS:

BAY TYPE	EXISTING QUANTITY	OPTION B
Normal	23	19
15 Minute	3	5
Loading	1	1
Total Car Bays	27	25
Taxi	3	0
Motorcycle	4	0

CHANGES MADE BASED ON FEEDBACK:

- 2 X ADDITIONAL 15 MINUTE BAYS
- 5 X ADDITIONAL PARKING BAYS TO THE NORTH SIDE OF THE STREET
- EXTENSION OF LOADING ZONE TO ALLOW FOR TRUCK MOVEMENT
- NEW ARRANGEMENT OF SOUTH SIDE ALFRESCO AREA
- RED ASPHALT TO PARKING BAYS

MOTORBIKE PARKING TO BE ACCOMODATED ON STEPHEN STREET



AMENDMENTS			
REV	DATE	DESCRIPTION	DRAWN
C	03/2024	ISSUED FOR DISCUSSION	CJS AND CM
B	03/2024	ISSUED FOR DISCUSSION	CJS AND CM
A	01/2024	ISSUED FOR DISCUSSION	CJS AND CM

CITY OF BUNBURY

THESE PLANS ARE NOT TO BE USED FOR CONSTRUCTION UNLESS SIGNED FOR CONSTRUCTION

SIGNATURES:		
DESIGNED BY: CS AND CM	APPROVED BY: AARON LINDSAY	PROJECT MANAGER: JOHN CARBONE
DATE SIGNED:	DATE SIGNED:	DATE SIGNED:

