# CHRMAP

2019

COASTAL HAZARD RISK MANAGEMENT AND ADAPTATION PLAN

city of Rockingham

where the coast comes to life

# Frequently Asked Questions

## What is a CHRMAP?

A Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) is a strategic planning document that informs the community and decisions makers about potential coastal hazards, the consequences and necessary actions.

The CHRMAP is required under the State Planning Policy 2.6 State Coastal Planning (SPP 2.6) and aims to provide long term direction, while giving context to planning decisions in the short term.

Please refer to Section 1 to learn about the CHRMAP objectives and Section 3 for more information on why the CHRMAP is required.

## Why release a draft CHRMAP?

The purpose of the draft CHRMAP is to provide an opportunity for the community to view and provide input on the document and its proposed recommendations. All actions in the draft CHRMAP are only proposals at this stage for consideration by the community and Council.

Once all community comments have been received, the draft CHRAMP will be updated to incorporate feedback and reported back to Council.

## What are coastal hazards?

The two main coastal processes that are considered hazards are erosion and inundation. The 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. Please refer to Section 4 for more information.

## How can I tell if my property is in a coastal hazard area?

To determine if your property may be vulnerable to erosion, please refer to Section 5.

To determine if your property may be vulnerable to inundation, please refer to Section 6.

## What are the options for adapting to coastal hazards?

The State Coastal Policy identifies four options for adapting to coastal hazards:

- Avoid
- Retreat
- Accommodate
- Protect

Please refer to Section 7.2 to learn more about these options and the pros and cons for each.

## How does this affect me?

Coastal vulnerability 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 more information.

| I am a… | |
|---|---|
| Private property owner in a coastal hazard area | If a planning or development application is submitted for a lot located in a coastal hazard area then the State Coastal Policy 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. This will also be communicated in any Land Enquiry requested from the City. |
| User of the City's coastline | Some areas of the City's coastline may become vulnerable over the next 100 years. This includes beaches, access ways, footpaths, carparks, toilets, roads and public open space areas.<br><br>Section 9.7 provides a summary of the short term management actions to be undertaken by 2030. These actions are largely focused 'behind the scenes' to better prepare the City for future coastal hazards and are not expected to impact the way in which you currently use and enjoy the coastline.<br><br>Long term, adaptation strategies such as protection or managed retreat may be required if and when coastal hazards are realised, as explained in Section 8.<br><br>In areas identified for future protection (Section 8.2), structures such as seawalls may be constructed in the future. This means that the natural sandy beach will eventually be lost in these locations, but existing infrastructure will be protected.<br><br>In areas identified for future managed retreat (Section 8.2), existing infrastructure may gradually be permanently removed or relocated if coastal hazards cause damage during storm events. The natural sandy beach and dunes will be retained in these areas. |
| A lessee or user of one the City's coastal buildings | If you lease or use a City building that is located in a coastal hazard area, it may be impacted within the 100 year planning timeframe.<br><br>Please refer to Section 9.3.2 for short and long term measures relating to land and facilities leased by the City. |

## Who is responsible if my property is affected? Will the state or local government protect my property?

There is no legal obligation on the State or Local Governments to either protect public and private assets within coastal hazard areas, or to compensate for any losses incurred due to coastal hazards.

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.

## What changes can I expect to see in the short term?

It is unlikely that you will see any major adaptation works along the City's coastline before 2030. In the short term, proposed actions will be primarily 'behind the scenes' with a focus on establishing;

- A long term coastal monitoring program, to ensure the City has accurate and timely data to track coastal hazard impacts and inform future decision making;
- A coastal adaptation fund, to ensure the City is well placed to implement best practice coastal adaptation works if and when they are required; and
- Measures for education and engagement, to ensure the community is well informed and property owners are aware of any potential coastal hazard risks that may affect them.

Please refer to Section 9 for more information on the short term actions to 2030.

## What will the City be doing in the long term?

Long term, adaptation strategies such as protection or managed retreat may be required if and when coastal hazards are realised. This is further explained in Section 8, with priority areas identified for protection or managed retreat shown in Section 8.2.

## Who will pay for adaptation?

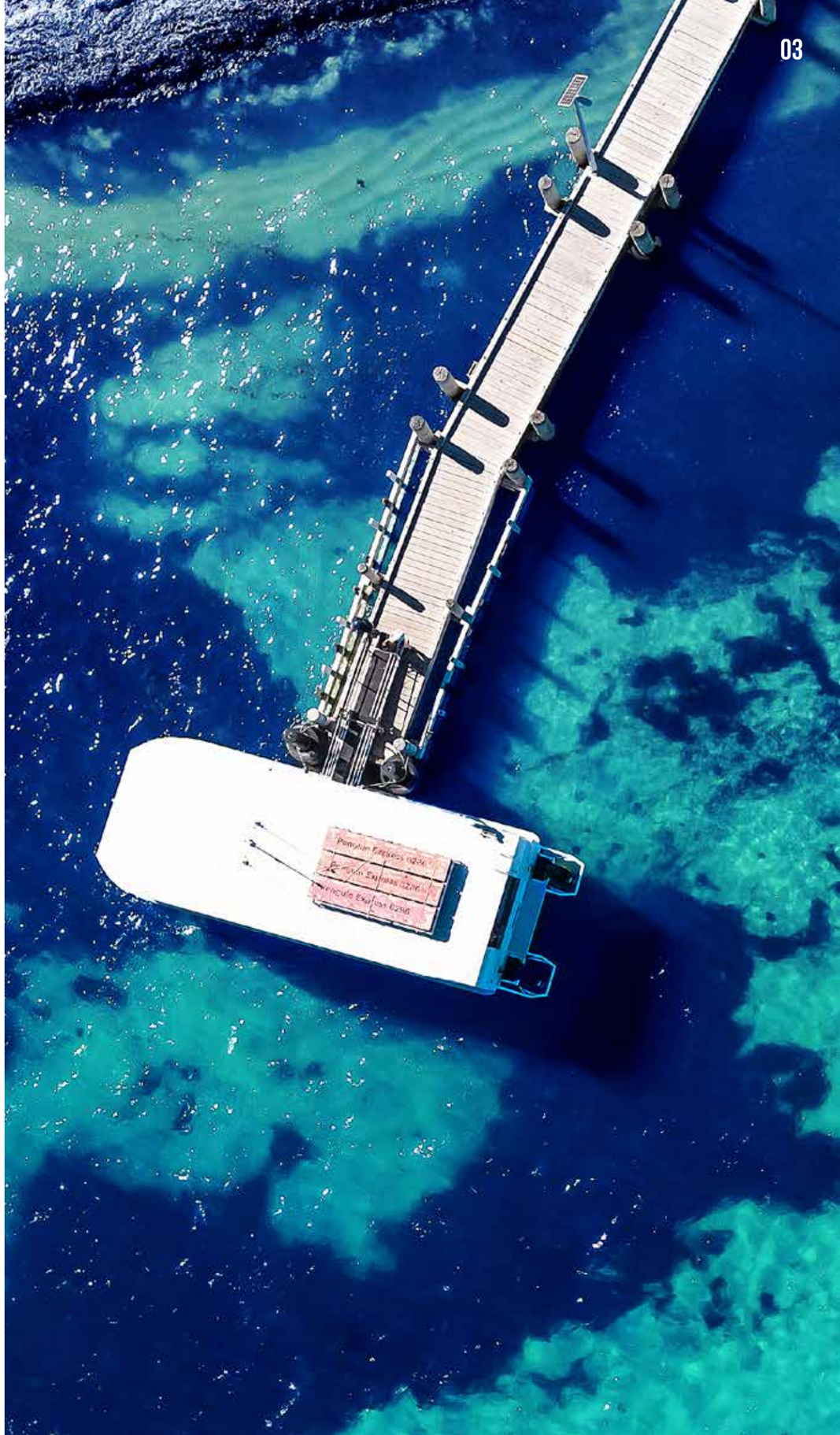
Currently, both the state and federal governments do not propose any funding to assist local governments in paying for coastal adaptation. Knowing that any type of coastal adaptation will be expensive, it is recommended that the City establish a dedicated fund for Coastal Adaptation to ensure the City is well placed to undertake works as necessary, when the time comes. This is further explained in Section 9.2.

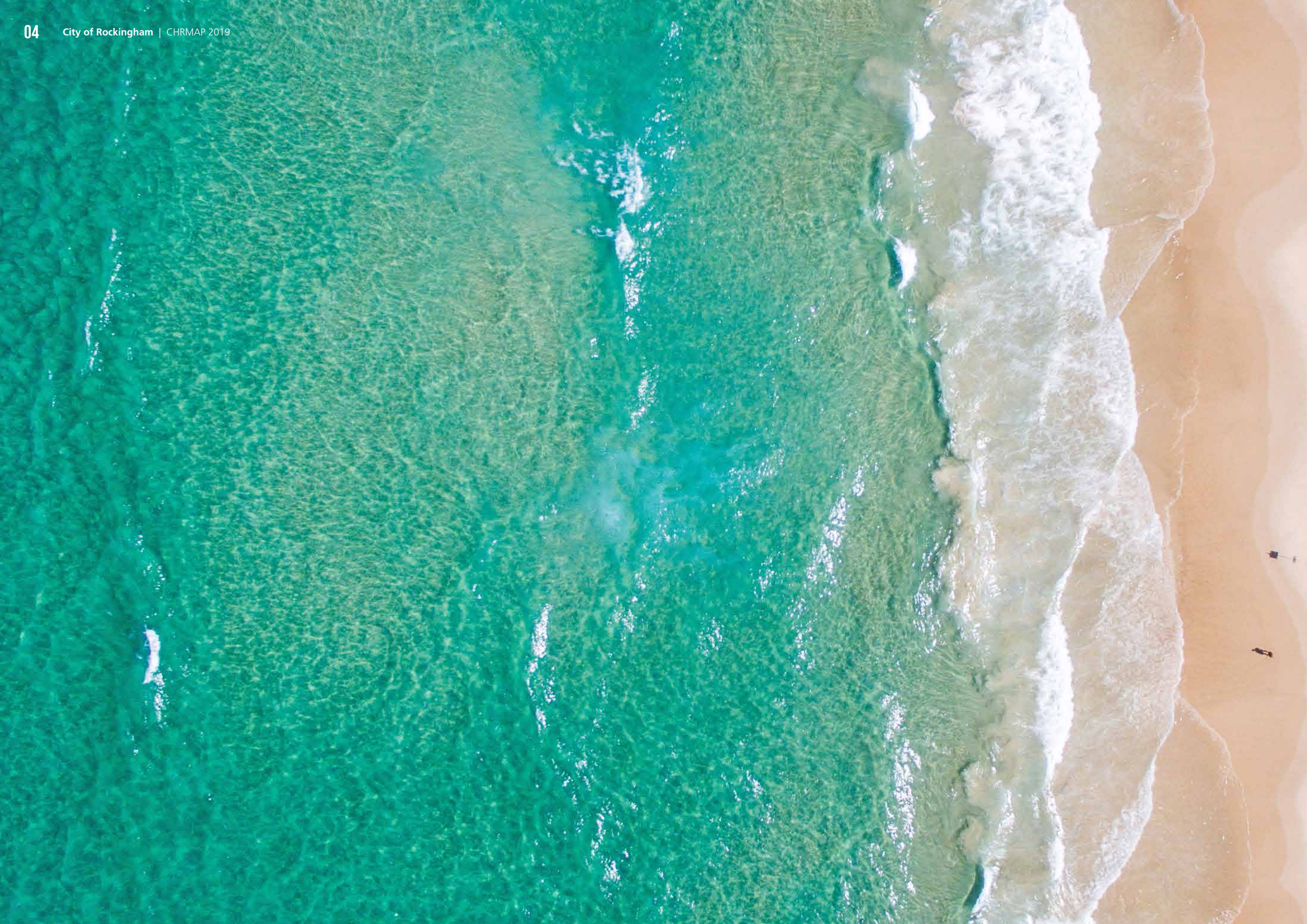
## Will it affect my insurance?

The impact on insurance premiums when a lot is identified as potentially vulnerable to coastal hazards is unclear. Insurance premiums are determined by insurance providers not the City.

## Will it affect my property values?

Property values are determined by the property market. As there are numerous factors affecting property values, the potential impact of identifying that a lot may be vulnerable to coastal hazards over the next 100 years is not readily ascertained or predicted.





# Contents

# 1 Introduction

The City of Rockingham has over 37 km of coastline. The adjacent land, known as the coastal zone, supports a variety of recreation, conservation, residential and commercial land uses. The coastal zone is highly valued by the community and underpins the City's identity, prosperity and lifestyle. The City's coastal zone is already subject to the impacts of coastal hazards, such as erosion and inundation, and it is expected that the vulnerability of these areas may increase in the future due to the predicted effects of climate change and sea level rise.

This Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) provides a long term view of the potential future coastal hazards for the City, and highlights pathways to adapt to the changing future oceanic and coastal conditions. The CHRMAP aims to ensure the City is well placed to deal with impacts to the coastal zone, if and when those hazards arise.

The CHRMAP process is designed to be ongoing, with regular updates associated with the emergence and collection of new information. Development of the City's CHRMAP has followed the requirements of Western Australian State Planning Policy No. 2.6: State Coastal Planning Policy (SPP2.6) and supporting guideline documents. A summary of the planning context, from a state level to local level, can be viewed in Appendix B.

A coastal hazard assessment was undertaken to determine potential extents of coastal erosion and inundation hazards over future planning timeframes to 2110. A risk and vulnerability assessment was then applied according to different sectors, with results highlighting the most vulnerable assets and areas along the City's coastline, for which a more detailed investigation of adaptation options was undertaken.

**Based on the work undertaken to date, this CHRMAP provides a series of recommended actions for implementation before 2030, as well as potential long term adaptation pathways for consideration by current and future generations.**

The CHRMAP acknowledges the challenges associated with managing risks in a dynamic coastal environment, together with the need to balance environmental, social and economic values to ensure the long term sustainable use and management of the City's unique coastline.

## 1.1 Vision

The CHRMAP aims to deliver the following aspiration contained in the City's Strategic Community Plan 2019-2029:

**Aspiration 3**
Plan for Future Generations

**Strategic Objective:**
Climate change adaptation

*Acknowledge and understand the impacts of climate change, and identify actions to mitigate and adapt to those impacts.*

## 1.2 Purpose

The purpose of the CHRMAP is to provide a framework for adapting to coastal hazards over the next 100 years, while prioritising adaptation management actions over the next 10 years.

## 1.3 Objectives

The CHRMAP is driven by the following overarching objectives:

- Ensure that development and the location of coastal facilities takes into account coastal processes, landform stability, coastal hazards, climate change and biophysical criteria;
- Guide the identification of appropriate areas for the sustainable use of the coast for housing, tourism, recreation, ocean access, maritime industry, commercial and other activities;
- Provide for public coastal foreshore reserves on the coast and ensure access to them; and
- Protect, conserve and enhance coastal zone values, particularly in areas of landscape, biodiversity and ecosystem integrity, indigenous and cultural significance.

Note: there is no legal obligation on the State or Local Governments to either protect public and private assets within the coastal hazard zone, or to compensate for any losses incurred due to coastal hazards.

## 1.4 Study area

The entire City of Rockingham coastline is included in the CHRMAP, from the City of Kwinana boundary in the north, to the City of Mandurah boundary in the south. The study area encompasses sediment cells in adjoining coastal areas to ensure effective consideration of coastal processes. The area has been divided into the following sectors for the purpose of defining detail at an appropriate scale for assessment and management:

- **Sector 1:** Municipal Boundary (North) to Wanliss Street
- **Sector 2A:** Wanliss Street to Garden Island Causeway
- **Sector 2B:** Garden Island Causeway to Boundary Road
- **Sector 3:** Boundary Road to Shelton Street
- **Sector 4A:** Shelton Street to Bayeux Avenue
- **Sector 4B:** Bayeux Avenue to Becher Point
- **Sector 5:** Becher Point to Turtles Bend
- **Sector 6:** Turtles Bend to Municipal Boundary (South)

The CHRMAP includes all areas of the coastline, not only those under management by the City, to ensure future adaptation pathways are considered in a holistic context. The relevant stakeholders, including Water Corporation, Department of Biodiversity Conservation and Attractions, and the Department of Defence, have been consulted through development of this CHRMAP.

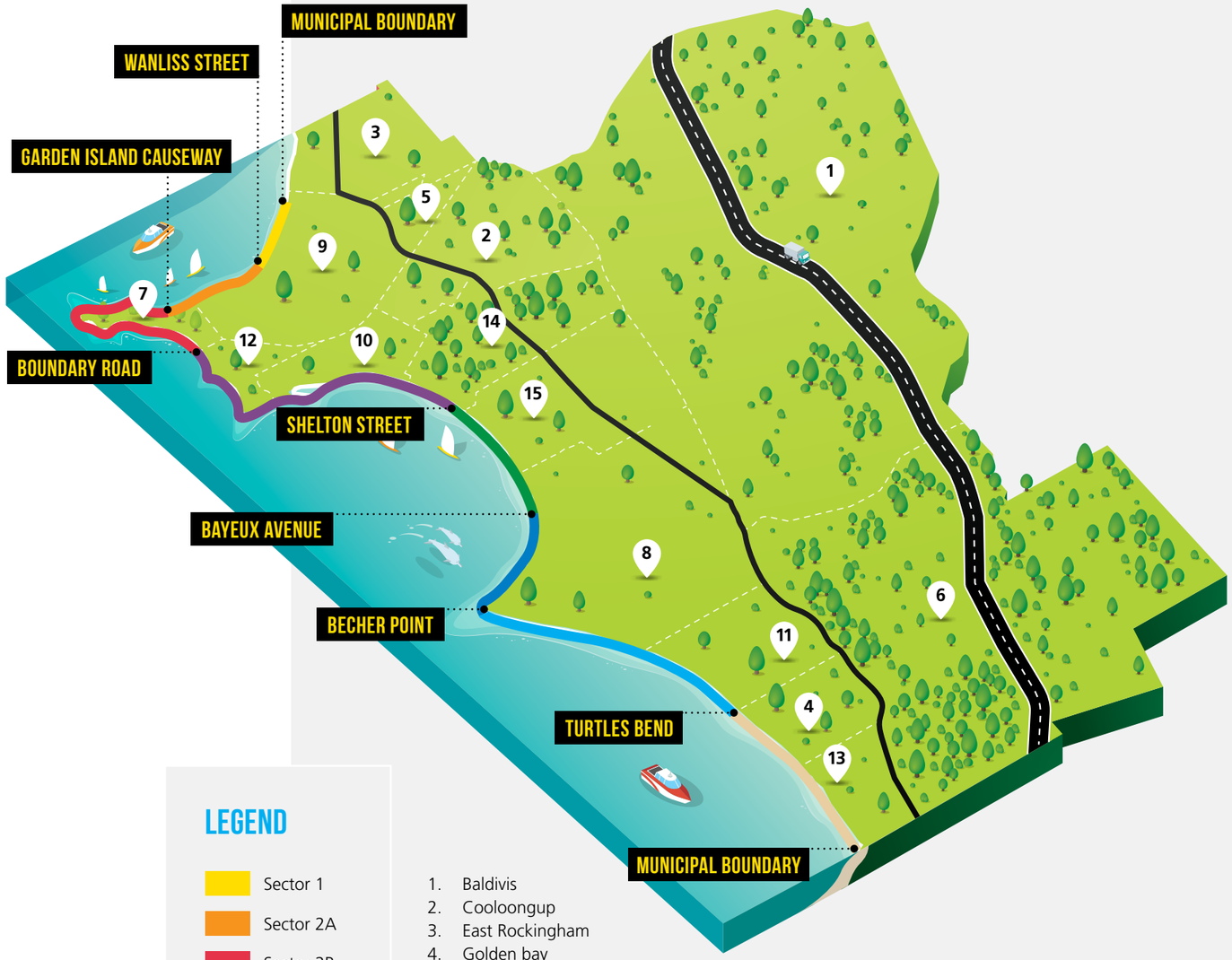
## 1.5 Assets and values

For the purpose of the CHRMAP, assets are defined as:

- natural features such as beaches and natural vegetation;
- buildings and other structures (houses and commercial buildings);
- infrastructure relating to drainage, water and sewerage;
- roads, paths and walkways; and
- coastal structures, such as jetties, boat ramps, seawalls and groynes.

As defined in the Australian Standard for Climate change adaptation for settlements and infrastructure – A risk based approach (AS 5334-2013), an asset's value can be tangible or intangible, financial or non-financial. Examples of non-tangible assets include ecological function and coastal views.

The value of an asset also includes consideration of risks and liabilities, and can be positive or negative at different stages of the asset's life. Values in the context of the CHRMAP further encompass the economic, social (including heritage) and environmental values of the coastal area.




LEGEND

- Sector 1
- Sector 2A
- Sector 2B
- Sector 3
- Sector 4A
- Sector 4B
- Sector 5
- Sector6

1. Baldivis
2. Cooloongup
3. East Rockingham
4. Golden bay
5. Hillman
6. Karnup
7. Point Peron
8. Port Kennedy
9. Rockingham
10. Safety Bay
11. Secret Harbour
12. Shoalwater
13. Singeton
14. Waikiki
15. Warnbro


# Existing environment

## 2.1 Climate

The south west of Western Australia has a Mediterranean climate with hot, dry summers and cool, wet winters. Mean daily maximum temperatures vary from 30˚C in summer and 18˚C in winter. The mean annual rainfall is approximately 730 mm, with most falling from May through to October.

## 2.2 Geology and landform

The City is situated on the Swan Coastal Plain bioregion, which is a long coastal strip that extends from Dunsborough in the south to Gingin in the north.

The area is dominated by the Quindalup dune system, which is a relatively recent landform characterised by a series of low sand dunes made up of marine sands and Aeolian (windblown) soils. The Quindalup dunes are underlain by the Safety Bay sand formation which comprises calcareous soils derived from Tamala limestone (Semeniuk 1989).

