

Capel to Leschenault CHRMAP

Chapter Report: Vulnerability Analysis

Peron Naturaliste Partnership

1 July 2022





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1 July 2022

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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

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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 1-1 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 approach is developed according to the PNP's scope and is in line with the CHRMAP Guidelines (WAPC, 2019).

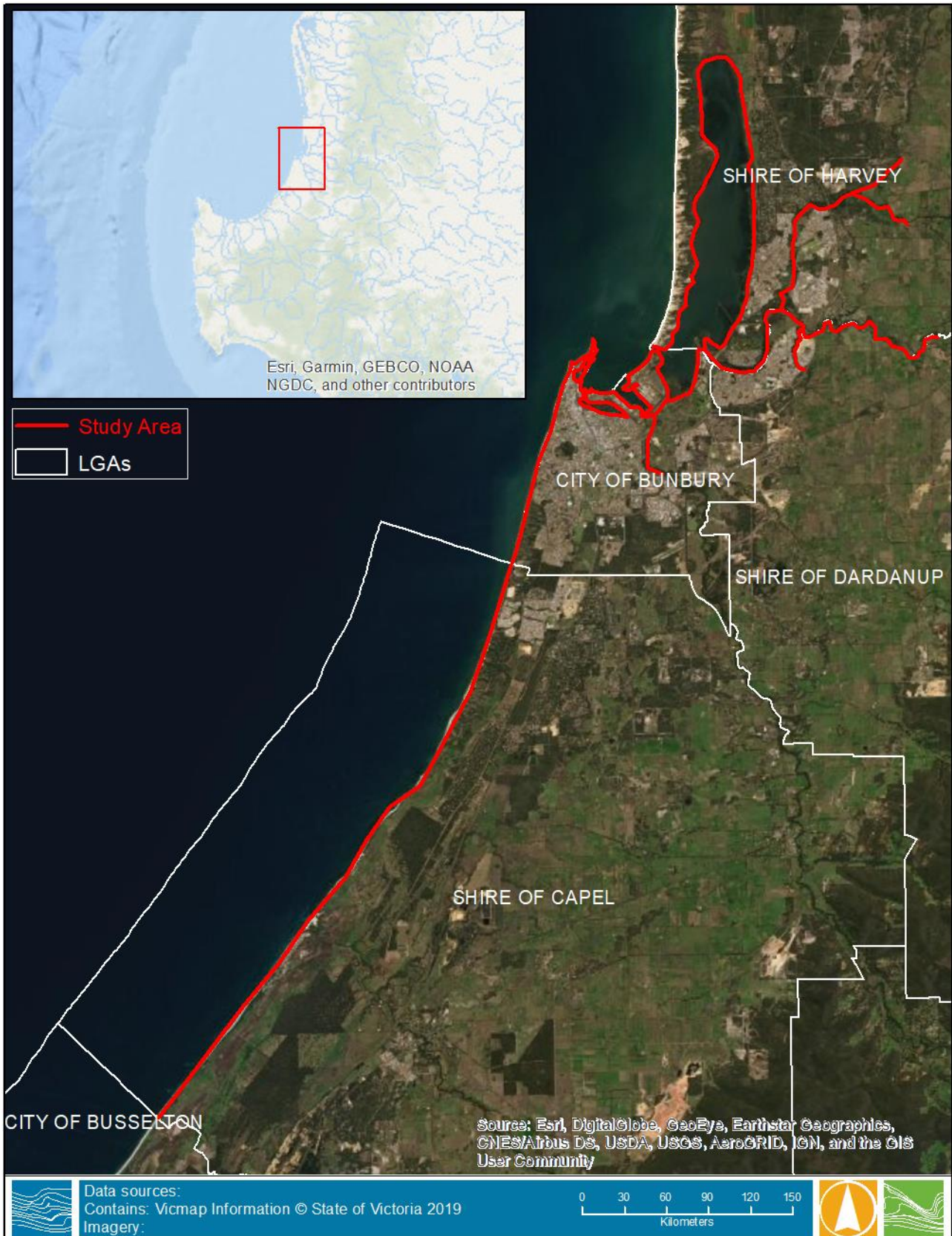


Figure 1-1 Project Area

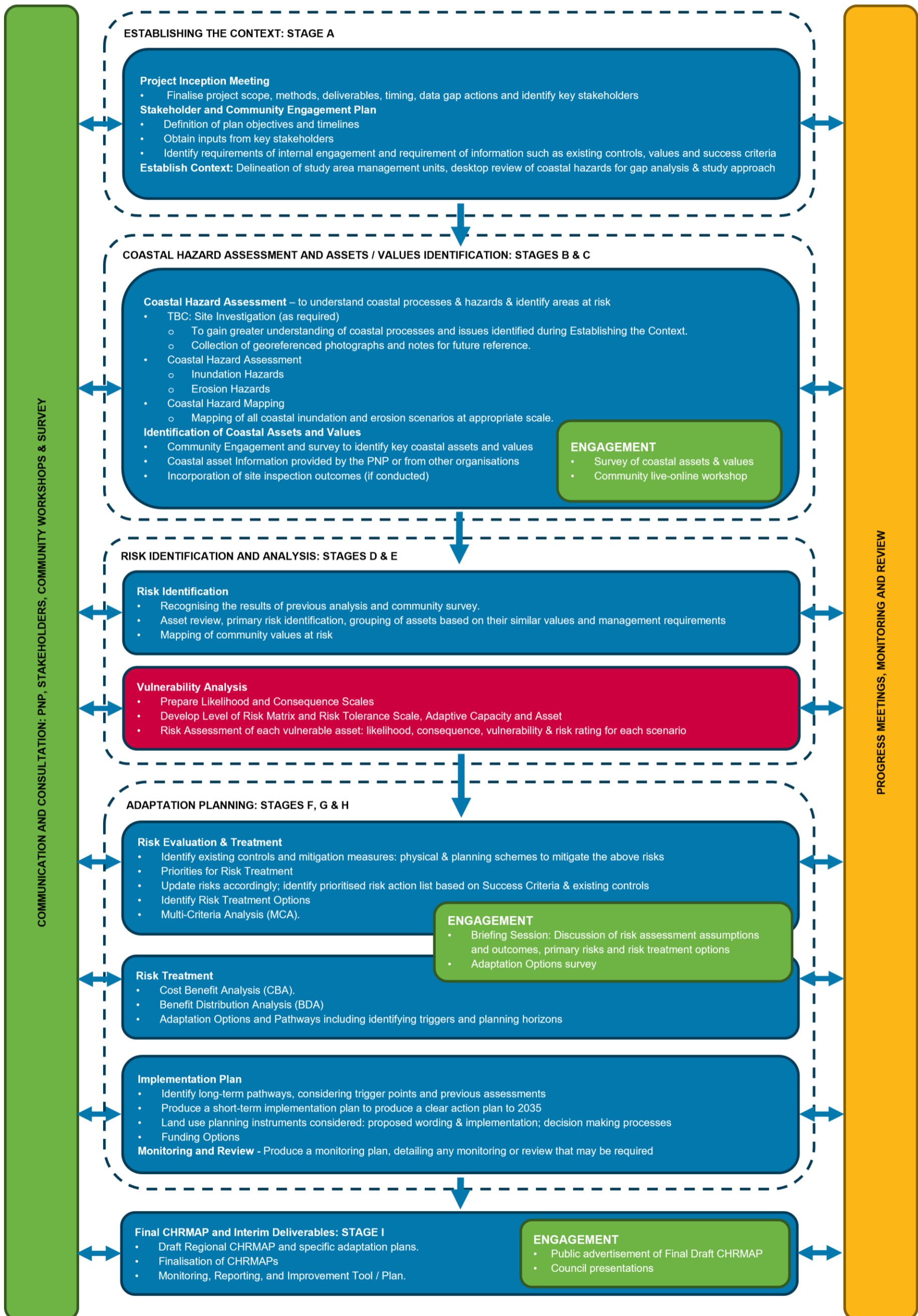


Figure 1-2 CHRMAP Methodology Flow Chart (adapted from WAPC, 2019)



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.