DATUM V: AHD71 | DATUM H: MGA94

SURVEYOR: KELLEE NUNN

BEFORE YOU DIG www.byda.com.au

DRAWING FILENAME: N:\Assets & Design\Landscape\Prinsep Street

DRAWING NO: COB/6218

SHEET: 1 OF 2 | SCALE: 1:200

ISSUED FOR COMMENTS

PRINSEP STREET - VICTORIA STREET TO HALEY STREET OPTION B

A1

REV.C

CM10 FOLDER: COB/6218

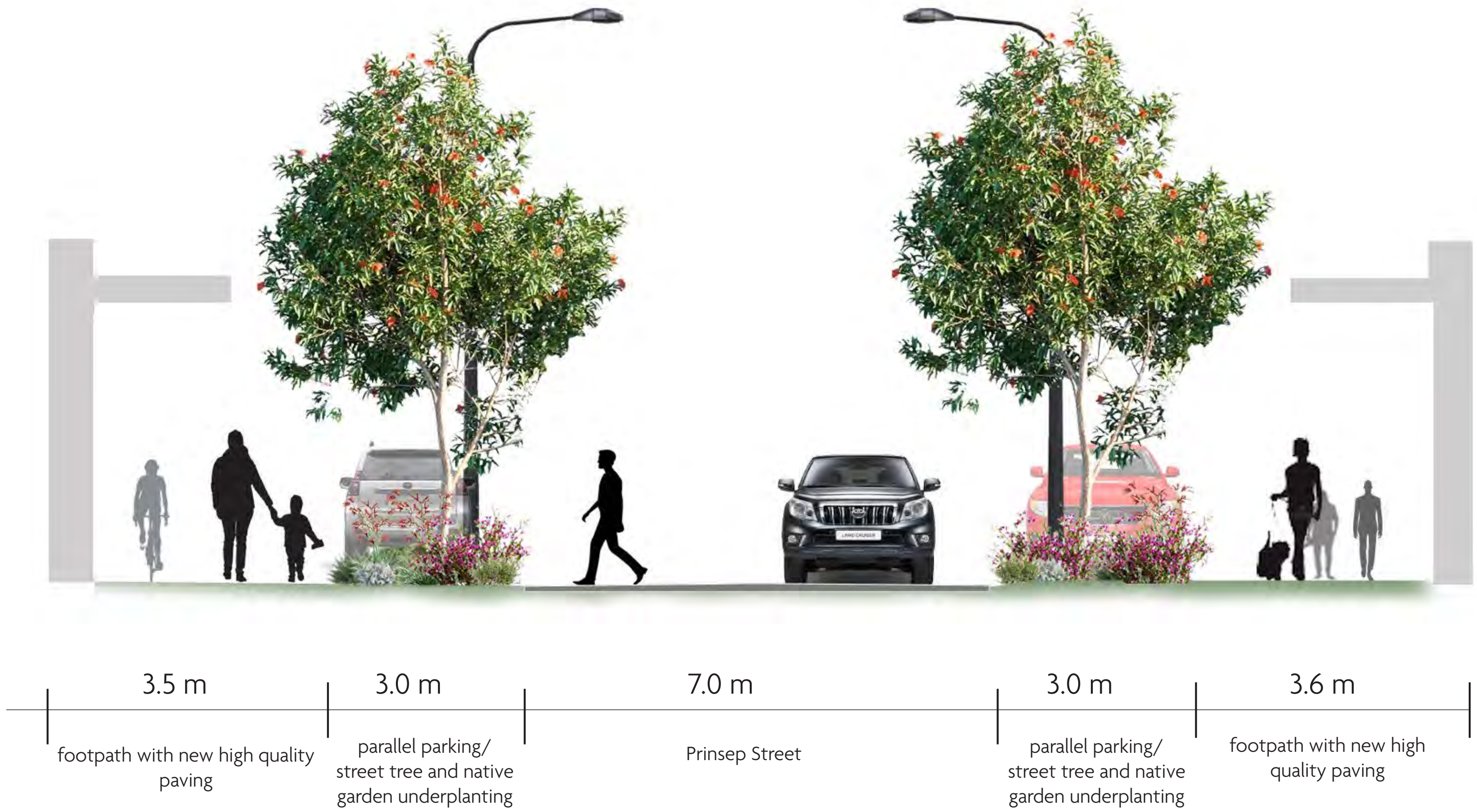
CITY OF BUNBURY

Feburary 2024
Rev. A

Prinsep Streetscape

Victoria Street to Haley Street
Concept Plan

INDICATIVE CROSS SECTION



INDICATIVE VISUALISATION

CITY OF BUNBURY

Prinsep Streetscape

Victoria Street to Haley Street
Concept Plan

Feburary 2024
Rev. A

Feedback summary - Targeted Stakeholder Engagement Prinsep Street

Business Owners

Feedback form number	Q.1. Yes/No	Written notes on Q.1	Q.2. Yes/No	Written notes on Q.2.	Other Feedback Comments	Officer Comments	Proposed Amendments to design based on feedback received
1	Yes	The reduced parking is not ideal.	Yes		A vast improvement but would like to know additional disruption to trading details.	All business and property owners will be kept up to date on the construction timing and process, should this project proceed.	Include additional 2 x parallel parking bays to option A and present option B with angled parking for Council consideration.
2	Yes	Include 15 minute bay in front of Glitz and Glamour, no tree near loading zone bay. Too hard for trucks to get in and out.	Yes				Relocate tree and remove planting from loading bay area. Install tree in Alfresco zone garden bed area (south side). Extend loading zone.
3	No	The 3 bays removed on the plans are the only carparks my customers use for grab and go, parking is a problem for my customers.	No	July-August-September are the busiest times of the year for my café.	Alfresco area in front of the Beauty Shop instead of carpark would affect my café very badly.	Council staff have met with this submitter on two occasions to discuss these concerns. We are confident that we have addressed concerns raised and the submitter has warmed to the design considerably.	Investigate use of the alfresco area for this café's patrons. Relocate tree from loading bay and install tree in alfresco garden bed area. Extend loading zone. Reconfigure alfresco zone (south). Install 1 x 15 minute park to south side of road. Include additional 2 x parallel parking bays to option A and present option B with angled parking, for Council consideration.
4	Yes	The continuation of new paving from Victoria Street and Carmody Place intersections, improved street drainage, beautified roadway, fresh overhead green canopy and wider footpaths will make the street an attractive and walkable section of our CBD.	No	We would prefer a mid to late January commencement as revenue tends to significantly reduce shortly after Christmas and remain uninspiring through to the end of April. We find the first part of the calendar always underperforms relative to the rest. In talking to our retail neighbours, this seems to be consistent for them.	We love the concept for the streetscape. A range of attractive and functional enhancements which we believe will improve the walkability and general appeal of the street for businesses and pedestrians. It is time for the side streets of our CBD to deliver the beauty and atmosphere so long reserved for the cafe strip. We particularly applaud the removal of the taxi parking. Suggestions are, Relocate MC parking to the opposite side outside DHS building and install single car bay and one tree outside 22 Prinsep Street, car bays are more valuable here than MC bays as there is more retail to the north side of the street. Relocate 1 x 15 minute bay further west along Prinsep Street to increase the churn and allow for quick stops further up. Provide a loading Bay that can be driven directly into unobstructed at the rear of the bay without a tree to allow simple access for delivery and space at the rear for high doors to swing open, a flat surface for lowering flatbeds and loading trolleys. As traffic heads west from Carmody, the first bay on the left could be modified for loading bay. As there is no retail frontage on that side it will suit the aesthetics of the street.	We have summarised this submission to key points and will arrange a separate meeting to discuss the other items further.	Relocate motorbike parking to Stephen Street. Relocate tree in this location and plant in the garden bed next to the alfresco area. Create 1 x parallel parking bay outside 22 Prinsep for option A. Install one further 15 minute bay to south side of road. Relocate tree to loading bay and install tree in alfresco garden bed area. Extend loading zone.
5	No	We see a reduction of parking and the taxi rank reduces the amount of shoppers in the area. This street already struggles with parking bays, elderly need to be able to park near where they are shopping.	No	Reducing the parking by 7 bays will see up to 400 people per week that struggle to shop in this street. I don't support this project in any level.	There is never that much foot traffic in this street so widening for pedestrians seems a waste of time, so does removing the taxi rank. This street needs a bike rack for cyclists.		Present option B with angled parking for Council consideration.