For the majority of the Swan Coastal Plain, the Quindalup dune system occurs as a thin stretch adjacent to the ocean; however within the City, the dunes form a wide plain known as the Rockingham – Becher Plain (Semeniuk 1989). This plain consists of a series of multiple, parallel, linear sandridges that are stranded former beach ridges, providing an important example of Holocene sedimentation and stratigraphic evolution.

The City's coastal environment has site elevations ranging from 0 m to 20 m Australian Height Datum (AHD), with higher dunes generally found in the Point Peron area (up to 10 m), Waikiki (up to 20 m), Warnbro (up to 15 m), Port Kennedy (up to 15 m), and Secret Harbour (up to 12 m).

## 2.3 Hydrology

No natural drainage lines or wetland areas occur within the foreshore. However, the Becher Point Wetlands, an internationally significant Ramsar site, is located in close proximity. Lake Richmond also occurs in proximity to the coast, supporting two endangered Threatened Ecological Communities.

Groundwater in the region comprises unconfined, semi-confined and confined aquifers that exist as separate layered systems. The aquifers, in order of increasing depth, include:

- The Superficial and Rockingham Sand Aquifers (unconfined)
- The Leederville Aquifer (semi-confined to confined)
- The Yarragadee Aquifer (confined)

## 2.4 Coastal processes

The geomorphological complexity of the City's coastline supports significant biological diversity and a range of recreational opportunities, encompassing highly unique stretches of coastline within the Cockburn Sound, Warnbro Sound and Shoalwater Islands Marine Park. Situated along the coast is a chain of islands, offshore ridges and depressions, which extend from Garden Island in the north to Long Point in the south, providing protection from swell and limiting offshore sediment feeds, resulting in low energy beaches. Conversely, the beaches south of Long Point are high energy as they are not protected by offshore geomorphology and are therefore exposed to significantly more swell.

A detailed understanding of coastal processes which effectively considers past, present and predicted future shoreline change is critical to effective coastal planning and management.

At varying intensities and magnitudes, the interaction of the following key coastal processes impact on coastal landforms and shoreline movement.

**2.4.1 Wind**

The nature of local seas, particularly in sheltered areas like Warnbro and Cockburn Sounds, are significantly influenced by the speed, direction and duration of wind. In the summer months, winds are characterised by a dominant sea breeze, with strong south to south-westerlies which can result in significant longshore movement of sediment.

Sea breezes are generated because land heats up faster than the ocean, resulting in a significant difference between land and sea temperatures in summer, particularly in the afternoon when solar radiation is at its maximum.

During the day, air over the land becomes warm and rises, resulting in an area of low pressure. This air then moves out toward the ocean where the temperature is lower. As the air cools it sinks, resulting in an area of high pressure over the water. The air then moves from the high pressure area over the ocean to the low pressure area over land and it is this movement which is known as the sea breeze. The strength of a sea breeze is therefore dependent on the difference in land and sea temperature.

In winter, north-westerly winds dominate due to the movement of low pressure systems. While strong, these winds generally result in less sediment movement than the summer winds as the duration is shorter and the sand is usually wet.

Ultimately, the winds which have the most significant impact on nearshore coastal processes are those with extreme speed and these can occur in both summer and winter (WAPC, 2008).

**2.4.2 Tides**

Tides are caused by the gravitational pull of the sun and moon on the earth. When the sun and moon are aligned, the tidal bulge is large and this is known as a spring tide. When the sun and moon are perpendicular, the tidal bulge is small and this is known as a neap tide.

The tidal environment in Rockingham is known as microtidal, with a range of less than 2 m between high and low tides. Tides in the region are predominantly diurnal in form, with one high and low tide each day, although semidiurnal components do occur during certain lunar phases resulting in two high and two low tides per day.

There are a range of other tidal cycles which also influence sea level due to the orbit of the moon, including the 18.6 year nodal cycle and 8.8 year cycle of lunar perigee.

**2.4.3 Waves**

In the south west of Western Australia, swell is primarily generated by large storm systems over the Indian Ocean or Southern Ocean. The direction of swell varies seasonally, from south/southwest in summer to west/south-west in winter. Within the City, the coastal areas south of Becher Point are exposed to the most wave energy.

North of Becher Point, the swell refracts around the series of islands, offshore ridges and depressions which extend north to Garden Island. This refraction results in varying energy zones and levels of sediment deposition.

**2.4.4 Currents**

The marine ecology in Western Australia is predominantly driven by the Leeuwin Current, which travels south along the continental shelf transporting warm water from the north. Closer to shore, localised currents caused by winds and tides are responsible for the longshore transport of sediment and are therefore a key consideration for coastal planning.

These currents can result in a range of erosion or accretion impacts along the shore. The level of these impacts is dependent on a number of factors, including high and low energy zones in the water column and interaction with other coastal processes.

**2.4.5 Sea level**

While tides cause small, predictable changes in sea level, storm surge can also result in short term sea level rises associated with strong winds and barometric pressure changes. In particular, strong winds generate high steep waves which erode higher sections of beach which are not typically vulnerable. The level of beach impact can be substantial, particularly if storm events occur during high tide. Overall, the impact on beach profile is dependent on the magnitude, intensity and duration of the associated storm system.

As previously mentioned, the beaches of the Warnbro and Cockburn Sounds are largely protected from offshore wave energy by a chain of islands and offshore reef and therefore an increase in sea level could enable the transfer of more wave energy over the reef and into the nearshore environment.

This wave energy can have a significant impact on the coast particularly when combined with strong winds as result of storm surge or sea breeze, further illustrating the potential consequence of interaction between coastal processes.

When looking at sea level, it is important to consider other tidal cycles. For example, the next high point in the nodal cycle (18.6 years) will occur in 2025. If storm events occur around that time, it is possible that they may result in more damage as the sea levels will be higher. Conversely, a severe storm may cause less damage if it were to occur at the low point of that cycle as sea levels will be lower.

# 3 Why does the City need a CHRMAP?

Globally, mean sea level has risen since the 19th century and is predicted to continue to rise, at an increasing rate, through the 21st century bringing changes to the Western Australian (WA) coastline over the coming decades.

Changes to mean sea level over the past century have been observed for the coastline adjacent to the Perth Metropolitan Area. Under State Planning Policy 2.6, the City is required to consider a projected sea level rise of 0.9m over the next 100 years.

For low lying sandy coastlines such as the City's, increases in local mean sea level generally result in shoreline recession, with the rule of thumb being that a 1 cm rise in sea level will result in the shoreline moving 1 m further inland (Figure 1). As such, the projected 0.9m rise in sea level could have significant impacts on the City's coastal zone in the future.

Long term projected increases in mean sea level have the potential to exacerbate existing coastal processes, particularly when coupled with a predicted increase in storm frequency and severity. As such, all levels of government are putting measures in place to ensure that communities understand the risks to values and assets on the coast, with a plan to adapt over time.

While the scientific community has established that human-induced climate change is occurring, uncertainty remains about the magnitude and extent of the impacts from these changes. Despite the uncertainty, early consideration of coastal hazards and the adaptation and management of appropriate planning responses is important to ensure economic, environmental and social objectives are achieved.

National and international coastal planning practices are increasingly adopting a risk management approach to deal with the potential adverse impacts of coastal hazards. This ensures that coastal hazards are appropriately factored into decision-making processes for sustainable land use and development in the coastal zone.

Given our coastline is already subject to the impacts of coastal hazards (Figure 2), it is critical that the City has a plan in place irrespective of whether the projected sea level rise of 0.9m is realised.

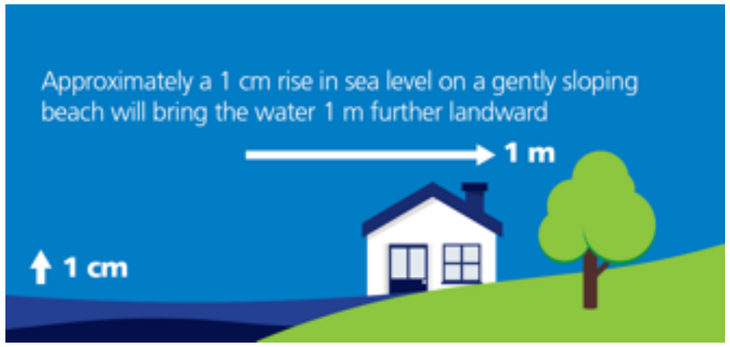



*Figure 1 Generalised impact of sea level rise on low lying sandy coastlines (CoastAdapt, 2017)*

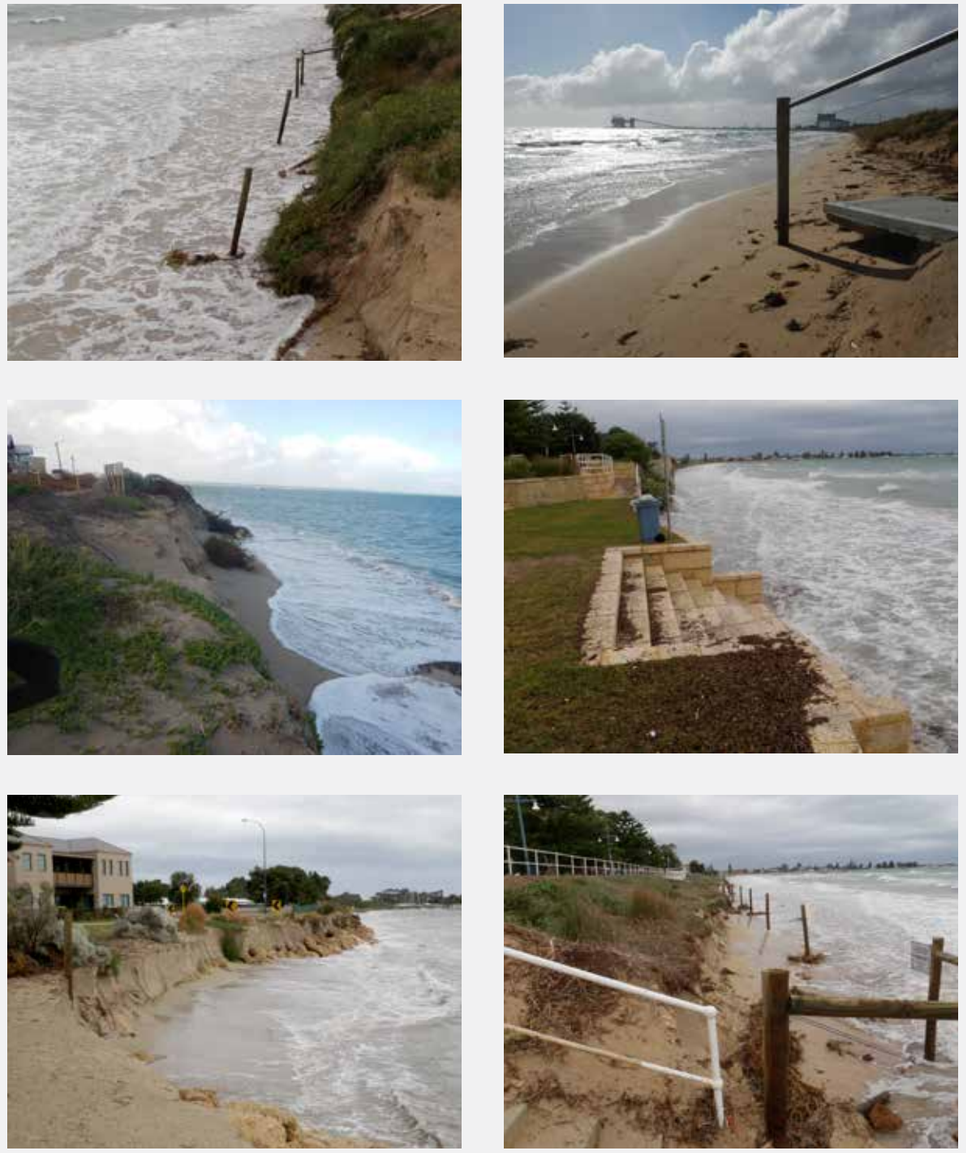


*Figure 2 Impacts of coastal hazards already experienced in the City*

## 3.1 Community and stakeholder engagement

Community input is the cornerstone of an effective CHRMAP process, in order to understand how the community uses and values the coast, and how it should be managed in the future.

**Historical uses of the City's coastline**

*Rockingham Jetty*

*Late 1800's*

*Late 1800's*

**Palm Beach Jetty**

Community consultation has underpinned the development of this CHRMAP, being undertaken at key milestones as shown below.

**CHRMAP Part 1**
Hazard assessment

↓

Community Coastal Values Survey

↓

**CHRMAP Part 2**
Risk assessment and potential adaptation options

↓

Public Information Sessions and Adaption Workshops

↓

**CHRMAP Part 3**
Draft Adaption Plan

↓

Draft Adaptation Plan released for public comment

↓

**CHRMAP Part 4**
Final Adaptation Plan

### 3.1.1 Community Coastal Values Survey

Community consultation for the City's CHRMAP began in August 2017, with a Community Coastal Values Survey to better understand how our community uses and values the coast.

A link to the survey was available for the public to access via the City's Facebook page and website. The survey was also mailed out to a random selection of 5,000 homes, with a reasonably even distribution across suburbs.

Both methods of surveying were utilised for the consultation to gauge an accurate cross section of the City's demographic, not only those who were online. A total of 1,040 responses were received.

Furthermore, 743 community members requested their names be placed on a stakeholder register to be notified of future events relating to the CHRMAP project.

The results were centred on aspects such as demographics, proximity to the coast, favoured coastal attributes, the average amount of time per visit, the benefits of beach visits, modes of transport, boat ramps, priority aspects to protect and recommendations for improvement.

Together these elements highlight the varying character of beaches along the City's coastline and provide direction in planning for the future use and management of these areas, with the key findings being:

- 66% of respondents with homes within 1 km of the beach noted that living close to the beach was extremely important to them
- Rockingham Beach was the most frequently visited beach among respondents, with many residents travelling over 10 km to visit this beach.
- Residents tend to prefer beaches that are close to home, have an attractive natural setting and are easy to access. Other important deciding factors include environmental qualities (such as clear water and vegetated dunes), facilities (such as BBQs, toilets, seating and playgrounds), being able to access sandy beach, parks and grassed areas, being close to cafes and restaurants, and being able to enjoy shaded areas.
- The natural setting and environmental qualities (clear water/vegetated dunes) were the most significant drawcard for those choosing to visit Shoalwater Bay, whereas the facilities, grassed areas and proximity to cafes and restaurants was the biggest drawcard for those visiting Rockingham Beach.
- Most respondents visit their preferred beach at least once a week.
- Overall, walking, running or exercise was the most popular activity at the beach.
- In terms of the benefits to lifestyle, health and wellbeing, visiting the beach is perceived as most important for mental and emotional health as well as physical fitness.
- Approximately half of respondents feel that erosion is the same as it has always been. This perception is most common among those who frequently visit Mangles Bay, Waikiki and East Rockingham Horse Beach. Around 37% of respondents feel that erosion of beaches is getting worse. Erosion is a greater concern for Golden Bay and Shoalwater Bay beach users. 12% of respondents feel that erosion is not as bad as it used to be.
- Residents feel it is most important to protect the environmental qualities of local beaches, such as preserving water quality and dune vegetation. This perception is strongest among those who most frequently visit Golden Bay, Port Kennedy and Singleton beaches.
- The second highest priority is protecting sandy areas of the beach. This is more important for users of Golden Bay, Warnbro, Waikiki and East Rockingham Horse Beach.

### 3.1.2 Coastal Adaptation Workshop and Information Evening

In August 2018, following completion of the coastal hazard modelling and risk assessment, the City commenced the second phase of community consultation with an Information Evening and Coastal Adaptation Workshop.

Emails and letters were sent to all 743 community members on the project stakeholder register with an invitation to attend the walk-in Information Evening and/or the two hour Coastal Adaptation Workshop. These events were also advertised with notices in the local newspaper and in libraries, as well as online through RockPort (the City's online portal), the City's website and social media.

Thirteen people attended the Information Evening and 30 people attended the Coastal Adaptation Workshop.

The workshop centred around a presentation on potential coastal hazards, adaptation options and costs. In the context of this information, 30 residents participated in a number of activities and engaged in valuable discussion. Key questions for discussion at the workshop included:

- Generally speaking, would you favour 'protect' or 'managed retreat', and why?
- If you could only keep three stretches of sandy beach (each 600 m long) which would they be?
- If you could only install three seawalls (each 600 m long) which areas of the coastline would you choose and why?
- Who do you think should pay to manage coastal hazards in the future?
- Do you think residents on the coast should pay more than those who live inland? Or should all residents pay equally?
- Hypothetically, how much would you be willing to pay to manage coastal hazards on top of your rates? i.e. $20, $50, $100
- Do you think it is reasonable to start putting money in a cash reserve now? Why?

The various responses and feedback provided in response to these question are detailed in Appendix D. A report summarising discussions from the Coastal Adaptation Workshop was circulated to attendees after the event to ensure all views had been appropriately captured. In view of this, feedback received on the workshop and the Summary Report was generally positive.

The responses received, together with ephemeral feedback obtained from the workshop, greatly assisted in development of this CHRMAP and the identification of priority areas for long term protection and/or managed retreat.

### 3.1.3 External stakeholders

The City engaged with the following government and external stakeholders in preparation of this CHRMAP and will continue to liaise with the relevant agencies as required, to ensure coastal hazard management and planning is coordinated within the municipality and across the region.

- Department of Biodiversity, Conservation and Attractions
- Department of Defence
- Department of Transport
- Department of Planning, Lands and Heritage
- Water Corporation
- Peron Naturaliste Partnership
- Various local governments on the Swan Coastal Plain

# 4 What are coastal hazards and how are they estimated?

## 4.1 Coastal hazard modelling

Coastal hazards are modelled as per the parameters outlined in SPP 2.6, which stipulates allowances for storm events, historic shoreline movements and future sea level rise. Hazards were assessed relative to projected sea level rise for the planning timeframes of 2017, 2030, 2070 and 2110.

**Storm events are characterised based on an average recurrence interval (ARI). The recurrence interval is a statistical probability of that event occurring, so:**

A **500 year** ARI storm event has a 0.2% chance of occurring in any given year.

A **100 year** ARI storm event has a 1% chance of occurring in any given year.

A **50 year** ARI storm event has a 2% chance of occurring in any given year.

All CHRMAP maps were prepared by certified engineers. This section provides a summary of the methods used, however, the detailed technical methodology can be viewed in the CHRMAP Technical Assessment Report (Cardno 2018).

### 4.1.1 Erosion

**Erosion is when sediment is transported away by waves, wind and currents, reducing the size of sandy beach.**

*Figure 3 Example of erosion at Hymus Street, Rockingham*

Coastal erosion hazards have been estimated using an allowance for the current risk of storm erosion based on a 100-year average recurrence interval storm event (S1 erosion), an allowance for future erosion based on historic shoreline movement trends (S2 erosion), an allowance for erosion associated with future sea level rise (S3 erosion) and an additional factor of uncertainty. These components were combined to derive coastal erosion hazard extents at each of the planning timeframes.

Existing coastal protection structures were not factored into the modelling for coastal erosion for the various planning timeframes. Rather, the presence, condition and design life of existing coastal protection structures was considered as part of the risk assessment.

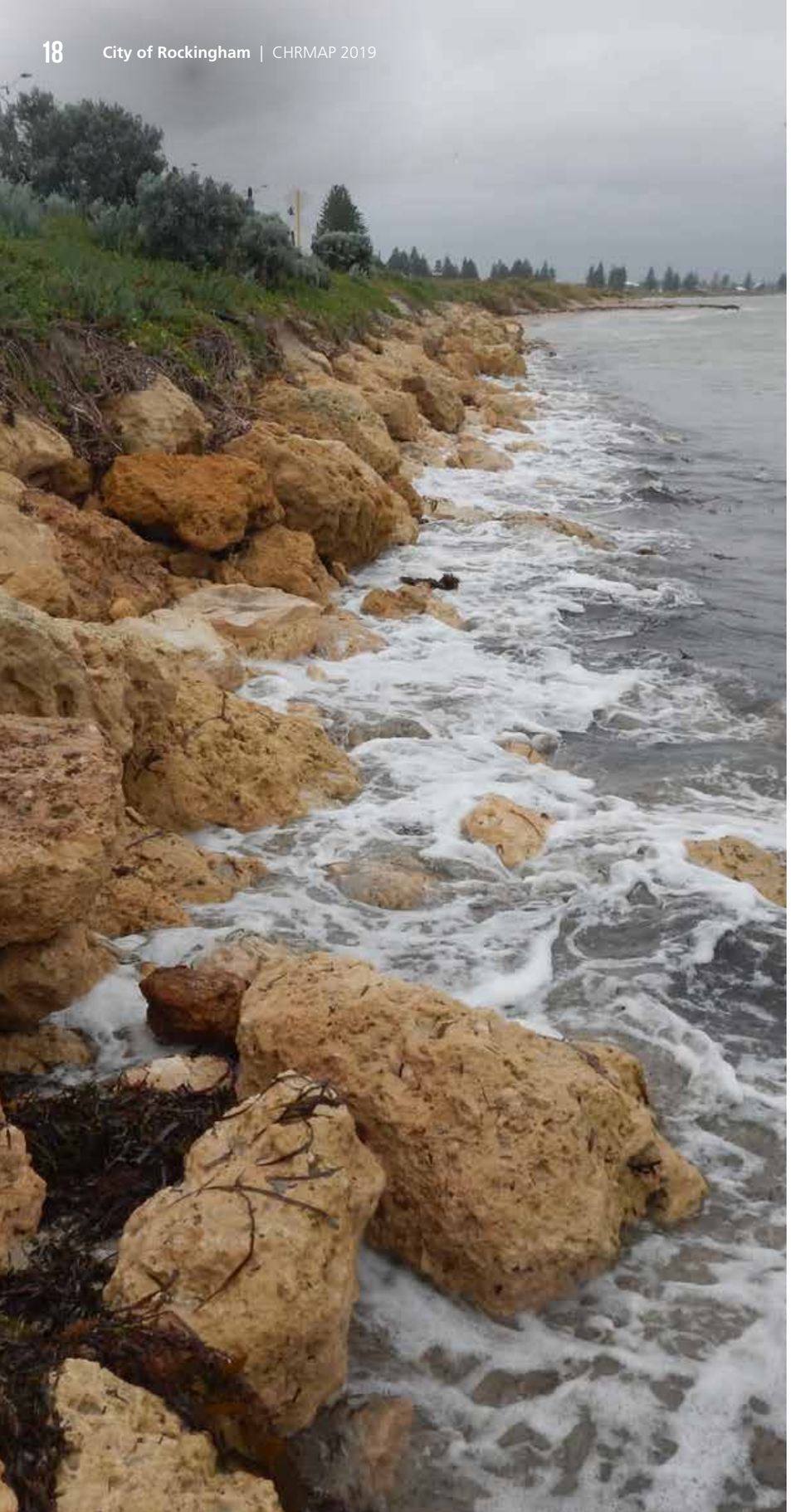
### 4.1.2 Inundation

**Inundation is the temporary flooding of a portion of land with ocean water, particularly during storm events or high tides.**

SPP 2.6 requires coastal inundation hazards to be estimated for a 500-year ARI water level for each of the planning timeframes. This assessment involved the estimation of coastal inundation water levels based on a combination of estimated ARI water levels from tide gauge measurements, an estimate of wave setup along the City's coastline and an allowance for predicted sea level rise over the 100-year planning timeframe.