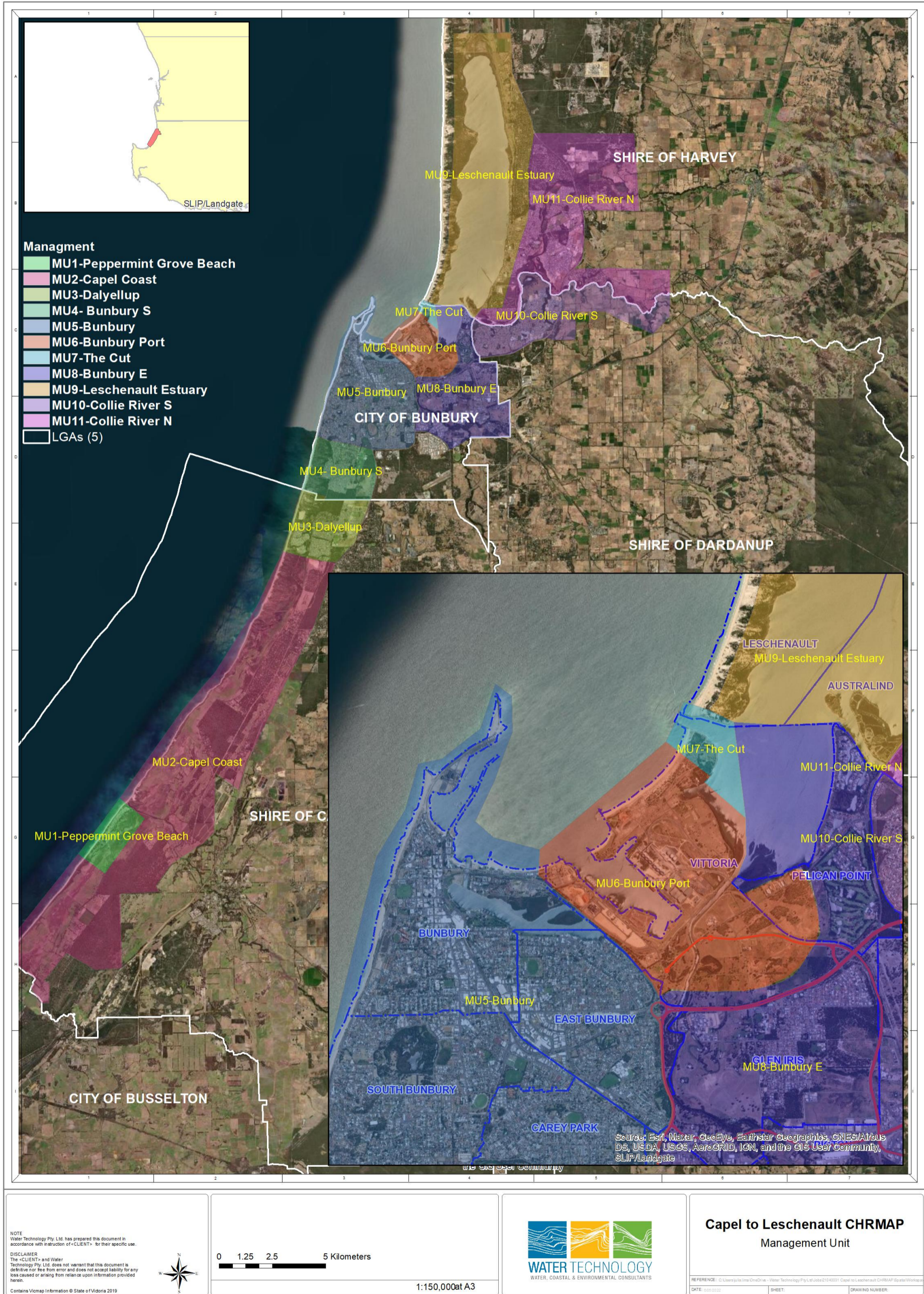


Figure 2-1 Study Area and Management Units



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.

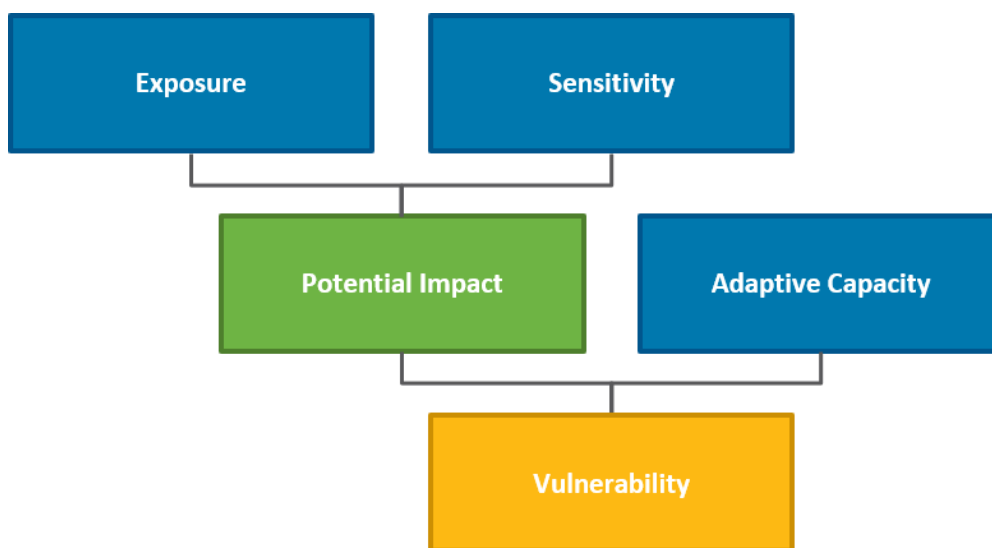


Figure 3-1 Vulnerability assessment components (reproduced from Allen Consulting, 2005)

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.