6	No	The reduction of bays by 7 (30%) is a further reduction to the bays lost 10 years ago, it makes no sense to abolish diagonal bays that were introduced to minimise that loss, the economic value of car bays is not understood. The challenge of the City Planners is to increase appeal and amenity of the street without losing bays. Where are the business metrics suggesting Prinsep Street businesses will not be worse off after the removal of 7 bays?	Maybe	Without being privy to a timeline of scheduled works its hard to comment. Feedback form lists items that need to be taken into consideration.	Taxi bays should have been removed years ago and the pots. Maintain diagonal parking on one side of the street to reduce unnecessary loss of bays. Loading zone is too small. What street tree is proposed and how big, who caters for gutter cleans. Concept drawings that flip out car bays for feel good artist impressions are synonymous for CBDs that are 25x the size of Bunbury with better public transport and high density urban - drive to locations need bays.	Phone conversation was had with this submitter who explained the points raised in the submission. This submission has been summarised to key points relevant to the project. While appreciated, some comments are outside of the scope of this project.	Relocate tree to loading bay and install tree in alfresco garden bed area. Extend loading zone. Include additional 2 x parallel parking bays to option A. Present option B with angled parking for Council consideration. Street trees proposed have a small canopy size, and will not be deciduous.

Property Owners

Feedback form number	Q.1. Yes/No	Written notes on Q.1	Q.2. Yes/No	Written notes on Q.2.	Other Feedback Comments	Officer Comments	Proposed Amendments to design based on feedback received
7	Not provided	The loss of 7 parking bays concerns us as we anticipate more people illegally parking in our property.	Not provided		We like the idea of the raised pedestrian tables and see how this will increase safety. The artists impression depicts a street that is much more modern and pedestrian friendly and we hope that the public will be more likely to patronise the nearby businesses, creating a vibrant community. Loading zone relocation - If there was a tall truck in the bay it will be impossible to see vehicles coming from the right making it dangerous when pulling out of driveway. If there was a way to make the loading zone 10 minute time this may be improved. We have unauthorised parking in our parking bays with people with disabilities as there are no disabled parks on the street. Can the bay to the east of the loading zone be a designated disabled bay for the public to use. We like the placement of the two trees in front of our building - we trust that the trees will not be a type that will have roots that create a problem for our building.	This submission has been summarised to key points- some points raised in this submission are outside of the scope of this project. Officers will arrange a separate meeting to discuss further. Small canopy trees are proposed due to space constraints.	Present option B with angled bays for Council consideration. Investigate rules for loading zones and consider shared use arrangements - Council officers are in discussions with CoDap around this.
8	Yes		Yes		Please note - 3 x 15 minute parking in front of Bakery and Bucks Diner, and request another 2 x 15 minutes across the road.	Submission requested 2 x 15 minute bays to the first two carparks to the south side of the street, opposite 3 x 15 minute bays on the north side of street. The intent is to spread 15 minute bays out throughout the street.	Include one additional 15 minute parking bay in front of Glitz and Glamour nails and Bucks Diner. Include 1 x 15 minute Bay to south side of road.
9	Yes	I like the plan and hope it goes ahead.	Yes		The middle street tree location is blocking the main entry sign for the arcade - can this be moved to the proposed street tree location area. The alfresco zone would be better located in front of the arcade for use by our cafes instead of the beauty shop - can I suggest swapping the proposed alfresco zone location with the proposed street furniture location. I think you have met with my tenant she didn't seem happy with the plan at first but she is warming to the idea especially of the possibility of accessing the alfresco zone.		Reconfigure south side alfresco area.

Business Owners and
Property Owners

Feedback form number	Q.1. Yes/No	Written notes on Q.1	Q.2. Yes/No	Written notes on Q.2.	Other Feedback Comments	Officer Comments	Proposed Amendments to design based on feedback received
10	No	People already complaining they don't have enough parking on the Prinsep Street or near the shops	Maybe	July - August better for trade - not near Christmas	Design has street appeal but just concerned about losing 7 parking bays and closing the road off (not clear).		Include additional 2 x parallel parking bays to Option A. Present option B, with angled bays for Council consideration.
11	No	Convenient parking holds paramount importance for local business therefore I must express my opposition of the proposal to reduce the number of parking spaces. Our customers frequently lament the scarcity of parking and the lack of covered pedestrian path from Centrepoint, parking spot close to our store remain crucial.	No	The proposed timing from July to November 2024 coincides closely with the Christmas period. Hence I respectfully suggest that the construction period be rescheduled to Feb to June aligning with the quieter season.	In front of 15 Prinsep Street - the alfresco zone is unnecessary here and impractical. Such amenities would obstruct the visibility of the store from our street. I propose that these features are better suited to businesses in the dining sectors		Reconfigure South side alfresco area. Present option B with angled parking for Council consideration.

11. Applications for Leave of Absence

Nil

12. Motions on Notice

Nil

13. Questions from Members

13.1 Response to Previous Questions from Members taken on Notice

Nil

13.2 Questions from Members

14. New Business of an Urgent Nature Introduced by Decision of the Meeting

15. Meeting Closed to Public

15.1 Matters for which the Meeting may be Closed

15.2 Public Reading of Resolutions that may be made Public

16. Closure