Further to this, inundation was also estimated for a 1, 10, 50 and 100 year ARI, to provide an indication of potential inundation risks for more storm events with a greater likelihood of occurring, together with the depth and duration of inundation. Although not required under SPP 2.6, this was done to better understand potential impacts and inform risk based decision making. For example, the community may tolerate the risk associated with a 500 year ARI event, but do not tolerate the risk associated with more frequent 1 year or 10 year ARI events.

*Figure 4 Example of inundation in Florida, USA*



#### 4.1.3 Groundwater rise

It is generally accepted that sea level rise will cause groundwater levels adjacent to the coast to also increase. This can have a number of impacts including:

- Seawater intrusion (migration inland of the freshwater/saline water interface);
- Increased salinity in groundwater dependent ecosystems (such as Lake Richmond);
- Impacts on drainage infrastructure; and
- Contamination of production bores.

A macro-scale estimate of the potential rise in groundwater due to sea level rise to 2110 was completed and mapped. This was undertaken using the Department of Water and Environmental Regulation's maximum groundwater level contours. The projected sea level rise of 0.9m was then added to the groundwater levels to provide an estimate of groundwater elevations in 2110.

#### 4.1.4 Stormwater drainage assessment

An assessment of the City's stormwater drainage infrastructure, which may be impacted by coastal erosion and inundation, was completed based on the estimated inundation and erosion hazard areas. This included physical surveying of pits and pipes estimated to be affected by 2070, based on a typical 50 year asset replacement lifespan of drainage infrastructure.

## 4.2 How are the risks assessed?

To provide a transparent and logical basis for determining adaptation planning priorities, a risk assessment was undertaken based on the Australian Standard Guideline Climate change adaptation for settlements and infrastructure – A risk based approach (AS5334-2013), and the CHRMAP guidelines (WAPC, 2019).

Risk was assessed in relation to the:

- Likelihood of a hazard occurring
- Consequence if it were to occur
- Capacity for the assets to adapt and cope with the impacts of coastal hazards

Likelihood was assigned using the results of the coastal hazard assessment. Consequence ratings were informed by estimated economic values and additional values determined through community consultation.

Risk is considered to be the combination of likelihood and consequence, with consideration of adaptive capacity determining an asset's overall vulnerability in the face of coastal hazards.

Vulnerability has a specific meaning in the context of risk-based approaches to climate change adaptations, in accordance with the Australian Standard (AS 5334-2013) and SPP2.6, which defines vulnerability as:

"the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity. Systems that are highly exposed, sensitive and less able to adapt are vulnerable"

Values in the context of the CHRMAP further encompass the economic, social (including heritage) and environmental values of the coastal area.

A detailed explanation of the methods and criteria used in the risk assessment can be viewed in the CHRMAP Technical Assessment Report.

#### 4.2.1 Existing coastal protection structures

The risk assessment assumes that existing coastal protection structures (i.e. buried sea walls), will not perform a function beyond their design life. These structures typically have a 50 year design life and there is no guarantee that they will be repaired or reinstated in the future. Further, SPP2.6 has a preference against the construction of new coastal protection structures and retrofit of existing structures. For the purpose of estimating worst case scenario coastal hazards, it is assumed that no other adaptation intervention will occur.

## 4.3 What could be impacted?

**COLLECTIVELY, THE TOTAL VALUE OF ASSETS POTENTIALLY IMPACTED BY COASTAL HAZARDS, BOTH EROSION AND INUNDATION, TO 2110 IS OVER $1.9 BILLION AND INCLUDES:**

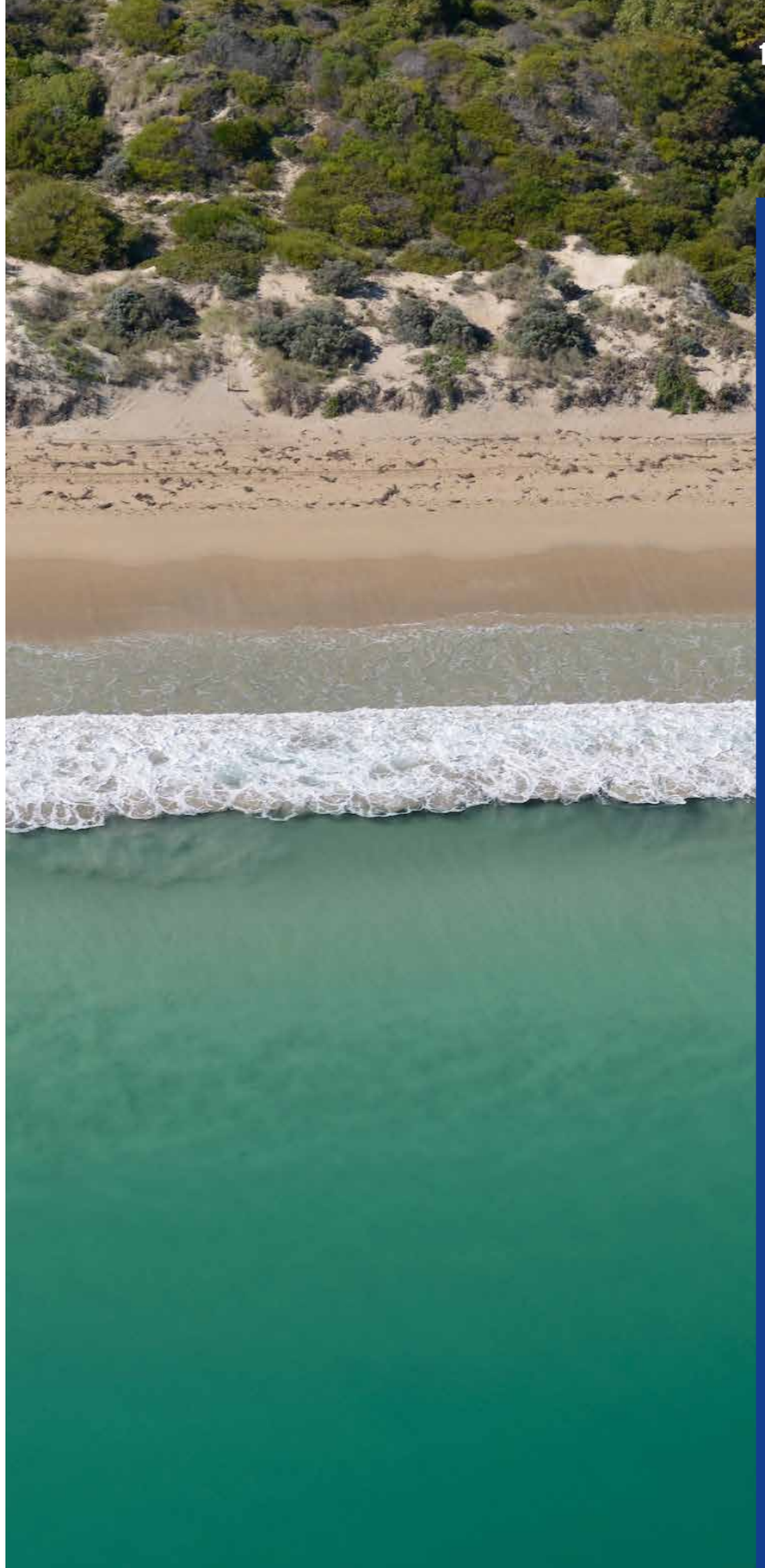
- residential properties: 847 potentially at risk from erosion, 4,591 potentially at risk from inundation
- coastal dune vegetation
- usable sandy beaches
- parks
- carparks
- dual use paths
- roads
- stormwater pits
- stormwater pipes
- underground storage
- drainage channels
- lakes (including Lake Richmond)
- groundwater bores
- commercial areas
- boat launching facilities
- jetty abutments

The impacts from coastal erosion are typically much more damaging than the impacts of inundation. For example, if a carpark is temporarily inundated with salt water during a storm event, the water will subside and may not result in structural damage. If a carpark is eroded during a storm event it is likely to require significant repair or complete replacement. As such, the potential impacts of erosion and inundation have been considered separately.

In terms of risk, coastal erosion hazards generally lead to the highest vulnerability in the short-term, due to their greater capacity to damage assets. The risk of coastal inundation, however, increases substantially over future planning timeframes and extends across large areas of low-lying land along the City's coastline.

**In viewing the erosion and inundation hazard maps, it is important to note that these are based on a suite of assumptions and have varying degrees of uncertainty, which may influence the likelihood of the predicted extent of erosion or inundation occurring at each planning horizon.**

**SPP 2.6 requires revision of the CHRMAP every 10 years (or sooner if required), including an update of hazard estimates using the most up to date information, the findings of specialist investigations undertaken, changes to projected sea level rise, climate change effects and any changes to the use of the foreshore.**



# 5 Which areas of the City could be impacted by erosion?

**Erosion is when sediment is transported away by waves, wind and currents, reducing the size of sandy beach.**

- The total value of assets potentially impacted by erosion to 2110 is estimated to be around $530 million.
- While there are coastal erosion risks along the length of the City's coastline, the following areas have significant hazards:
  - almost the entire shorelines of Sectors 1, 2, 3 and 4 (East Rockingham around to Port Kennedy); and
  - the existing residential area adjacent to the Port Kennedy Boat Ramp (Sector 4).

A detailed list of assets vulnerable within each sector is presented alongside each Sector Hazard Map.

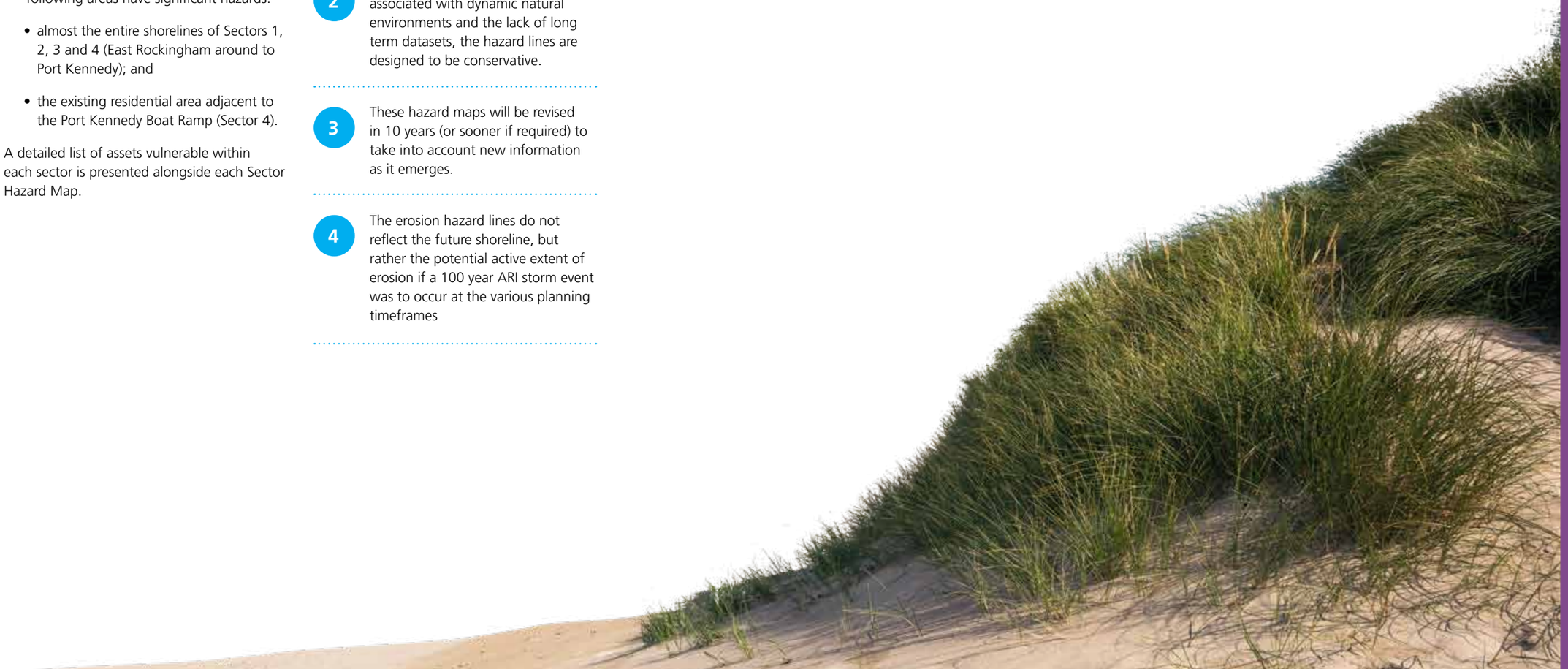
In viewing these maps, keep in mind that:

1. The erosion hazard lines are based on a suite of assumptions and have varying degrees of uncertainty, which may influence the likelihood of these impacts being realised at each planning horizon.

2. To account for the uncertainty associated with dynamic natural environments and the lack of long term datasets, the hazard lines are designed to be conservative.

3. These hazard maps will be revised in 10 years (or sooner if required) to take into account new information as it emerges.

4. The erosion hazard lines do not reflect the future shoreline, but rather the potential active extent of erosion if a 100 year ARI storm event was to occur at the various planning timeframes



## 5.1 Sector 1 Municipal Boundary (North) to Wanliss Street

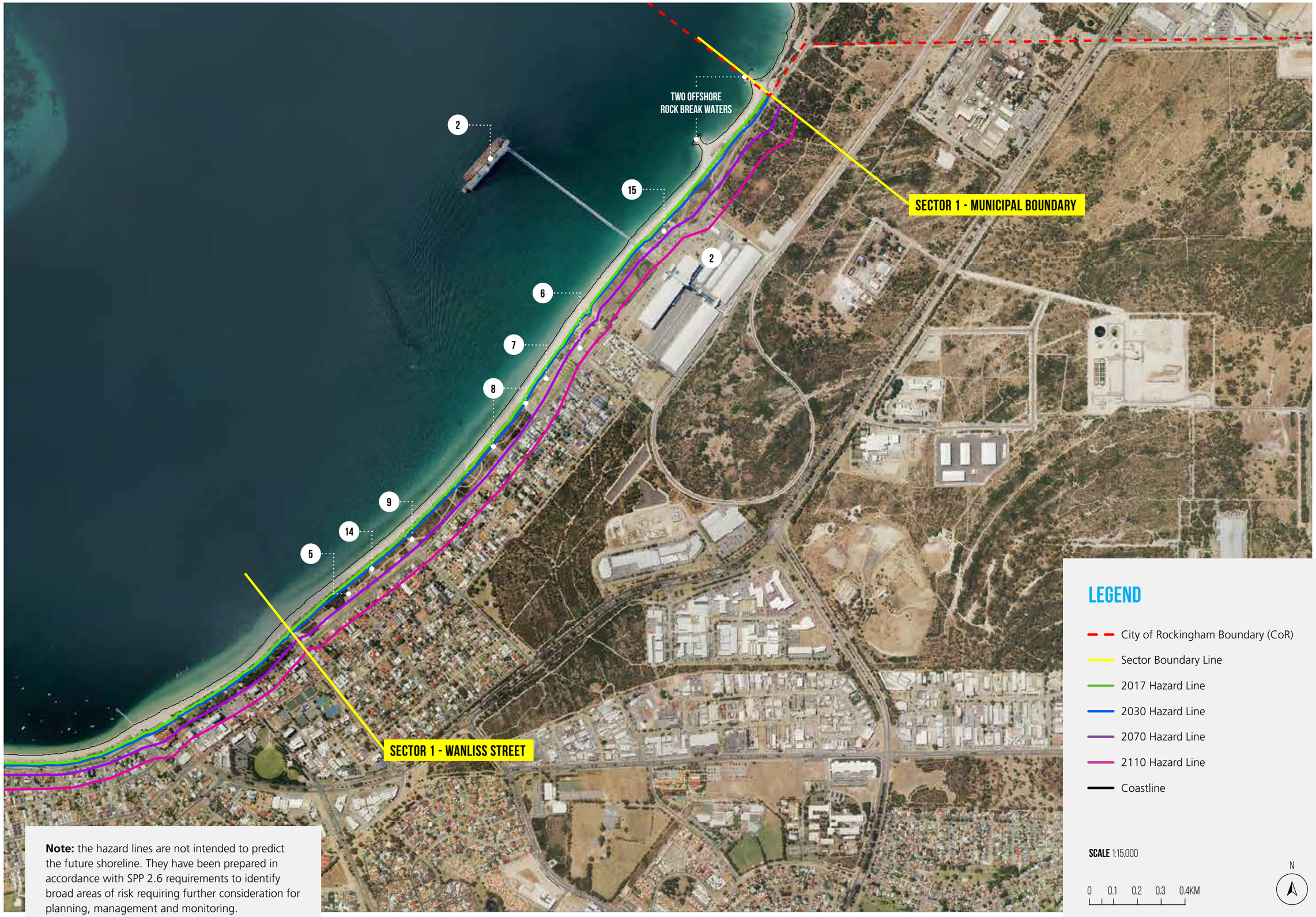
| Existing coastal structures | Year |
|---|---|
| Two offshore breakwaters | 2007 |

Vulnerability of assets to erosion

| Sector 1 | | 2017 | 2030 | 2070 | 2110 |
|---|---|---|---|---|---|
| **Vulnerability** | | | | | |
| 1 | Beach | ● | ● | ● | ● |
| 2 | CBH Kwinana Grain Terminal | ● | ● | ● | ● |
| 3 | Coastal dune/vegetation | ● | ● | ● | ● |
| 4 | Dual use paths | ● | ● | ● | ● |
| 5 | Emerald Park Carpark | ● | ● | ● | ● |
| 6 | Governor Reserve Carpark | ● | ● | ● | ● |
| 7 | Naval Memorial Park | ● | ● | ● | ● |
| 8 | Naval Memorial Park Carpark | ● | ● | ● | ● |
| 9 | Phoebe Hymus Carpark | ● | ● | ● | ● |
| 10 | Pipes | ● | ● | ● | ● |
| 11 | Pits | ● | ● | ● | ● |
| 12 | Residential properties (102) | ● | ● | ● | ● |
| 13 | Road (Rockingham Beach Rd) | ● | ● | ● | ● |
| 14 | Rockingham Foreshore Park | ● | ● | ● | ● |
| 15 | Rockingham Rd Conservation Reserve Carpark | ● | ● | ● | ● |

● Low ● Medium ● High ● Very High

**ESTIMATED TOTAL VALUE OF ASSETS AT RISK BY 2110 IS OVER $37 MILLION.**


**Note:** the hazard lines are not intended to predict the future shoreline. They have been prepared in accordance with SPP 2.6 requirements to identify broad areas of risk requiring further consideration for planning, management and monitoring.