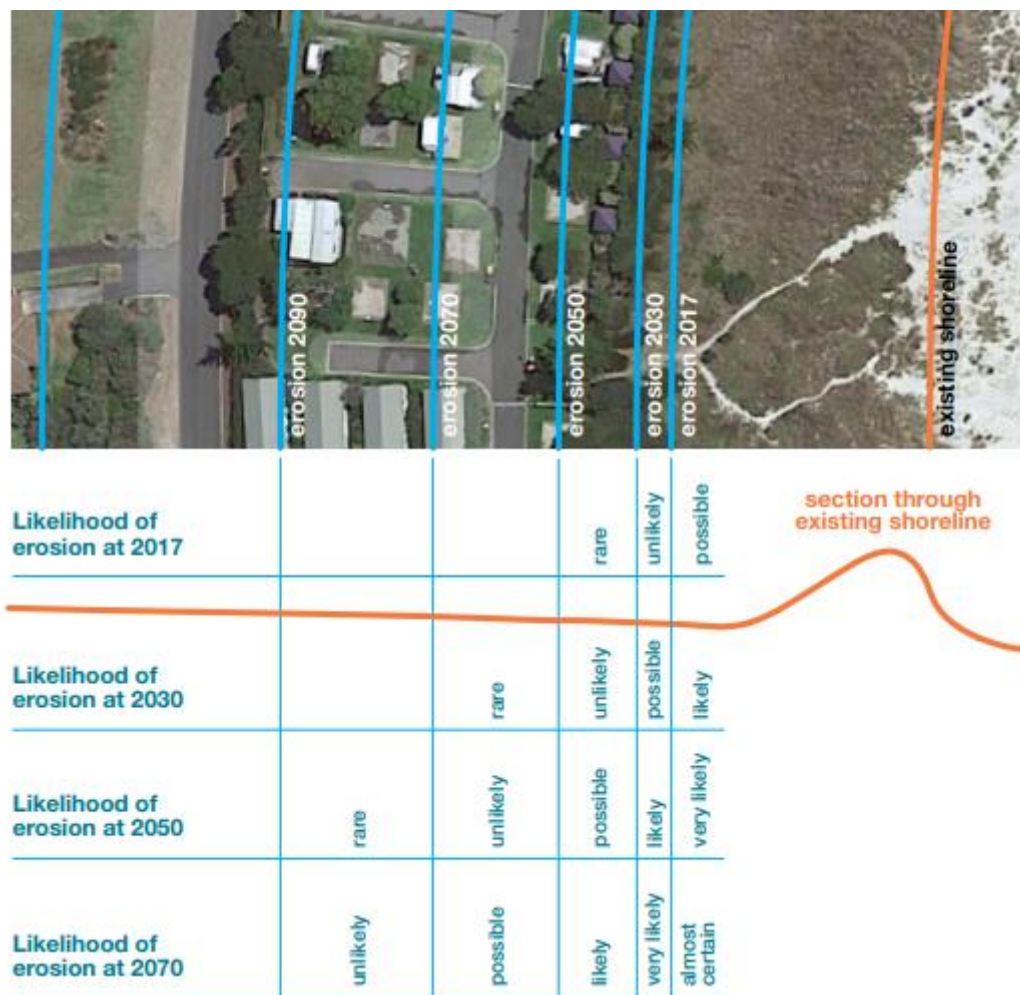


Figure 3-2 Example of likelihood rating based on erosion hazard lines (adapted from WAPC, 2019)



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.

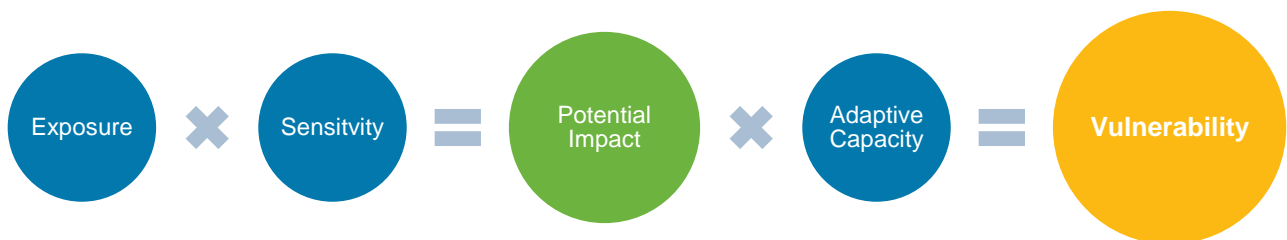


Figure 3-3 Vulnerability relationship



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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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.



6 REFERENCES

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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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