## LEGEND

- City of Rockingham Boundary (CoR)
- Sector Boundary Line
- 2017 Hazard Line
- 2030 Hazard Line
- 2070 Hazard Line
- 2110 Hazard Line
- Coastline

**SCALE** 1:15,000

0 0.1 0.2 0.3 0.4KM

N

## 5.2 Sector 2A Wanliss Street to Garden Island Causeway; and Sector 2B Garden Island Causeway to Boundary Road

*Timeline of coastal protection structures:*

**1944** Original Palm Beach Jetty

**Late 1950s** Original Val Street Jetty

**1971** Garden Island Causeway

**1973** 200 m groyne to west of Garden Island Causeway

**1986** 65 m long 90° groyne extension to west of Garden Island Causeway

**1987** Informal rock seawall west of camp school

**1990** Spur added to groyne west of Garden Island Causeway for sand trap

**2002** Palm Beach West Boat Ramp

**2002** Hymus St Timber Groyne

**2004** Rockingham Foreshore - GSC Seawall

**2007** Val St Jetty extended 40 m

**2009** Palm Beach Jetty

**2010** Palm Beach East Boat Ramp

**2013** GSC Groyne at Point Peron Camp School

**2014** Val St Jetty 0-80 m reconstructed

**2014** Palm Beach Boat Ramp rock armour modified

**ESTIMATED TOTAL VALUE OF ASSETS AT RISK BY 2110 IS OVER $234 MILLION.**

Vulnerability of assets to erosion

| Sector 2 | | 2017 | 2030 | 2070 | 2110 |
|---|---|---|---|---|---|
| **Vulnerability** | | | | | |
| 1 | Alfred Hines Seaside Home | Low | Low | High | Very High |
| 2 | Beach | High | Very High | Very High | Very High |
| 3 | Bell Park | Low | Medium | Very High | Very High |
| 4 | Bell Park Carpark | High | Very High | Very High | Very High |
| 5 | Boat Ramps (Catalpa Park) | Low | Low | High | Very High |
| 6 | Bores | Low | Low | Low | Medium |
| 7 | Catalpa Park | Low | Very High | Very High | Very High |
| 8 | Catalpa Park Carpark | Low | Low | High | High |
| 9 | Churchill Park | Low | Low | Medium | Very High |
| 10 | Coastal/dune vegetation | Low | Medium | Very High | Very High |
| 11 | Commercial area (Railway Tce) | Low | Low | Low | Medium |
| 12 | Commercial area (Rockingham Beach Rd) | Low | Medium | Very High | Very High |
| 13 | Department of Defence Land | Low | Medium | Very High | Very High |
| 14 | DoBCA Managed Land | Medium | High | Very High | Very High |
| 15 | Dual use paths | Low | High | Very High | Very High |
| 16 | Flinders Lane Carpark | Low | Low | Low | Medium |
| 17 | Jetty abutments (Val St and Fisher St) | Medium | High | Very High | Very High |
| 18 | L&S Recreation Centre | Low | Low | Low | Medium |
| 19 | Mangles Bay Fishing Club | Low | Medium | Very High | Very High |
| 20 | Maritime Union of Australia Holiday Camp | Low | Medium | Very High | Very High |
| 21 | Pipes | Low | Low | Low | Medium |
| 22 | Pits | High | Very High | Very High | Very High |
| 23 | Point Peron Boating Facility | Low | Medium | High | Very High |
| 24 | Point Peron Boating Facility Carpark | Low | Low | Low | High |
| 25 | Point Peron Camp School | Low | Medium | Very High | Very High |
| 26 | Point Peron Dive Site Carpark | Medium | High | Very High | Very High |
| 27 | Point Peron Foreshore Carpark (Central) | Low | Medium | Very High | Very High |
| 28 | Point Peron Foreshore Carpark (NE) | Low | Medium | High | Very High |
| 29 | Point Peron Foreshore Carpark (SW) | Low | Low | Low | Medium |
| 30 | Point Peron Wastewater Treatment Plant | Low | Low | Low | High |
| 31 | Railway Terrace Carpark | Low | Low | Low | Very High |
| 32 | Residential properties (157) | Low | Low | High | Very High |
| 33 | Roads | Low | High | Very High | Very High |
| 34 | Rockingham Beach Road Parking | Medium | Medium | High | Very High |
| 35 | Rockingham Naval Club | Low | Medium | Very High | Very High |
| 36 | Rockingham Recreation Centre (Memorial Dr) | Low | Low | Medium | High |
| 37 | Rotary Park | Low | Low | Low | Very High |
| 38 | Samuel Street Carpark | Low | Low | Medium | Very High |
| 39 | The Cruising Yacht Club | Low | Low | High | Very High |
| 40 | The Cruising Yacht Club Carpark | Low | Low | High | High |
| 41 | Underground Storage | Medium | High | Very High | Very High |

Low Medium High Very High

POINT PERON GSC GROYNE

POINT PERON SPUR GROYNE AND SAND TRAP

PRIORITY AREA FOR SHORT TERM COASTAL MANAGEMENT

LIMESTONE SEAWALL AND GSC SCOUR PROTECTION AT VAL ST AND PALM BEACH JETTIES

BURIED GSC SEAWALL 170M NORTH OF FLINDERS LANE

SECTOR 2 - WANLISS STREET

HYMUS STREET TIMBER GROYNE AND ROCK SEAWALL

ROCK PROTECTION AT PALM BEACH BOATRAMPS

KENT STREET

PARKIN STREET

SECTOR 2 - BOUNDARY ROAD

28 25 27 23 24 13 19 29 30 35 18 20 14 36 8 5 1 7 37 17 31 16 4 3 9 11 38 34 39 40 12

## LEGEND

- Sector Boundary Line
- 2017 Hazard Line
- 2030 Hazard Line
- 2070 Hazard Line
- 2110 Hazard Line
- Coastline

**SCALE** 1:15,000

0 0.1 0.2 0.3 0.4KM

N

**Note:** the hazard lines are not intended to predict the future shoreline. They have been prepared in accordance with SPP 2.6 requirements to identify broad areas of risk requiring further consideration for planning, management and monitoring.

## 5.3 Sector 3 Boundary Road to Shelton Street

**2003** South Mersey Point Rock Seawall (200 m long)

**2004** Bent Street Boat Ramp

**2010** Waikiki Rock Seawall

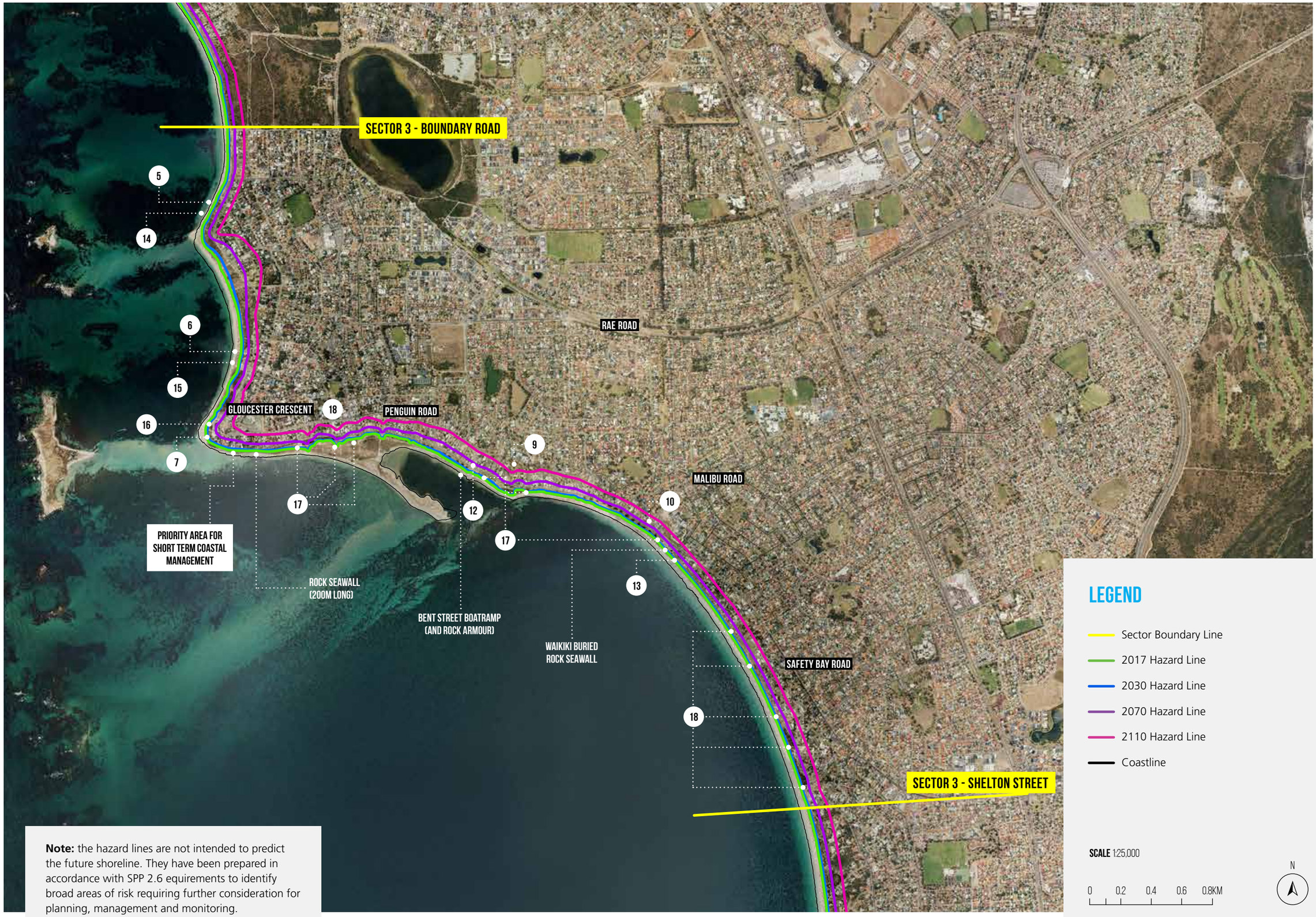
**2015** Bent Street Boat Ramp rock armour modified

Vulnerability of assets to erosion

| Sector 3 | | 2017 | 2030 | 2070 | 2110 |
|---|---|---|---|---|---|
| **Vulnerability** | | | | | |
| 1 | Beach | Low | Medium | Very High | Very High |
| 2 | Coastal/dune vegetation | Low | Low | High | High |
| 3 | Residential properties (520) | Low | Low | Low | Medium |
| 4 | Roads | Medium | Medium | Very High | Very High |
| 5 | Shoalwater Foreshore Park | Low | Medium | Very High | Very High |
| 6 | Lions Park | Low | Low | High | Very High |
| 7 | Mersey Point / Rockingham Wild Encounters | Medium | High | Very High | Very High |
| 8 | Safety Bay Foreshore Park | Low | Medium | Very High | Very High |
| 9 | Noel France Reserve (park) | Medium | High | High | Very High |
| 10 | BP Petrol Station | Low | Low | High | High |
| 11 | Safety Bay Yacht Club | Low | Low | Medium | High |
| 12 | Commercial area (Bent St) | Low | Low | Very High | Very High |
| 13 | Waikiki Foreshore Park | Low | Low | High | High |
| 14 | Shoalwater Foreshore Carpark | Low | Low | Low | Low |
| 15 | Lions Park Carpark | Low | High | Very High | Very High |
| 16 | Mersey Point Carpark | Medium | High | Very High | Very High |
| 17 | Safety Bay Foreshore Carparks (7 total) | Low | Low | Very High | Very High |
| 18 | Waikiki Foreshore Carparks (5 total) | Medium | Medium | High | Very High |
| 19 | Dual use paths | Low | Medium | Very High | Very High |
| 20 | Pipes | Medium | Medium | Very High | Very High |
| 21 | Pits | Low | Medium | Very High | Very High |
| 22 | Bores | Low | Low | Medium | Medium |

Low Medium High Very High

**ESTIMATED TOTAL VALUE OF ASSETS AT RISK BY 2110 IS OVER $193 MILLION.**


## LEGEND

- Sector Boundary Line
- 2017 Hazard Line
- 2030 Hazard Line
- 2070 Hazard Line
- 2110 Hazard Line
- Coastline

**SCALE** 1:25,000

0 0.2 0.4 0.6 0.8KM

N

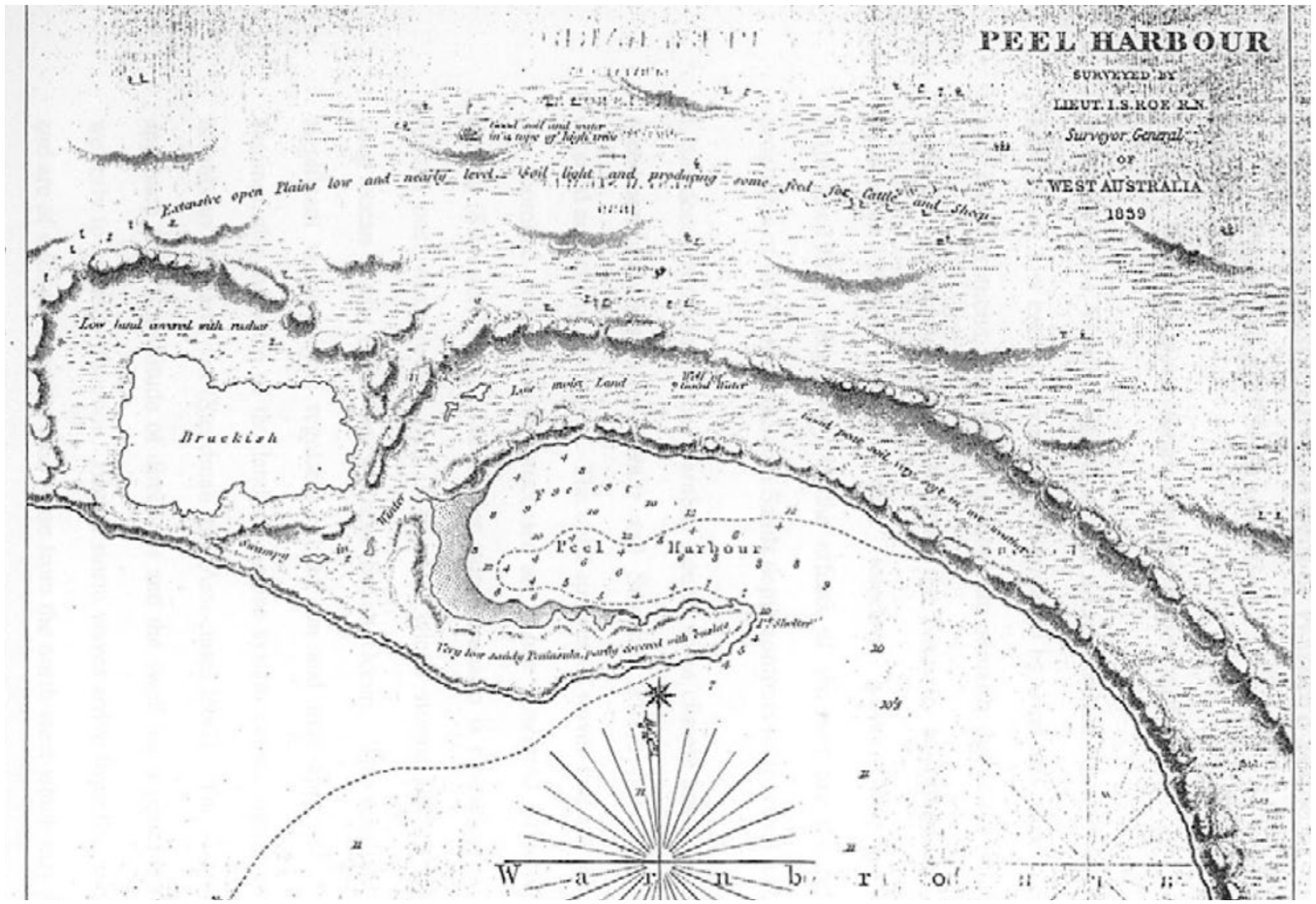
**Note:** the hazard lines are not intended to predict the future shoreline. They have been prepared in accordance with SPP 2.6 equirements to identify broad areas of risk requiring further consideration for planning, management and monitoring.

## Tern Island History

Tern Island is a prominent feature of the City's coastal landscape. Historical surveys of the Warnbro Sound highlight the dynamic nature of sediment transport in the region.

When John Septimus Roe surveyed the area in 1839, he highlighted the Tern Island spit similar to its configuration today and labelled it Peel Harbour.

Currently, it is estimated that Tern Island is accreting by up to 10,000m³ per year, however, given the dynamic nature of this feature, the coastal hazard modelling takes a conservative approach and assumes that the bank will not offer any future protection to landward assets.




*Survey of Peel Harbour by John Septimus Roe in 1839. (Image source: Hollings 2004).*

*Tern Island 1953*

*Tern Island 2015*

*Safety Bay Yacht Club 1950*

*Safety Bay Yacht Club 1950*

## 5.4 Sector 4A Shelton Street to Bayeux Avenue
## Sector 4B Bayeux Avenue to Becher Point

| Existing coastal structures | Year |
|---|---|
| Port Kennedy Boat Ramp | 2010 |

Vulnerability of assets to erosion

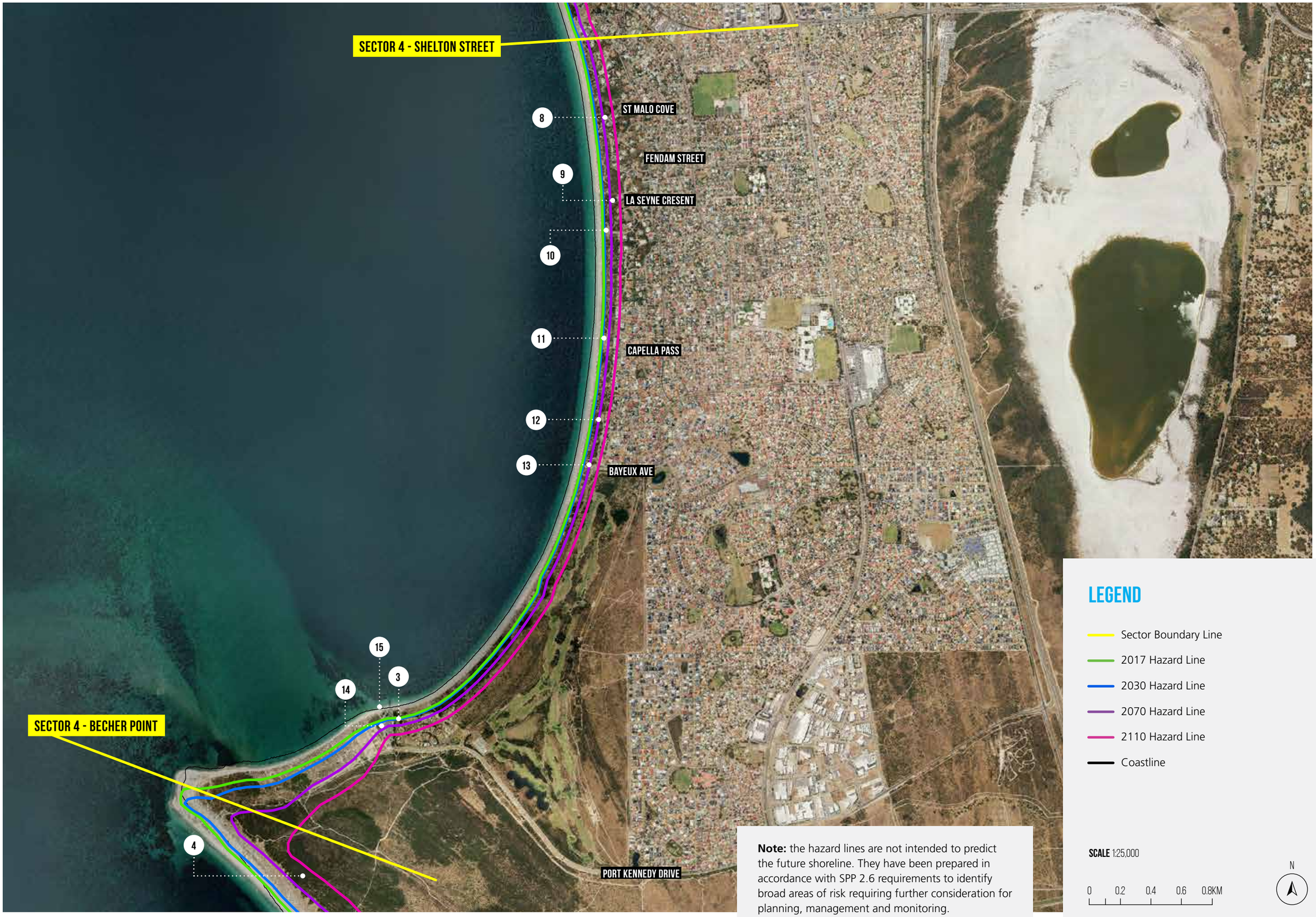
| Sector 4 | | | | | |
|---|---|---|---|---|---|
| | | 2017 | 2030 | 2070 | 2110 |
| **Vulnerability** | | | | | |
| 1 | Beach | ● | ● | ● | ● |
| 2 | Coastal/dune vegetation | ● | ● | ● | ● |
| 3 | Port Kennedy Foreshore Recreation Area (park) | ● | ● | ● | ● |
| 4 | Port Kennedy Scientific Park | ● | ● | ● | ● |
| 5 | Residential - north (98 properties, in whole sector) | ● | ● | ● | ● |
| 6 | Roads | ● | ● | ● | ● |
| 7 | Residential - Port Kennedy (98 properties, in whole sector) | ● | ● | ● | ● |
| 8 | St Malo Cove Carpark | ● | ● | ● | ● |
| 9 | La Seyne Crescent Carpark | ● | ● | ● | ● |
| 10 | St Ives Cove Carpark | ● | ● | ● | ● |
| 11 | Capella Pass Carpark | ● | ● | ● | ● |
| 12 | Cote D'Azur Gardens Carpark | ● | ● | ● | ● |
| 13 | Bayeux Avenue Carpark | ● | ● | ● | ● |
| 14 | Port Kennedy Foreshore Carpark | ● | ● | ● | ● |
| 15 | Port Kennedy boat ramp | ● | ● | ● | ● |
| 16 | Dual use paths | ● | ● | ● | ● |
| 17 | Pipes | ● | ● | ● | ● |
| 18 | Pits | ● | ● | ● | ● |

● Low ● Medium ● High ● Very High

**ESTIMATED TOTAL VALUE OF ASSETS AT RISK BY 2110 IS OVER $59 MILLION**






## LEGEND

- Sector Boundary Line
- 2017 Hazard Line
- 2030 Hazard Line
- 2070 Hazard Line
- 2110 Hazard Line
- Coastline

**SCALE** 1:25,000

0 0.2 0.4 0.6 0.8KM

N

**Note:** the hazard lines are not intended to predict the future shoreline. They have been prepared in accordance with SPP 2.6 requirements to identify broad areas of risk requiring further consideration for planning, management and monitoring.

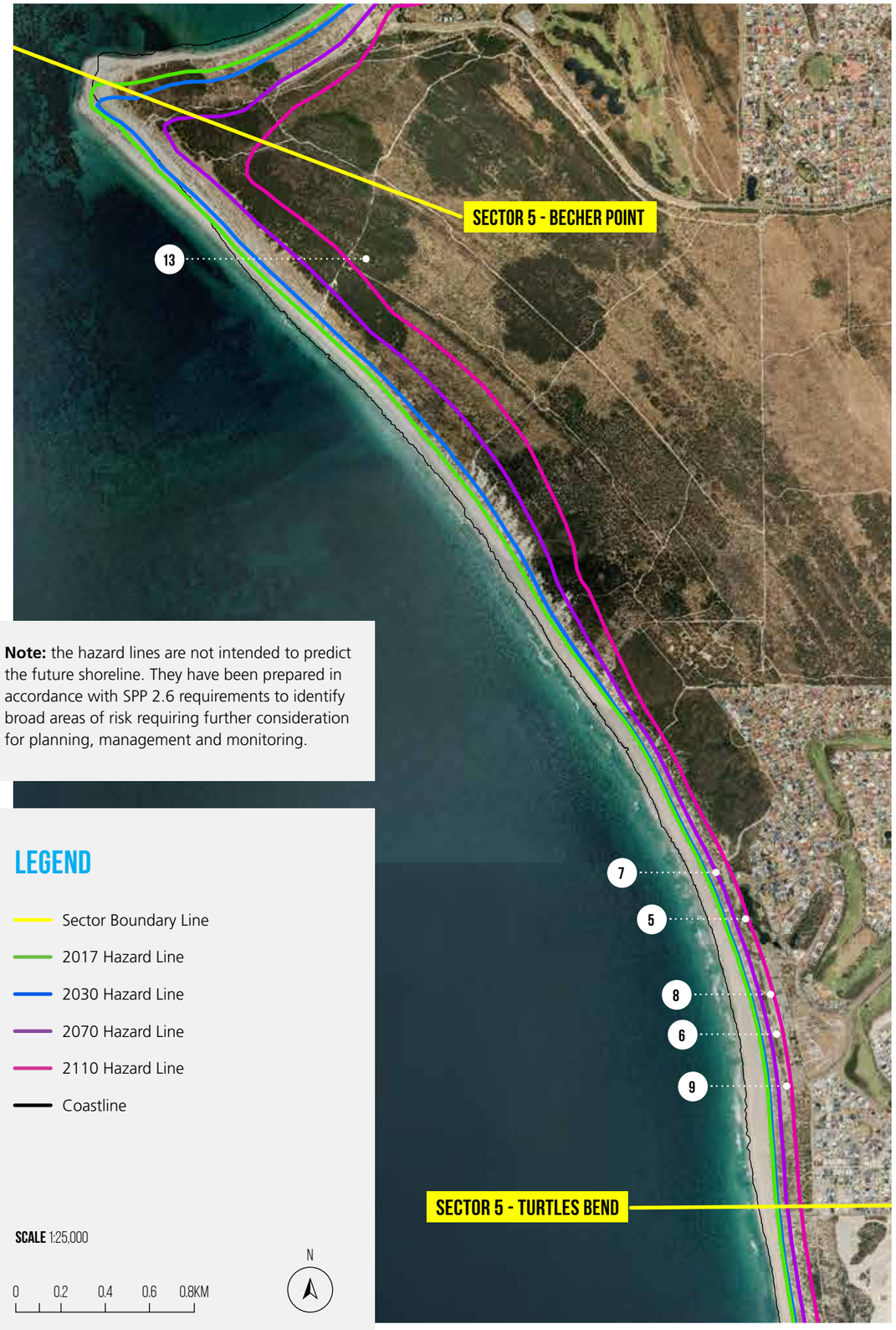
## 5.5 Sectors 5 Secret Harbour Foreshore Park to Turtles Bend

Vulnerability of assets to erosion

| Sector 5 | | | | | |
|---|---|---|---|---|---|
| | | 2017 | 2030 | 2070 | 2110 |
| **Vulnerability** | | | | | |
| 1 | Beach | ● | ● | ● | ● |
| 2 | Coastal/dune vegetation | ● | ● | ● | ● |
| 3 | Port Kennedy Scientific Park | ● | ● | ● | ● |
| 4 | Road (Siracusa Ct) | ● | ● | ● | ● |
| 5 | Lagoon Park | ● | ● | ● | ● |
| 6 | Secret Harbour Surf Lifesaving Club | ● | ● | ● | ● |
| 7 | Secret Harbour Beach Carpark (Siracusa St) | ● | ● | ● | ● |
| 8 | Secret Harbour Beach Carpark (Albenga Pl) | ● | ● | ● | ● |
| 9 | Secret Harbour Beach Carpark (Palisades Bvd) | ● | ● | ● | ● |
| 10 | Pedestrian pathway | ● | ● | ● | ● |
| 11 | Pipes | ● | ● | ● | ● |
| 12 | Pits | ● | ● | ● | ● |

● Low ● Medium ● High ● Very High

**ESTIMATED TOTAL VALUE OF ASSETS AT RISK BY 2110 IS OVER $6 MILLION**




**Note:** the hazard lines are not intended to predict the future shoreline. They have been prepared in accordance with SPP 2.6 requirements to identify broad areas of risk requiring further consideration for planning, management and monitoring.

### LEGEND

- Sector Boundary Line
- 2017 Hazard Line
- 2030 Hazard Line
- 2070 Hazard Line
- 2110 Hazard Line
- Coastline

**SCALE** 1:25,000

0 0.2 0.4 0.6 0.8KM

N

## 5.5 Sector 6 Turtles Bend to Municipal Boundary (South)

Vulnerability of assets to erosion

| Sector 5 | | 2017 | 2030 | 2070 | 2110 |
|---|---|---|---|---|---|
| **Vulnerability** | | | | | |
| 1 | Beach | ● | ● | ● | ● |
| 2 | Coastal/dune vegetation | ● | ● | ● | ● |
| 3 | Singleton Foreshore Park | ● | ● | ● | ● |
| 4 | Pipes | ● | ● | ● | ● |
| 5 | Pits | ● | ● | ● | ● |

● Low ● Medium ● High ● Very High

**ESTIMATED TOTAL VALUE OF ASSETS AT RISK BY 2110 IS OVER $52,000**



**Note:** the hazard lines are not intended to predict the future shoreline. They have been prepared in accordance with SPP 2.6 requirements to identify broad areas of risk requiring further consideration for planning, management and monitoring.

### LEGEND

- City of Rockingham Boundary (CoR)
- Sector Boundary Line
- 2017 Hazard Line
- 2030 Hazard Line
- 2070 Hazard Line
- 2110 Hazard Line
- Coastline

**SCALE** 1:20,000

0 0.15 0.3 0.45 0.6KM

N

6

# Which areas of the City could be impacted by inundation?

**Inundation is the temporary flooding of a portion of land with ocean water, particularly during storm events or high tides.**

- The total value of assets potentially impacted by inundation to 2110 is estimated to be around $1.3 billion. However, it is uncertain how damaging this inundation would be to these assets.
- While there are coastal inundation risks along the length of the City's coastline, the following areas have significant hazards:
  - the low-lying southern coastline of Cockburn Sound between approximately Wanliss Street and Cape Peron (Sectors 1 and 2);
  - the low-lying, west and south-facing sections of both Shoalwater and Safety Bay (Sector 3);
  - the low-lying areas of Safety Bay, Shoalwater, Peron and Rockingham between areas 1 and 2 above (Sectors 1, 2 and 3); and
  - the low-lying areas around Becher Point in Port Kennedy (Sectors 4 and 5).

A detailed list of assets vulnerable within each sector is presented alongside each Sector Hazard Map.

The impact of sea level rise and inundation on drainage infrastructure has also be assessed. These figures are presented in Appendix A.

Figures showing the depth and duration of inundation in 2110 have been included in this section. The complete suite of depth and duration maps for all timeframes in all sectors can be viewed in the CHRMAP Technical Assessment Report.

In viewing these maps, keep in mind that:

1. The inundation extents are based on a suite of assumptions and have varying degrees of uncertainty, which may influence the likelihood of these impacts being realised at each planning horizon.
2. To account for the uncertainty associated with dynamic natural environments and the lack of long term datasets, the extents shown are designed to be conservative for the purpose of future planning.
3. These hazard maps will be revised in 10 years (or sooner if required) to take into account new information as it emerges.
4. The depth and duration maps are based on a 500 year ARI as per SPP 2.6, which is a very significant storm event with a statistical chance of recurring once per 500 years or a 0.2% chance of occurring in any given year.
5. The duration of inundation maps are an indicative estimate presented for information only and are not comparable to a flooding and drainage study as they do not include consideration of drainage, rainfall or stormwater flow.

## 6.1 Sector 1 Municipal Boundary (North) to Wanliss Street

Vulnerability of assets to erosion

| Sector 4 | | | | | |
|---|---|---|---|---|---|
| | | 2017 | 2030 | 2070 | 2110 |
| **Vulnerability** | | | | | |
| 1 | Beach | ● | ● | ● | ● |
| 2 | Coastal/dune vegetation | ● | ● | ● | ● |
| 3 | Pipes | ● | ● | ● | ● |
| 4 | Rockingham Beach Rd | ● | ● | ● | ● |
| 5 | Rockingham Foreshore Park | ● | ● | ● | ● |

● Low ● Medium ● High ● Very High

**ESTIMATED TOTAL VALUE OF ASSETS AT RISK BY 2110 IS $84,494**

**Storm events are characterised based on an average recurrence interval (ARI). The recurrence interval is a statistical probability of that event occurring, so:**

A **500 year** ARI storm event has a 0.2% chance of occurring in any given year.

A **100 year** ARI storm event has a 1% chance of occurring in any given year.

A **50 year** ARI storm event has a 2% chance of occurring in any given year.

A 1 in **10 year** storm event has a 10% chance of occurring in any given year.

A 1 in **1 year** storm event has a 99% chance of occurring in any given year.


**Note:** the hazard areas shown are not intended to predict the exact impact of future events. They have been prepared in accordance with SPP 2.6 requirements to identify broad areas of risk requiring further consideration for planning, management and monitoring.

## LEGEND

- City of Rockingham Boundary (CoR)
- Sector Boundary Line
- Coastline

### INUNDATION EXTENT

- 1yr ARI
- 10yr ARI
- 50yr ARI
- 100yr ARI
- 500yr ARI

**SCALE** 1:15,000

0 0.1 0.2 0.3 0.4KM

N

**INUNDATION 2110 HAZARD MAP**


SECTOR 1 DEPTH OF COASTAL INUNDATION 2110 – 500 YEAR ARI


**Note:** the hazard areas shown are not intended to predict the exact impact of future events. They have been prepared in accordance with SPP 2.6 requirements to identify broad areas of risk requiring further consideration for planning, management and monitoring.

## LEGEND

- Sector Boundary Line
- Coastline

**DURATION OF INUNDATION (HOURS)**

- 0 - 20
- 20 -40
- 40 - 60
- 60 - 80
- 80 - 100
- 100 - 120

**SCALE** 1:15,000

0 0.1 0.2 0.3 0.4KM

N

SECTOR 1 DURATION OF COASTAL INUNDATION 2110 - 500 YEAR ARI

## 6.2 Sector 2A Wanliss Street to Garden Island Causeway
## Sector 2B Garden Island Causeway to Boundary Road

Vulnerability of assets to inundation

| Sector 4 | | | | | |
|---|---|---|---|---|---|
| | | 2017 | 2030 | 2070 | 2110 |
| **Vulnerability** | | | | | |
| 1 | Beach | ● | ● | ● | ● |
| 2 | Alfred Hines Seaside Home | ● | ● | ● | ● |
| 3 | Bell Park Carpark | ● | ● | ● | ● |
| 4 | Boat Ramps (Catalpa Park) | ● | ● | ● | ● |
| 5 | Bores | ● | ● | ● | ● |
| 6 | Catalpa Park Carpark | ● | ● | ● | ● |
| 7 | Coastal/dune vegetation | ● | ● | ● | ● |
| 8 | Department of Defence Land | ● | ● | ● | ● |
| 9 | DoBCA Managed Land | ● | ● | ● | ● |
| 10 | Dual use path | ● | ● | ● | ● |
| 11 | Jetty abutments (Val St and Fisher St) | ● | ● | ● | ● |
| 12 | Mangles Bay Fishing Club | ● | ● | ● | ● |
| 13 | Parks & Recreation areas | ● | ● | ● | ● |
| 14 | Pipes | ● | ● | ● | ● |
| 15 | Pits | ● | ● | ● | ● |
| 16 | Point Peron Boating Facility Carpark | ● | ● | ● | ● |
| 17 | Point Peron Camp School | ● | ● | ● | ● |
| 18 | Point Peron Wastewater Treatment Plant | ● | ● | ● | ● |
| 19 | Residential properties (985) | ● | ● | ● | ● |
| 20 | Roads | ● | ● | ● | ● |
| 21 | Rockingham Beach Primary | ● | ● | ● | ● |
| 22 | Rockingham Naval Club | ● | ● | ● | ● |
| 23 | Samuel St Carpark | ● | ● | ● | ● |
| 24 | Star of the Sea Catholic Primary School | ● | ● | ● | ● |
| 25 | Underground Storage | ● | ● | ● | ● |

● Low ● Medium ● High ● Very High

**ESTIMATED TOTAL VALUE OF ASSETS AT RISK BY 2110 IS OVER $405 MILLION**

**Storm events are characterised based on an average recurrence interval (ARI). The recurrence interval is a statistical probability of that event occurring, so:**

A **500 year** ARI storm event has a 0.2% chance of occurring in any given year.

A **100 year** ARI storm event has a 1% chance of occurring in any given year.

A **50 year** ARI storm event has a 2% chance of occurring in any given year.

A 1 in **10 year** storm event has a 10% chance of occurring in any given year.

A 1 in **1 year** storm event has a 99% chance of occurring in any given year.

**Note:** the hazard areas shown are not intended to predict the exact impact of future events. They have been prepared in accordance with SPP 2.6 requirements to identify broad areas of risk requiring further consideration for planning, management and monitoring.

### LEGEND

- City of Rockingham Boundary (CoR)
- Sector Boundary Line
- Coastline

**INUNDATION EXTENT**

- 1yr ARI
- 10yr ARI
- 50yr ARI
- 100yr ARI
- 500yr ARI

**SCALE** 1:15,000

0 0.1 0.2 0.3 0.4KM

N

## 2017 INUNDATION HAZARD MAP


## 2030 INUNDATION HAZARD MAP


## 2070 INUNDATION HAZARD MAP


## 2110 INUNDATION HAZARD MAP


**Note:** the hazard areas shown are not intended to predict the exact impact of future events. They have been prepared in accordance with SPP 2.6 requirements to identify broad areas of risk requiring further consideration for planning, management and monitoring.

## LEGEND

- Sector Boundary Line
- Coastline

**WATER DEPTH (M)**

- 0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5

**SCALE** 1:15,000

0 0.1 0.2 0.3 0.4KM

N

SECTOR 2 DEPTH OF COASTAL INUNDATION 2110 – 500 YEAR ARI


**Note:** the hazard areas shown are not intended to predict the exact impact of future events. They have been prepared in accordance with SPP 2.6 requirements to identify broad areas of risk requiring further consideration for planning, management and monitoring.

## LEGEND

- Sector Boundary Line
- Coastline

**DURATION OF INUNDATION (HOURS)**

- 0 - 20
- 20 -40
- 40 - 60
- 60 - 80
- 80 - 100
- 100 - 120

**SCALE** 1:15,000

0 0.1 0.2 0.3 0.4KM

N

SECTOR 2 DURATION OF COASTAL INUNDATION 2110 - 500 YEAR ARI

## 6.3 Sector 3 Boundary Road to Shelton Street

Vulnerability of assets to inundation

| Sector 4 | | 2017 | 2030 | 2070 | 2110 |
|---|---|---|---|---|---|
| **Vulnerability** | | | | | |
| 1 | Beach | Medium | Medium | High | Very High |
| 2 | Bores | Low | Low | Low | Medium |
| 3 | Coastal/dune vegetation | Low | Low | Medium | Medium |
| 4 | Dual use paths | Low | Low | High | Very High |
| 5 | Mersey Point Carpark | High | High | Very High | Very High |
| 6 | Parks and Recreational areas | Low | Low | Medium | Medium |
| 7 | Pipes | Low | Low | Low | Medium |
| 8 | Pits | Low | Low | Medium | Medium |
| 9 | Residential properties (3,578) | Low | Low | Medium | Medium |
| 10 | Roads | Low | Medium | High | High |
| 11 | Mersey Point / Rockingham Wild Encounters | Medium | Medium | High | Very High |
| 12 | Safety Bay Foreshore Carparks (6 total) | Low | Medium | High | Very High |
| 13 | Safety Bay Primary School | Low | Medium | High | Very High |
| 14 | Safety Bay Tennis Club | Low | Low | Low | Medium |
| 15 | Safety Bay Yacht Club | Medium | Medium | Medium | High |

Low Medium High Very High

**ESTIMATED TOTAL VALUE OF ASSETS AT RISK BY 2110 IS OVER $969 MILLION**

**Storm events are characterised based on an average recurrence interval (ARI). The recurrence interval is a statistical probability of that event occurring, so:**

A **500 year** ARI storm event has a 0.2% chance of occurring in any given year.

A **100 year** ARI storm event has a 1% chance of occurring in any given year.

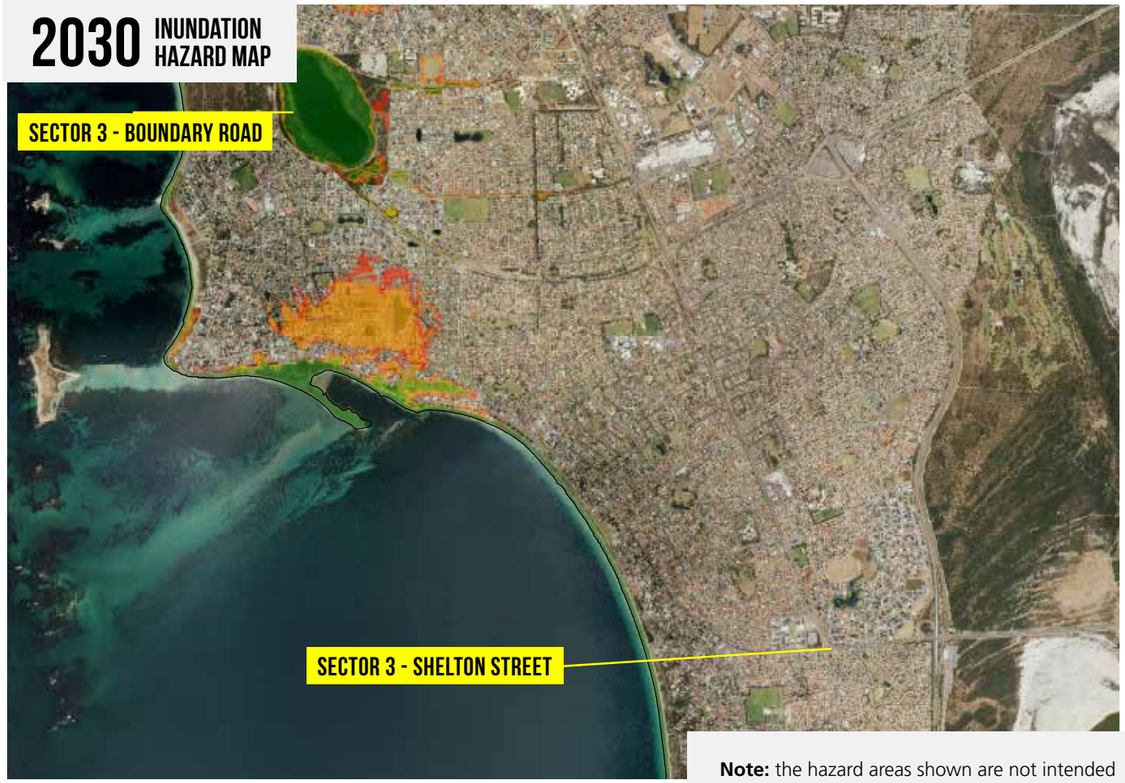
A **50 year** ARI storm event has a 2% chance of occurring in any given year.

A 1 in **10 year** storm event has a 10% chance of occurring in any given year.

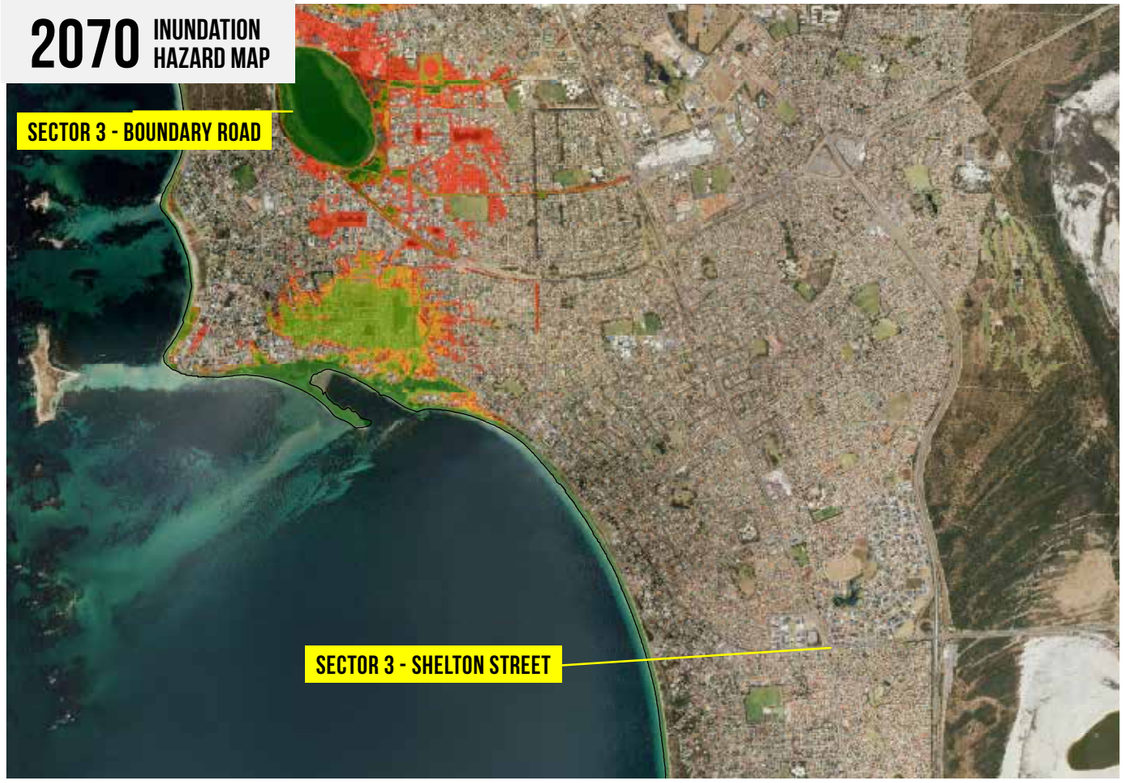
A 1 in **1 year** storm event has a 99% chance of occurring in any given year.

## 2017 INUNDATION HAZARD MAP

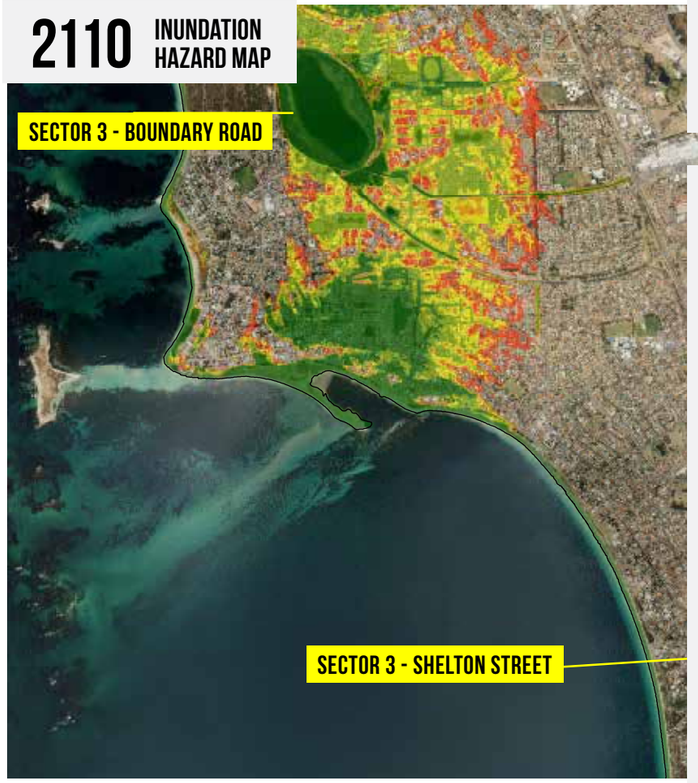

## 2030 INUNDATION HAZARD MAP




## 2070 INUNDATION HAZARD MAP




## 2110 INUNDATION HAZARD MAP




**Note:** the hazard areas shown are not intended to predict the exact impact of future events. They have been prepared in accordance with SPP 2.6 requirements to identify broad areas of risk requiring further consideration for planning, management and monitoring.

## LEGEND

- Sector Boundary Line
- Coastline

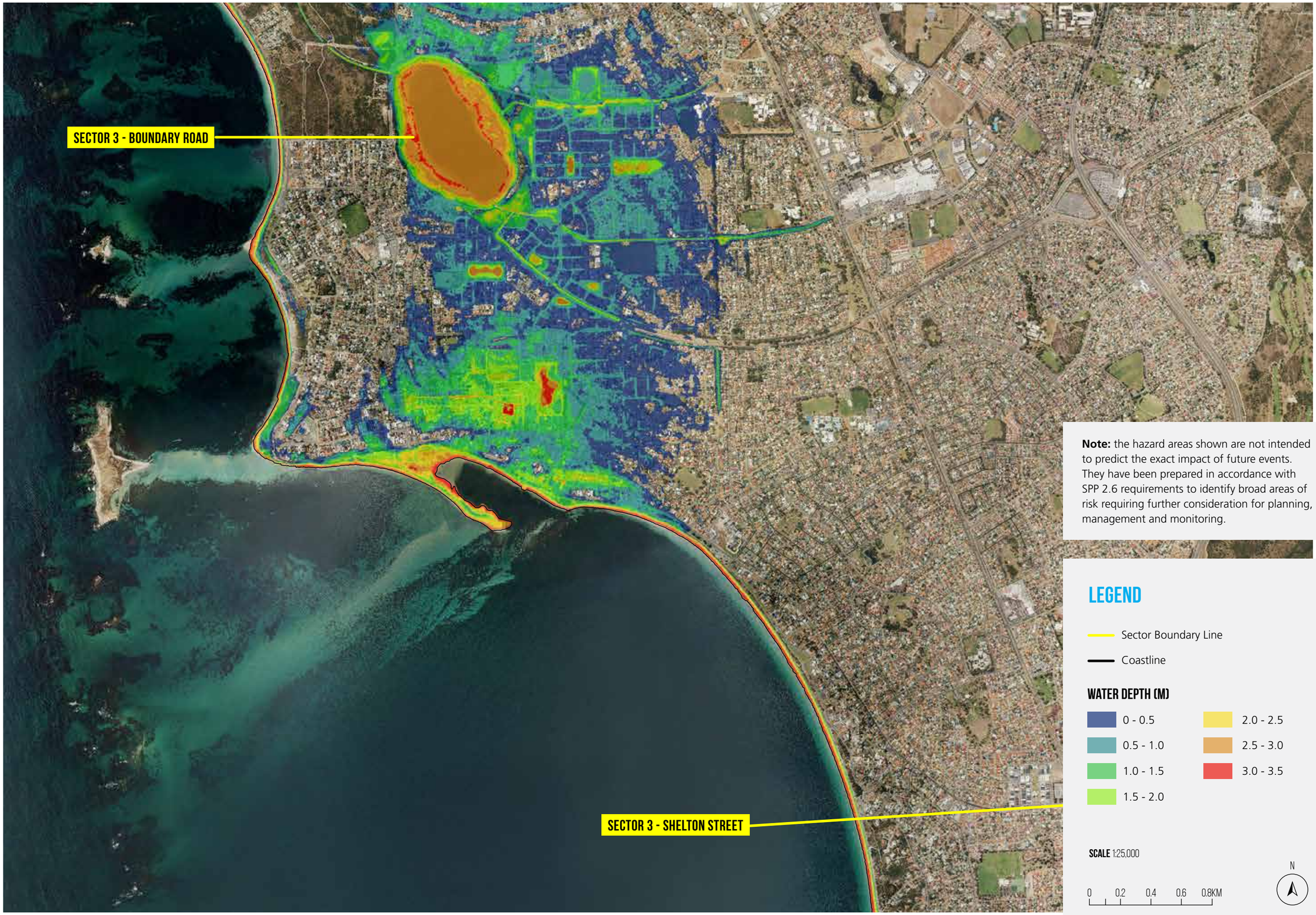
### INUNDATION EXTENT

- 1yr ARI
- 10yr ARI
- 50yr ARI
- 100yr ARI
- 500yr ARI

**SCALE** 1:25,000

0 0.1 0.2 0.3 0.8KM

N




**Note:** the hazard areas shown are not intended to predict the exact impact of future events. They have been prepared in accordance with SPP 2.6 requirements to identify broad areas of risk requiring further consideration for planning, management and monitoring.

## LEGEND

- Sector Boundary Line
- Coastline

**WATER DEPTH (M)**

- 0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5

**SCALE** 1:25,000

0 0.2 0.4 0.6 0.8KM

N

SECTOR 3 DEPTH OF COASTAL INUNDATION 2110 – 500 YEAR ARI


**Note:** the hazard areas shown are not intended to predict the exact impact of future events. They have been prepared in accordance with SPP 2.6 requirements to identify broad areas of risk requiring further consideration for planning, management and monitoring.

## LEGEND

- Sector Boundary Line
- Coastline

**DURATION OF INUNDATION (HOURS)**

| | |
|---|---|
| 0 - 20 | 60 - 80 |
| 20 -40 | 80 - 100 |
| 40 - 60 | 100 - 120 |

**SCALE** 1:25,000

N

0 0.2 0.4 0.6 0.8KM

**SECTOR 3 DURATION OF COASTAL INUNDATION 2110 - 500 YEAR ARI**

## 6.4 Sector 4A Shelton Street to Bayeux Avenue
## Sector 4B Bayeux Avenue to Becher Point

Vulnerability of assets to inundation

| Sector 4 | | | | | |
|---|---|---|---|---|---|
| | | 2017 | 2030 | 2070 | 2110 |
| **Vulnerability** | | | | | |
| 1 | Beach | ● | ● | ● | ● |
| 2 | Dual use paths | ● | ● | ● | ● |
| 3 | Parks and Recreation areas | ● | ● | ● | ● |
| 4 | Pipes | ● | ● | ● | ● |
| 5 | Pits | ● | ● | ● | ● |
| 6 | Port Kennedy Foreshore Carpark | ● | ● | ● | ● |
| 7 | Port Kennedy Scientific Park | ● | ● | ● | ● |
| 8 | Residential properties (28) | ● | ● | ● | ● |
| 9 | Roads | ● | ● | ● | ● |
| 10 | The Links Kennedy Bay Golf Course | ● | ● | ● | ● |

● Low ● Medium ● High ● Very High

**ESTIMATED TOTAL VALUE OF ASSETS AT RISK BY 2110 IS OVER $9 MILLION**

**Storm events are characterised based on an average recurrence interval (ARI). The recurrence interval is a statistical probability of that event occurring, so:**

A **500 year** ARI storm event has a 0.2% chance of occurring in any given year.

A **100 year** ARI storm event has a 1% chance of occurring in any given year.

A **50 year** ARI storm event has a 2% chance of occurring in any given year.

A 1 in **10 year** storm event has a 10% chance of occurring in any given year.

A 1 in **1 year** storm event has a 99% chance of occurring in any given year.


**Note:** the hazard areas shown are not intended to predict the exact impact of future events. They have been prepared in accordance with SPP 2.6 requirements to identify broad areas of risk requiring further consideration for planning, management and monitoring.

## LEGEND

- Sector Boundary Line
- Coastline

### INUNDATION EXTENT

- 1yr ARI
- 10yr ARI
- 50yr ARI
- 100yr ARI
- 500yr ARI

**SCALE** 1:25,000

0 0.1 0.2 0.3 0.8KM

N

SECTOR 4 2110 INUNDATION HAZARD MAP


**Note:** the hazard areas shown are not intended to predict the exact impact of future events. They have been prepared in accordance with SPP 2.6 requirements to identify broad areas of risk requiring further consideration for planning, management and monitoring.

## LEGEND

- Sector Boundary Line
- Coastline

**WATER DEPTH (M)**

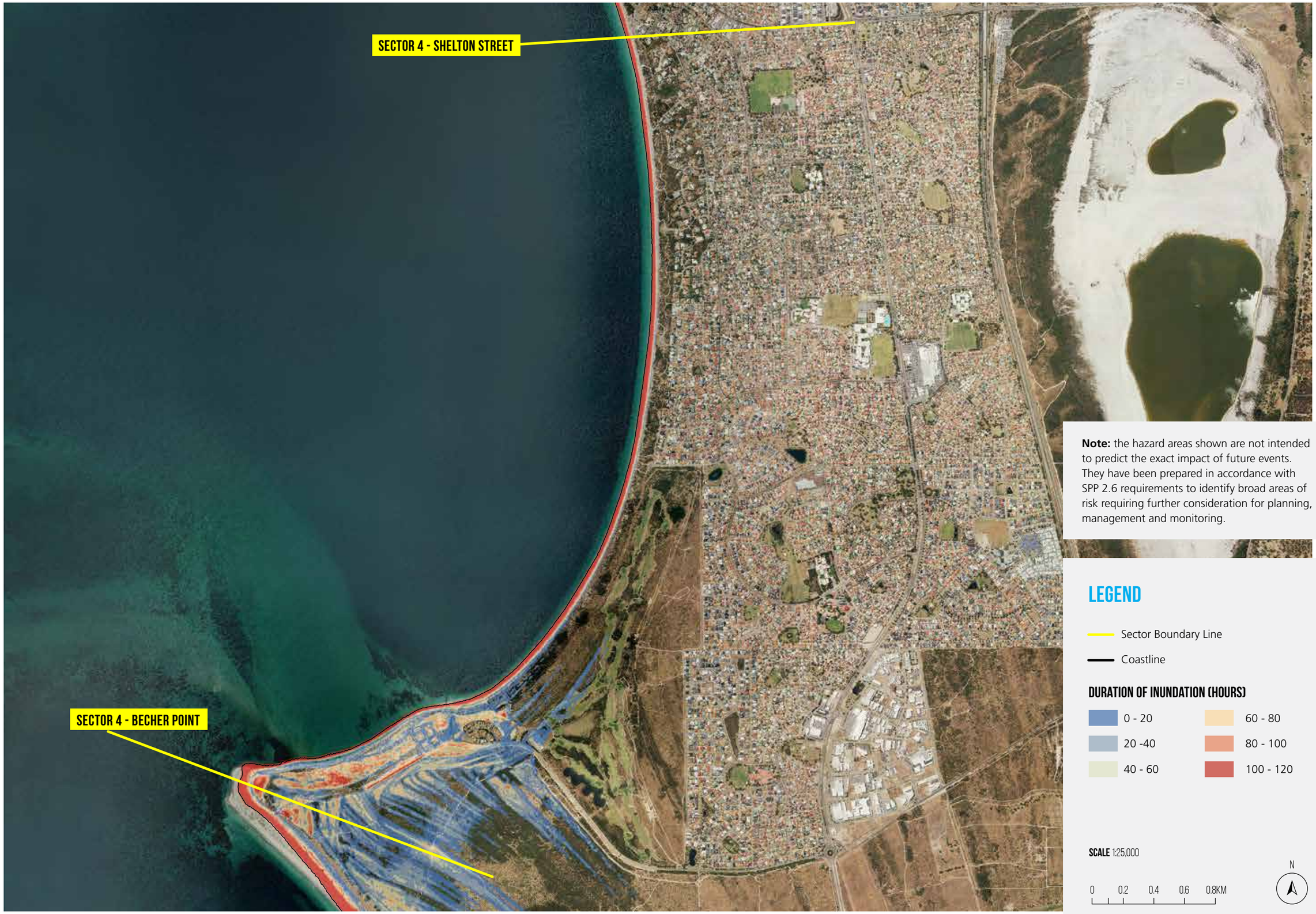
- 0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5

**SCALE** 1:25,000

0 0.2 0.4 0.6 0.8KM

N

SECTOR 4 DEPTH OF COASTAL INUNDATION 2110 – 500 YEAR ARI




SECTOR 4 DURATION OF COASTAL INUNDATION 2110 - 500 YEAR ARI

**Note:** the hazard areas shown are not intended to predict the exact impact of future events. They have been prepared in accordance with SPP 2.6 requirements to identify broad areas of risk requiring further consideration for planning, management and monitoring.

## LEGEND

- Sector Boundary Line
- Coastline

**DURATION OF INUNDATION (HOURS)**

- 0 - 20
- 20 -40
- 40 - 60
- 60 - 80
- 80 - 100
- 100 - 120

**SCALE** 1:25,000

0 0.2 0.4 0.6 0.8KM

N

## 6.5 Sector 5 Secret Harbour Foreshore Park to Turtles Bend

Vulnerability of assets to inundation

| Sector 4 | | | | | |
|---|---|---|---|---|---|
| | | 2017 | 2030 | 2070 | 2110 |
| **Vulnerability** | | | | | |
| 1 | Beach | ● | ● | ● | ● |
| 2 | Coastal/dune vegetation | ● | ● | ● | ● |
| 3 | Port Kennedy Scientific Park | ● | ● | ● | ● |

● Low ● Medium ● High ● Very High

As no built assets are at risk of inundation by 2110, a monetary value has not been assigned for Sectors 5. Acknowledging the important social and environmental values of these assets, it is recommended that further work be undertaken as an outcome of this CHRMAP to better quantify these intrinsic values and inform future risk assessments.

**Storm events are characterised based on an average recurrence interval (ARI). The recurrence interval is a statistical probability of that event occurring, so:**

500 A **500 year** ARI storm event has a 0.2% chance of occurring in any given year.

100 A **100 year** ARI storm event has a 1% chance of occurring in any given year.

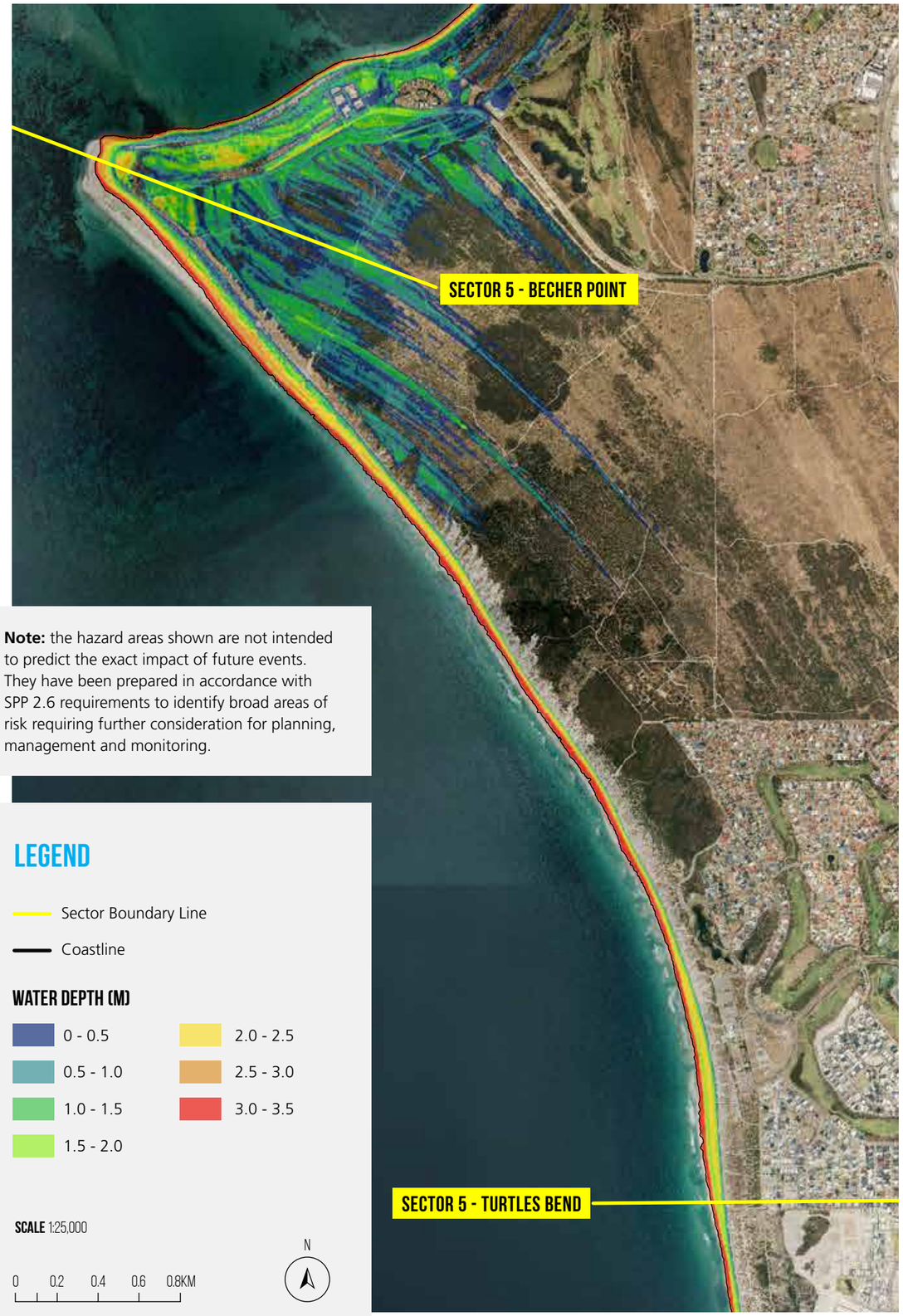
50 A **50 year** ARI storm event has a 2% chance of occurring in any given year.

10 A 1 in **10 year** storm event has a 10% chance of occurring in any given year.

1 A 1 in **1 year** storm event has a 99% chance of occurring in any given year.


**Note:** the hazard areas shown are not intended to predict the exact impact of future events. They have been prepared in accordance with SPP 2.6 requirements to identify broad areas of risk requiring further consideration for planning, management and monitoring.

SECTOR 5 INUNDATION 2110 HAZARD MAP




**Note:** the hazard areas shown are not intended to predict the exact impact of future events. They have been prepared in accordance with SPP 2.6 requirements to identify broad areas of risk requiring further consideration for planning, management and monitoring.

## LEGEND

- Sector Boundary Line
- Coastline

**WATER DEPTH (M)**

- 0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5

**SCALE** 1:25,000

0 0.2 0.4 0.6 0.8KM

N

SECTOR 5 DEPTH OF COASTAL INUNDATION 2110 – 500 YEAR ARI


## LEGEND

- Sector Boundary Line
- Coastline

**DURATION OF INUNDATION (HOURS)**

- 0 - 20
- 20 -40
- 40 - 60
- 60 - 80
- 80 - 100
- 100 - 120

**SCALE** 1:25,000

0 0.2 0.4 0.6 0.8KM

N

SECTOR 5 DURATION OF COASTAL INUNDATION 2110 – 500 YEAR ARI

## 6.5 Sector 6: Turtles Bend to Municipal Boundary (South)

Vulnerability of assets to inundation

| Sector 4 | | 2017 | 2030 | 2070 | 2110 |
|---|---|---|---|---|---|
| **Vulnerability** | | | | | |
| 1 | Beach | ● | ● | ● | ● |
| 2 | Coastal/dune vegetation | ● | ● | ● | ● |

● Low ● Medium ● High ● Very High

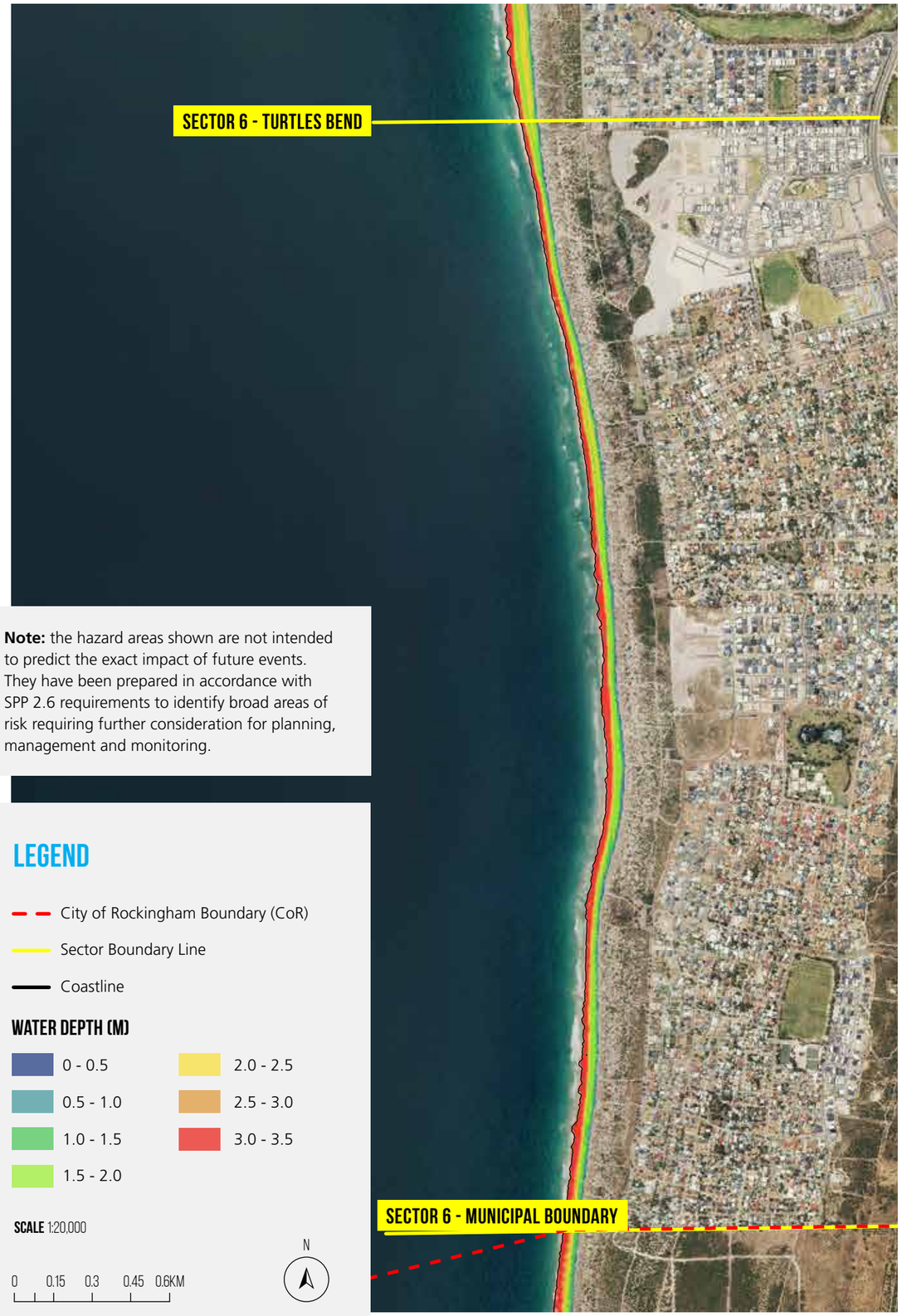
As no built assets are at risk of inundation by 2110, a monetary value has not been assigned for Sectors 6. Acknowledging the important social and environmental values of these assets, it is recommended that further work be undertaken as an outcome of this CHRMAP to better quantify these intrinsic values and inform future risk assessments.

**Storm events are characterised based on an average recurrence interval (ARI). The recurrence interval is a statistical probability of that event occurring, so:**

- A **500 year** ARI storm event has a 0.2% chance of occurring in any given year.
- A **100 year** ARI storm event has a 1% chance of occurring in any given year.
- A **50 year** ARI storm event has a 2% chance of occurring in any given year.
- A 1 in **10 year** storm event has a 10% chance of occurring in any given year.
- A 1 in **1 year** storm event has a 99% chance of occurring in any given year.


**Note:** the hazard areas shown are not intended to predict the exact impact of future events. They have been prepared in accordance with SPP 2.6 requirements to identify broad areas of risk requiring further consideration for planning, management and monitoring.

SECTOR 6 INUNDATION 2110 HAZARD MAP




**Note:** the hazard areas shown are not intended to predict the exact impact of future events. They have been prepared in accordance with SPP 2.6 requirements to identify broad areas of risk requiring further consideration for planning, management and monitoring.

## LEGEND

- City of Rockingham Boundary (CoR)
- Sector Boundary Line
- Coastline

**WATER DEPTH (M)**

- 0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5

**SCALE** 1:20,000

0 0.15 0.3 0.45 0.6KM

N

SECTOR 6 DEPTH OF COASTAL INUNDATION 2110 – 500 YEAR ARI


## LEGEND

- City of Rockingham Boundary (CoR)
- Sector Boundary Line
- Coastline

**DURATION OF INUNDATION (HOURS)**

- 0 - 20
- 20 -40
- 40 - 60
- 60 - 80
- 80 - 100
- 100 - 120

**SCALE** 1:20,000

0 0.15 0.3 0.45 0.6KM

N

SECTOR 6 DURATION OF COASTAL INUNDATION 2110 – 500 YEAR ARI

# 7 What are the management options and considerations for coastal hazards?

## 7.1 Key concepts

**7.1.1 Equity**

Equity is a concept central to the purpose of the CHRMAP process. Australia's coastline is highly valued by the community as a public asset, with stakeholders ranging from individual property owners in coastal areas, to all levels of government, ratepayers, taxpayers in general and users both from within and outside of jurisdictional boundaries.

Responsibility for coastal planning lies with both State and Local Governments, and with a need to ensure decision making considers equity in terms of:

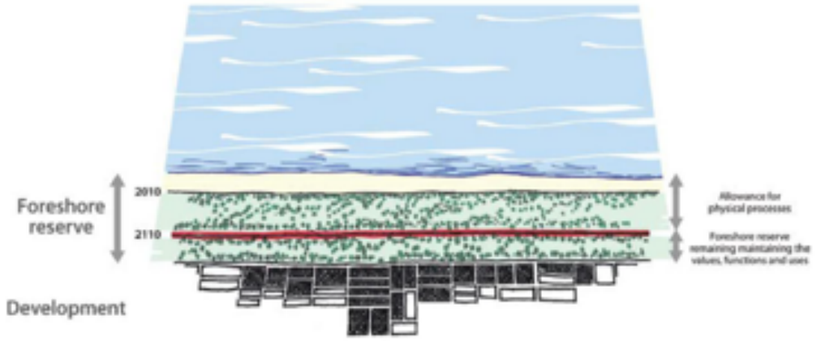
- Access - if the foreshore reserve erodes to the point where private houses directly front the beach, then this would restrict public access to those areas of beach. The coast and coastal foreshore reserves are public assets which should not, now or in the future, become the exclusive domain of private landholders by virtue of the erosion or other coastal processes.
- Enjoyment – if a seawall is installed, then a fisherman may still be able to enjoy the coastal environment by fishing from the rocks, however, the loss of the sandy beach would impact on enjoyment of the coastal environment by someone who wants to walk along the sandy beach and appreciate the natural dunes.
- Beneficiaries - coastal protection structures, such as groynes, may create beneficiaries (those who are protected from hazards) but potentially disadvantage others. For example, protection structures may exacerbate erosion adjacent to the structure, and limit sediment availability for maintaining beaches some distance from the protected area. Protection structures can also result in significant impacts to coastal ecosystems, well beyond the local area in which the structures are installed (Gittman et al., 2016).
- Intergenerational equity – in planning for a 100 year timeframe, how will the decisions made now affect future generations? Continuing to develop the coast without planning for hazards has potential to result in further issues and expense for future generations. Similarly, protecting existing assets now may be delaying proper management of the issue to future generations, and may not be considered economically responsible from a long term perspective.

In light of the above, it is critical that planning and management is as transparent and equitable as possible.

**7.1.2 Coastal Foreshore Reservation**

The coastal foreshore provides beach access, public space for recreation and conservation, is a tourist attraction and provides habitat for native flora and fauna. Importantly, it can also provide a buffer to protect built assets, such as buildings and infrastructure, from coastal hazards.

SPP2.6 Schedule One provides guidance for calculating the component of the coastal foreshore reserve required to allow for coastal processes. This should ensure that, at the end of the planning timeframe, a coastal foreshore reserve is still present for recreation and/or conservation and is not exposed to the adverse impacts of erosion and inundation. It is behind this reserve that additional development can be considered. This concept is shown in the figure below, as development is set back from the coast allowing a sufficient foreshore reserve for future generations.




Notwithstanding, Schedule One also contains Clause 7 – Variations, which outlines specific instances where certain types of development may be considered appropriate within a coastal foreshore reserve, regardless of the allowance for physical coastal processes.

In Secret Harbour, Golden Bay and Singleton, the foreshore reserve is of a sufficient width to ensure that private property and key public infrastructure is not impacted by coastal hazards over the next 100 years.

Conversely, from East Rockingham to Port Kennedy, the foreshore reserve is not of sufficient width to ensure that the values, functions and equitable use of the coast can continue to be provided as is over the next 100 years without management intervention.

**7.1.3 Rights and Responsibilities**

There is no law requiring any level of government to provide protection of private property from natural hazards, nor compensation when land is lost to the sea. There are, however, several laws that allow the intervention of governments to enforce eviction if private property becomes uninhabitable, or removal of property if it constitutes a public risk. In the event of coastal erosion causing a property to "fall into the sea", and the land to disappear below the high water mark, the loss is to be borne by the property owner.

The current situation in WA determines that property titles remain, even if the land is lost to coastal processes, and this can mean that public access to foreshore areas is lost in the event that erosion encroaches on private property.

Nonetheless, the CHRMAP process ultimately intends to minimise risks and maximise beneficial use of the coast from an economic, social and environmental perspective. For more information on rights and responsibilities, refer to the State Government's WA Coastal Zone Strategy (2017).

## 7.2 Hierarchy

SPP 2.6 provides the following hierarchy for consideration of risk management and adaptation options:


**Avoid**
Identify future 'no build areas' and use planning tools 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 land in developed areas and accommodate risk through raised floor levels, raised roads, etc.

**Protect**
Use hard structures (e.g. sea walls) or soft solutions (e.g. dunes and vegetation) to protect land from the sea.

### 7.2.1 AVOID

Avoid any further residential or commercial development within areas identified as vulnerable to the impacts of coastal hazards.

Avoid is seen as the preferred strategy but is generally only applicable to undeveloped coastal land and areas of the coast where intensification of development in hazardous areas might be proposed. This option is underpinned by the implementation of planning controls which should prevent inappropriate use of land in areas identified as potentially at risk from coastal hazards.

**Pros**

- Ensures that property and infrastructure will not require costly management in the future

**Cons**

- Not an option for much of the City's coastline, where development already exists in vulnerable areas.

### 7.2.2 MANAGED RETREAT

This option aims to remove assets from the risk of coastal hazards. This would be a significant undertaking and could potentially involve acquisition of vulnerable private property and the removal and relocation of public infrastructure in order to increase the width of the coastal foreshore reserve.

Although it may involve significant expenditure during implementation, this is generally considered the responsible approach for future communities in the long-term.

Managed retreat is identified as the preferred adaptation pathway under SPP 2.6. The Coastal Hazard Risk Management and Adaptation Plan Guidelines (WAPC 2019) outline mechanisms for actioning the transfer of land from private ownership to the public realm under this approach.

Although the State Government recommends managed retreat, it does not propose to fund it. While there is no obligation at any level of Government to compensate landholders for the impacts of coastal hazards and sea level rise, there is a responsibility to act in the best interests of the community.

This option can be facilitated in a number of ways, such as:

- leaving assets unprotected and repairing or removing them only when they are impacted (i.e. minor park infrastructure)
- removing or relocating assets before they are impacted (i.e. larger assets and infrastructure, including commercial/private property and roads).

- not acting to retreat until certain triggers have been reached (i.e. shoreline recedes to a defined point).
- pre-emptive planning controls, as described in Section 9.3 (i.e. application of a Special Control Area of vulnerable areas)
- reserving land to expand existing foreshore reserves; including acquisition of land either voluntary or compulsory

It is important to note that without acquisition of private property to expand the foreshore reserve, a managed retreat may result in a loss of public access to foreshore areas and a loss of amenity as houses become uninhabitable.

The estimated cost of managed retreat to 2100, based on the value of assets potentially impacted and the cost of demolition, is $530 million.

**Pros**

- Removing assets from hazardous areas eliminates the need to fund expensive ongoing protection, making it the economically responsible approach over the long term
- It ensures public access and maintenance of a sandy beach and dunes for the broader community long term
- There is no obligation at any level of Government to protect private property from coastal hazards. It is also unlikely that these properties would be insured against damage caused by coastal hazards.
- From an intergenerational equity perspective, failing to retreat when needed could be seen to disadvantage future generations, who would effectively be paying to rectify land mismanagement attributable to previous generations.

**Cons**

- Well defined trigger levels based on long term datasets are critical to ensure that management responses are appropriate and timely. For example, an arbitrary trigger might be that managed retreat will be implemented once more than 40 m of beach is lost. However, if 80 m of beach was lost in one storm, it would not allow time to implement a contingency response.
- There is currently no funding proposed by the State or Federal governments to assist with the costs of managed retreat, making it prohibitively expensive for local government to fund.
- With the progressive removal of significant infrastructure such as roads, there is a need to maintain safe public access to private property.
- The managed retreat option leads to considerable equity implications. The option is considered fair to the broader community, whose ability to access and use the beach and foreshore is maintained. Those owning residential properties that will be removed will be seen to lose out through the strategy if mechanisms for adequate compensation are not put in place.
- A managed retreat strategy would result in the blighting of existing residential areas over a period of time while homes and infrastructure are removed
- There will be management costs associated with rehabilitating expanded foreshore reserves.

## 7.2.3 ACCOMMODATE

Accommodate options aim to re-design existing infrastructure to mitigate potential impacts as they occur, and allow for land use of a low risk (for example temporary) nature. This option is rarely applicable to areas at risk of coastal erosion but is suitable to some areas prone to coastal inundation, where assets can be elevated above flooding to maintain land use in an otherwise hazardous area.

The ability for substantial, built assets to be redesigned to accommodate coastal erosion hazards is generally limited.

Emergency response plans and controls are also considered as a measure to accommodate hazards. This involves the implementation of plans for assets and areas that are at risk of coastal hazards, with procedures in place for before, during and after the events for safety. This would identify roles and responsibilities, and measures such as signage and barriers to prevent access.

**Pros**

- Relatively simple to implement for areas prone to inundation through planning controls i.e. requiring new developments to have minimum finished floor levels

**Cons**

- Is not effective for areas impacted by erosion
- Retrofitting existing structures to accommodate inundation would be challenging and costly
- Where substantial inundation levels are expected, the accommodate option may adversely impact on the character and amenity of the area.

## 7.2.4 PROTECTION

**7.2.4.1 Soft protection**

Dune management – involves development of ongoing program for revegetation and rehabilitation of the dune system, including wind break fencing.

Beach renourishment – involves placing sand on the beach or dunes following erosion to create an additional buffer for future storm events. Large scale beach renourishment can provide additional protection for 18 months to 5 years, before the shoreline recedes to its original position. The option can be used as an interim measure or on an ongoing basis, but should not be viewed as a permanent solution to protect against sea level rise.

To keep the shoreline in its current position to 2030, approximately 200,000m$^3$ of sand would be required for renourishment at an estimated cost of over $7 million. Further, only 10,000m$^3$ is currently excavated from the Point Peron sand trap annually and the availability of other beach sand sources to meet future demand is uncertain. As such, this temporary form of coastal management is not a feasible long term option.

**Pros**

- Relatively minor up front cost compared to other management options
- Does not require significant infrastructure
- Can delay the need for hard protection structures or managed retreat.

**Cons**

- Only offers interim temporary protection, not a feasible long term option.
- Significant ongoing cost
- The availability of suitable clean beach sand to meet future demand is uncertain

*Groyne, South Beach, Fremantle*

*Breakwaters, East Rockingham*

*Seawall, Mersey Point*

**7.2.4.2 Hard protection**

This option involves the construction of engineered revetments to protect landward assets from the impacts of coastal hazards.

It should be noted that no protection option is considered permanent, and all have associated expense to implement, maintain and remove.

This expense and the inability of protection options to permanently mitigate the risks associated with coastal hazards are the primary reasons why these options are considered the least favourable in the adaptation hierarchy.

Hard protection options also have the potential to divert coastal erosion hazards elsewhere, increasing risk for adjacent areas or assets and potentially creating liability for those responsible for the structures.

The feasibility of a number of protection measures (pictured) was investigated based on an assessment of local coastal dynamics, including the wave climate and sediment transport. The results are summarised below:

| Possible protection | Feasibility |
|---|---|
| Seawall | Most feasible |
| Groynes | Not recommended |
| Offshore breakwaters | Not recommended |

A selection of concepts for the purpose of illustrating these protection options can be seen in Appendix C. Based on the feasibility assessment, it was determined that seawalls were likely to be to most appropriate hard protection for the City's coastline, particularly as seawalls can be provide protection against both erosion and inundation.

Seawalls are hard structures built in front of assets along the coast, acting as a last line of defence against coastal erosion and inundation. Seawalls are very effective, however, they can increase the rate of erosion in front of the seawall due to wave refraction, resulting in complete loss of the sandy beach in front of the wall.

The potential to degrade beach amenity is likely to lower the acceptability of a seawall to the broader community, unless they perform the dual function of protecting broader areas from intermittent coastal inundation. Therefore, seawalls are not considered to be an option for areas that are only at risk from coastal erosion.

The estimated cost of constructing a seawall to protect areas vulnerable to erosion and inundation from Wanliss Street to the Causeway and from Boundary Road to Warnbro Beach Road is shown in the table below.

Note: In addition to the $31.71 million needed to protect key assets, there will be significant maintenance and asset replacement costs beyond the 50 year design life of the seawall. This does not include the cost of ongoing sand renourishment required to maintain some form of usable beach for public amenity in front of the wall.

Given that such volume of sand is unlikely to be available for this purpose in perpetuity, it is important to consider the social, commercial and environmental cost of eventually losing all usable beach in Rockingham, Shoalwater and Safety Bay.

| Total length of seawall (m) | Seawall cost | Maintenance cost to 2070 | Allowance for structural design | Total cost |
|---|---|---|---|---|
| 3900 | $23m | $ 8.5m | $210k | $31.71m |

**Pros**

- Provides interim protections against coastal hazards for the assets and private properties behind the seawall from coastal hazards

**Cons**

- Hard protection structures generally divert erosion issues elsewhere, such as to beaches either side of, and directly in front of, a seawall.
- They can have significant impact on coastal ecosystems.
- They require a significant up front capital cost and will require long term maintenance.
- Will result in complete loss of the beach (see picture).
- The beach may be reinstated through renourishment, however, this is not feasible in the long term due to cost and limited sand availability relative to increasing demand.
- Protects homes directly impacted by coastal hazards, however, the loss of beach amenity impacts on the broader community.

## 7.3 Triggers

An effective managed retreat strategy is dependent on well-defined triggers to commence actioning the transfer of private land to the public realm. In this regard, the CHRMAP Guidelines (WAPC 2019) provide the following guidance:

Managed retreat allows development to remain and be safely used until the coastal hazard risk becomes unacceptable. Initiation of the process to remove at risk development can be controlled by triggers such as:

1. 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 or structure.
2. Trigger 2. Where a public road is no longer available or able to provide legal access to the property.
3. Trigger 3. 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.

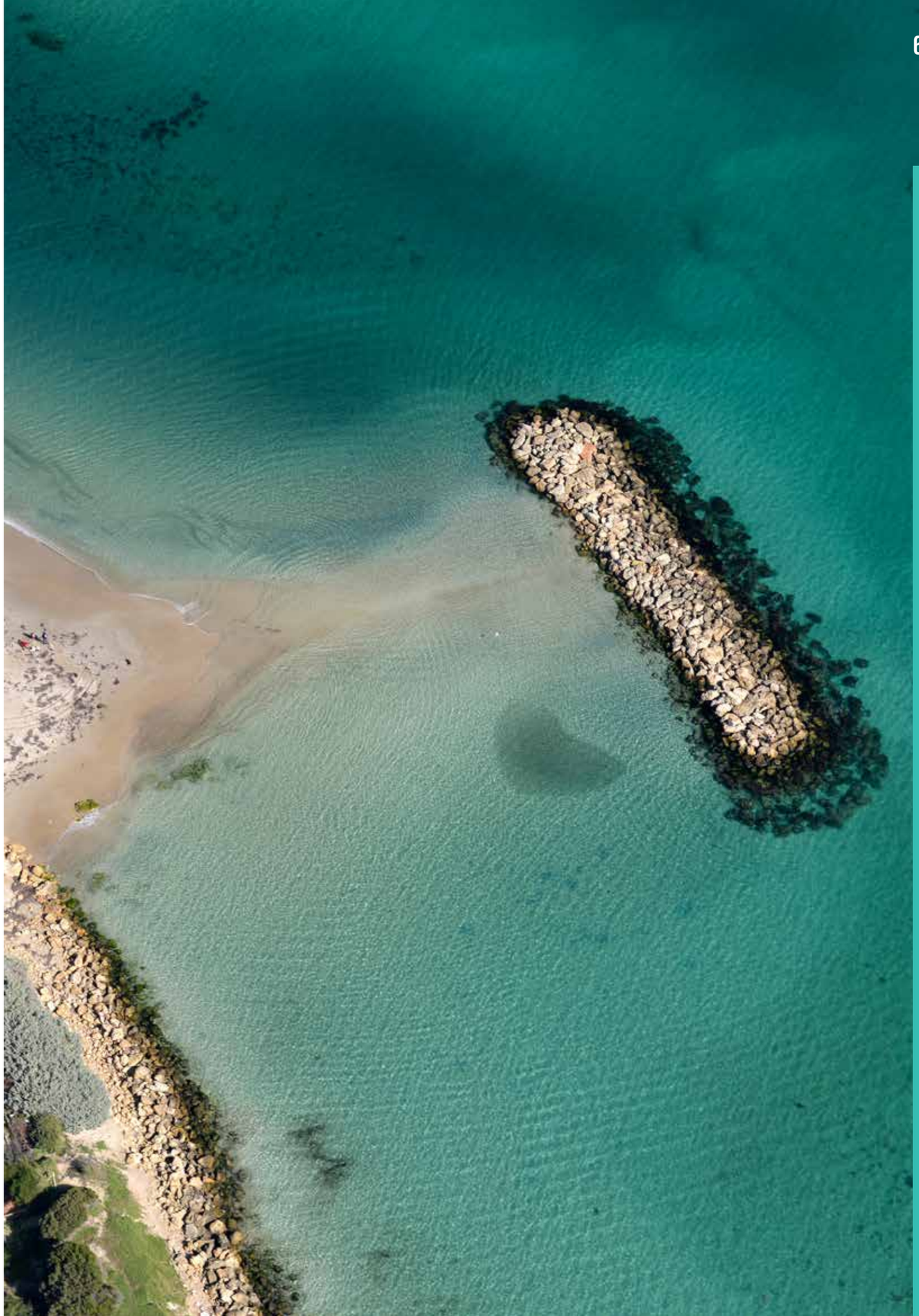
The CHRMAP Guidelines state that Trigger 1 can be varied where modelling has been undertaken in accordance with SPP2.6, to determine a suitable distance. As this modelling has been undertaken as part of the CHRMAP, the nominal 40 metre distance has been replaced with the calculated distance for this trigger (known as S1). This distance is site specific and varies along the City's coastline due to coastal exposure, shoreline profile and sediment size. These site specific S1 trigger values can be seen in the CHRMAP Technical Assessment Report.

For the purpose of guiding management pathways in this CHRMAP, various additional triggers have also been defined. These look at additional drivers for management actions, including social and economic drivers. The triggers also relate to the implementation of management responses other than managed retreat, such as the implementation of interim protection where this can be demonstrated to be appropriate.

## Recommendations

Given the CHRMAP is required to consider a 100 year planning timeframe, all recommendations are presented as:

- short term - requiring action before 2030; or
- long term - potential pathways are identified now, with decision points occurring beyond 2030.



# 8 Long term adaptation pathways beyond 2030

A range of options for addressing the challenges of coastal erosion and its effects on the coastal zone over the next century have been outlined. While it is natural that the community would prefer to protect and preserve the current features of the coastal zone, the reality is that unless some new and innovative protection methods are developed, the costs of maintaining current features will likely become prohibitively expensive at some point in the future, given current sea level rise projections. The interim nature of protection options needs to be recognised across the community, and the adaption options developed and solutions optimised for social, environmental and economic (affordability) drivers.

The CHRMAP Guidelines (WAPC, 2019) suggest the process for implementing future managed retreat should include compensation under provisions in the *Land Administration Act 1997*. In reality, this is unlikely to be financially feasible in the immediate to short term, unless the State or Commonwealth governments provide the majority of funding to acquire property.

It is important to note that while eventually managed retreat is recommended in some areas, future implementation will need further investigation of the implications for both government and private stakeholders.

Through further detailed economic and feasibility assessment, it is likely that the implementation of interim protection measures in certain areas will be confirmed as providing overall benefit to the City.

Interim protection would also delay the expensive implementation of managed retreat and allow decision points for long term adaptation pathways to be well in the future relative to the best available information and coastal hazard realities at the time.

The CHRMAP process is designed to be ongoing, with regular updates associated with the emergence and collection of new information, such as new legislation, climatic changes, or any new information that becomes available and that significantly modifies the understanding of coastal hazards.

## 8.1 Potential adaptation pathways, triggers and actions

Coastal hazards and their associated risks manifest over long time scales, generally not requiring implementation of costly response(s) until such time as a significant level of change has occurred. The adaptation pathway(s) approach enables for the establishment of a decision making strategy that is made up of a sequence of decision-points over time, preventing a decision maker from being locked into a particular management and adaptation option (and associated actions), 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, in that while not all decisions can be made today, they can be planned, prioritised and prepared for.

This approach is useful for dealing with uncertainty, ensuring that decisions made and associated actions undertaken today do not prevent alternative courses of action being chosen in the future consistent with the SPP 2.6 hierarchy and stakeholder and community values.

The key advantages of the pathways approach are:

1. It buys time to plan and reduces the pressure of making decisions now.
2. It reduces uncertainty by using events - not time - as decision points
3. Its flexibility enables the plan to reflect local circumstances
4. It keeps options open until there is more information, funding or support for options
5. It allows for learning along the adaptation journey.

Ultimately, decisions on adaptation pathways will be made by future communities and Councils.

Table 1 Summary of proposed adaptation pathways, triggers and possible actions.

| What is the pathway? | What are the triggers? | Recommended actions |
|---|---|---|
| Avoid residential or commercial development in areas identified for managed retreat, unless there is an overwhelming planning justification. | Where undeveloped land is identified as lying within the hazard extents. | • Implement planning controls to avoid inappropriate development of the land<br>• Continue to update hazard extent mapping as required relative to new information . |
| Managed retreat of minor public or drainage infrastructure where possible/appropriate. | When an asset is damaged, destroyed or becomes unsafe due to coastal hazards. | • Minor public and drainage infrastructure will be;<br>i) repaired to extend short term life and function, but left unprotected; or<br>ii) removed and relocated to a less vulnerable area. |
| Accommodate the risk of coastal hazards by implementing an Emergency Response Plan. | When the shoreline (HSD) is within the S1 distance refer to CHRMAP Technical Assessment Report for specific S1 values of most seaward asset. | • Remove major infrastructure (roads, carparks), residential and commercial buildings, and transfer land to public realm;<br>• Provide interim protection for major infrastructure (roads, carparks), residential and commercial buildings;<br>• Prepare response plans for minor infrastructure that could be impacted. |
| Investigate and implement planning controls for managed retreat. | Where residential or commercial property lies seaward of the 100 year coastal hazard erosion line. | • Include all affected land in a Special Control Area and ensure the hazard information is incorporated in structure planning<br>• Provide notification of potential hazards on certificates of title where possible or by direct contact with landowners. |
| Short term (to 2030) Undertake interim soft protection. | Where:<br>the beach and coastal foreshore reserve is significantly diminished with respect to its original state and function; or<br>the shoreline (HSD) is within the S1 distance (see CHRMAP Technical Assessment) of most seaward asset. | • Dune care to enhance a natural form of protection<br>• Sand renourishment where required. |
| Long term (beyond 2030)<br>Managed retreat in areas when triggers are reached | Where:<br>the shoreline (HSD) is within the S1 distance of most seaward asset;<br>a public road is no longer available or able to provide legal access to a property;<br>water, sewerage or electricity to a lot is no longer available as they have been removed/decommissioned by the relevant<br>authority due to coastal hazards;<br>an asset is damaged, destroyed or becomes unsafe due to coastal erosion; or<br>the overall community and stakeholders are no longer supportive of a specific coastal management technique or approach. | • Remove major infrastructure, buildings, acquire land and transfer to the public realm through MRS amendment<br>• Ensure mechanisms for compensation of landowners<br>• Realign public roads. |
| Long term (beyond 2030)<br>Implement long term hard protection in key areas when triggers are reached. | Where:<br>the shoreline (HSD) is within the S1 distance of most seaward asset;<br>the overall community and stakeholders are no longer supportive of a specific coastal management technique or approach;<br>a specific coastal management technique (i.e. soft protection) is forecast to no longer be economically or physically feasible within 10 years; or<br>the beach and coastal foreshore reserve is significantly diminished with respect to its original state and function. | Construct hard protection structures based on detailed analysis of feasible options (i.e. groynes, seawalls, breakwaters). |

*Refer to the CHRMAP Technical Assessment Report for a detailed explanation of adaptation and management options, pathways and triggers relative to each sector.*

## 8.2 Priority areas for long term protection and managed retreat

### PRIORITY AREAS FOR LONG TERM PROTECTION

**How were they selected?**

- Where both erosion and inundation impacts were present, meaning a large proportion of residents would benefit from costly protection.
- Areas of key community attraction and commercial activity.
- Significant infrastructure without clear alternative locations to perform the required function (i.e. Safety Bay Road).

**What does this mean?**

- Hard protection structures such as groynes, seawalls or breakwaters may be constructed in these locations to protect against erosion and inundation hazards.
- Increased development density may be permitted in areas vulnerable to coastal hazards where long term protection is identified and there is an overwhelming planning justification
- New development in these areas may be required to contribute to the ongoing maintenance of the seawall.

**Things to note:**

- If hard structures are installed to protect landward assets, this will significantly impact the amenity in the beach in these areas long term.
- The type and suitability of structures to be installed will require further modelling and detailed analysis.
- The City will not be constructing protection until triggers are reached, likely beyond 2030 or even 2070.
- The need for protection in these areas will be revised relative to new information when the CHRMAP is reviewed in 10 years.


*Example of Groynes (UK)*

*Example of Breakwater (UK)*

*Seawalls*

## PRIORITY AREAS FOR MANAGED RETREAT

### How were they selected?

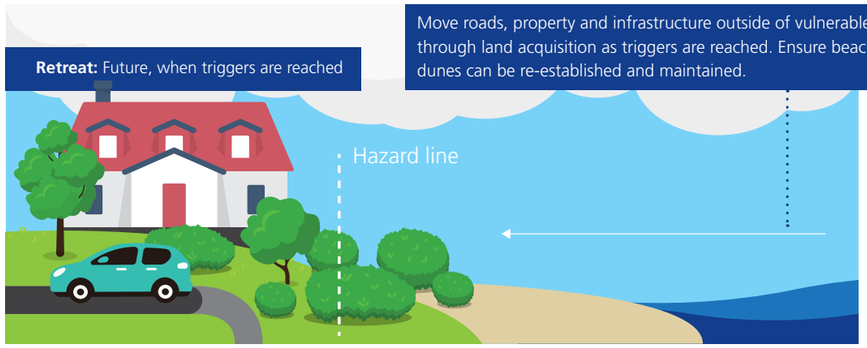
- Where only erosion impacts were present, with proportionately fewer residents benefiting from costly protection.
- Recognising the importance of maintaining natural beach environments along considerable portions of the coast, reflective of the community's values.

### What does this mean?

- All landward assets (private property, roads, public infrastructure) vulnerable to coastal hazards in these areas will eventually be retreated through land acquisition to ensure a foreshore reserve is retained for community use and future generations.
- Increased development density may not be permitted in areas vulnerable to coastal hazards where potential long term managed retreat is identified.
- New development might be considered where time limited approvals or other planning controls are in place.

### Things to note:

- The sandy beach, dunes and natural foreshore reserve will be preserved in these areas.
- Managed retreat will not be implemented until absolutely necessary, when certain triggers are reached likely beyond 2070.
- The City would not acquire private property for transfer to the public realm unless there was sufficient funding for compensation, with contributions from the state and federal government.
- The need for managed retreat in these areas will be revised relative to new information when the CHRMAP is reviewed in years.


*Dunes and sandy beach are retained*

## 8.2 Long term pathways – Summary by Sector

**8.2.1 Sector 1 Municipal Boundary (North) to Wanliss Street**

The assets in the sector are not predicted to be highly vulnerable in the short term. When affected by coastal hazards and no longer safe or serviceable, minor infrastructure should be removed and relocated or replaced (if necessary) in a less vulnerable area.

Significant public infrastructure and residential and commercial property is likely to be highly vulnerable at some stage across the future planning timeframes, hence there may be overall benefit in using an interim protection measure for the sector, to delay the timing of this managed retreat.

Such a protection measure should maintain the amenity of the coastal foreshore reserve and be funded under the beneficiary pays principle. Managed retreat is likely to be triggered when Rockingham Beach Road requires removal due to intolerable risk or to maintain a suitable foreshore reserve, which isn't expected beyond 2070. This would also trigger the removal of the first row of houses along Rockingham Beach Road, due to loss of legal access, although the houses aren't expected to be impacted until 2100. This is reflected in the erosion hazard maps in Section 5. As reflected in section 6, inundation is not a concern in this sector.

The maintenance and enhancement of the beach and dune system, through dune care, sand management and beach nourishment, should be considered in the sector as these assets provide a valuable, natural protective function.

Acknowledging the strategic economic importance of CBH Kwinana Grain Terminal to the State, this infrastructure has been identified as a priority area for long term protection, subject to this protection being funded by CBH Group or the State.

**8.2.2 Sector 2A: Wanliss Street to Garden Island Causeway**

Significant public infrastructure and residential and commercial property is predicted to be highly vulnerable in the short term, requiring interim protection. Palm Beach and the area near Hymus Street are identified as potentially vulnerable in the short term and are therefore hotspots for a detailed options assessment of protection structures before 2030.

Long term protection is likely to be triggered when Esplanade and/or Rockingham Beach Road is subject to intolerable risk as the interim protection is no longer sufficient. Long term protection is identified in this sector, as opposed to managed retreat, given:

- the importance of the commercial area at Railway Terrace to the community
- the social value of Bell and Churchill Parks to the community
- the dual function of addressing coastal erosion and inundation hazards in this area, protecting a significant portion of private and public assets.

There is likely to be overall benefit in using an interim protection measure for the sector, particularly if it also mitigates coastal inundation hazards, which are predicted to increase risk levels significantly over future planning timeframes.

Any protection measure should maintain the amenity of the coastal foreshore reserve, including key recreation areas such as parks, and be funded under the beneficiary pays principle. Further investigation is required to determine how best to prepare for and accommodate risk for Lake Richmond, which is predicted to be affected by sea level rise and other climate change impacts across the planning timeframes.

It is possible that the existing flap valves on the Rockingham Main Drain (Water Corporation), which currently offer protection to the hydrologic regime of Lake Richmond, may lessen the extent of inundation around and upstream of the lake in the medium term. In the long term, however, sea level rise and coastal process changes may mean the current flap valves become ineffective and new management measures would be required. The need to review the operation of this drain in the future has been acknowledged by Water Corporation through development of this CHRMAP.

**8.2.3 Sector 2B: Garden Island Causeway to Boundary Road**

Some assets in the sector have been assessed as highly vulnerable in the short term, which could require a significant change in the management approach for the area. The management pathway for the sector should look to avoid further permanent development in the coastal foreshore reserve.

When affected by coastal hazards and no longer safe or serviceable, minor infrastructure should be removed and relocated (or replaced if necessary) to a less vulnerable area.

Due to the low concentration of vulnerable assets in the sector along Cape Peron and their lower economic value compared to other key vulnerable assets in the City, a managed retreat approach would be applicable for all built assets in this sector. It is noted, however, that potentially vulnerable land uses and responsible authorities in this sector include:

- Point Peron Reserve and leased land, Department of Biodiversity, Conservation and Attractions
- Point Peron Waste Water Treatment Plan (WWTP), Water Corporation
- Garden Island Causeway abutment, Department of Defence
- Point Peron boat ramp, City of Rockingham

Long term, it is expected that the Department of Defence will apportion funding as required for protection and upgrade of the Garden Island Causeway to ensure access to HMAS Stirling is not impacted.

Water Corporation has advised that the infrastructure potentially affected on its land in this sector includes some drainage infrastructure, local reticulation networks for water and wastewater services, at least one pump station, the Point Peron wastewater treatment plant and the Sepia Depression Ocean Outlet Line (SDOOL) and associated infrastructure. Generally, significant impacts on identified infrastructure are not expected until after 2030.

Water Corporation's most critical potentially impacted assets are the Point Peron WWTP and the SDOOL. While Water Corporation currently plans to decommission Point Peron sometime around 2030, there is a long term intention to retain and expand infrastructure on that site in order to increase the capacity of the SDOOL. As part its future planning for the site, the Water Corporation will consider the need to protect and secure essential infrastructure in the long term, taking into account the results of the City's CHRMAP.

The boat ramp in this sector is not likely to be vulnerable in the short term and this will be monitored as recommended for all boat ramps. Long term, when this infrastructure is due for replacement, it would be designed and constructed to allow for coastal hazards as required.





**8.2.4 Sector 3: Boundary Road to Shelton Street**
The assets in the sector have been assessed as highly vulnerable in the short term, which could require a significant change in the management approach for the area.

The southern side of Mersey Point has been identified as a hotspot for further detailed assessment of interim protection options in the short term, before 2030. Any protection measure should maintain the amenity of the coastal foreshore reserve and be funded under the beneficiary pays principle. In the short term, maintenance and enhancement of the beach and dune system, through dune care, sand management and beach nourishment, should be applied in the sector as required.

The areas from the southern side of Mersey Point around to Donald Drive are identified as priority for long term protection, as opposed to managed retreat, given:

- the dual function of addressing coastal erosion and inundation hazards in this area, protecting a significant portion of private and public assets.

It is noted, however, that the construction of protection structures in this sector will require approval from the Department of Biodiversity, Conservation and Attractions, given its location within the Shoalwater Islands Marine Park.

Managed retreat in the remainder of this sector is likely to be triggered when Arcadia Drive or Warnbro Beach Road requires removal due to intolerable risk or to maintain a suitable foreshore reserve. This would require the removal of the first row of houses along these roads due to loss of legal access, but only when the risk of coastal hazards in these areas becomes intolerable and certain trigger levels are reached. Given Shoalwater Foreshore is very well valued by the community for its natural attributes, the importance of retaining these values through managed retreat is considered paramount. If long term protection via a seawall was identified in this location, community members would no longer be able to walk along the sandy beach of Shoalwater Bay in the future.

**8.2.5 Sector 4A: Shelton Street to Bayeux Avenue**
The assets in the sector are not predicted to be highly vulnerable until later in the century.

When affected by coastal hazards and no longer safe or serviceable, minor infrastructure should be removed and relocated or replaced (if necessary) to a less vulnerable area. In the short term, maintenance and enhancement of the beach and dune system, through dune care, sand management and beach nourishment, should be considered in the sector as required.

Public infrastructure and residential and commercial property may be highly vulnerable at some stage across the future planning timeframes, requiring managed retreat from the area. There may be overall benefit in using an interim protection measure in some parts of the sector, to delay the timing of this managed retreat. Such a protection measure should maintain the amenity of the coastal foreshore reserve.

Given this area is very well valued by the community for its natural attributes such as the Warnbro dunes, the importance of retaining these values through an eventual managed retreat pathway is considered paramount.

**8.2.6 Sector 4B: Bayeux Avenue to Becher Point**
The assets in the sector are not predicted to be highly vulnerable in the short term. The management pathway for the sector should look to avoid further permanent development in the coastal foreshore reserve.

When affected by coastal hazards and no longer safe or serviceable, minor infrastructure should be removed and relocated or replaced (if necessary) to a less vulnerable area.

Major built infrastructure, including residential property at Port Kennedy is likely to be highly vulnerable at some stage across the future planning timeframes. There may be overall benefit in using a seawall to provide interim protection for built assets, to delay the timing of long term protection or eventual managed retreat. Such a protection measure should maintain the amenity of the coastal foreshore reserve.

In relation to the future Kennedy Bay development, the proposed Town Centre area has also been identified as a priority for long term protection (i.e. with a seawall), provided it is funded by the developer or the State.

The boat ramp in this sector is not likely to be vulnerable in the short term and this will be monitored as recommended for all boat ramps. Long term, when this infrastructure is due for replacement, it would be designed and constructed to allow for coastal hazards as required.

**8.2.7 Sector 5 Secret Harbour Foreshore Park to Turtles Bend;**
Some assets in the sector are predicted to be highly vulnerable in the second half of the century.

When affected by coastal hazards and no longer safe or serviceable, minor infrastructure should be removed and relocated or replaced (if necessary) to a less vulnerable area.

Public infrastructure such as carparks and the Secret Harbour Surf Life Saving Club may be highly vulnerable at some stage across the future planning timeframes, requiring managed retreat from the area, however, it is likely that this would occur beyond 2070 by which time the infrastructure will be due for replacement.

The maintenance and enhancement of the beach and dune system, through dune care and sand management, should be considered in the sector. These assets provide a valuable, natural protective function.

**8.2.8 Sector 6 Turtles Bend to Municipal Boundary (South)**
There are very few built assets predicted to become vulnerable before 2110.

When affected by coastal hazards and no longer safe or serviceable, minor infrastructure should be removed and relocated or replaced (if necessary) to a less vulnerable area.

The maintenance and enhancement of the beach and dune system, through dune care and sand management, should be considered in the sector. These assets provide a valuable, natural protective function.

# 9 Short term actions to 2030

## 9.1 Building Understanding

Action1. Engage the community to present the results of this CHRMAP and collect their feedback on the acceptability of adaptation options and pathways.

Critical to the CHRMAP process is ongoing community engagement. The City will ensure the results of the CHRMAP are well communicated to ensure transparency, educate the community on coastal processes and the hazards associated with sea level rise, and seek their feedback on the acceptability of the range of adaptation measures presented.

## 9.2 Funding

Action 2. A detailed economic assessment should be undertaken to establish the economic value/contribution of natural assets in key vulnerable areas.

This assessment should look at the range of direct and indirect economic benefits provided by beaches and the coastal foreshore reserve (including parks). The assessment should focus on Sectors 2 and 3, where the highest vulnerability is present in the short term. The assessment should incorporate:

- estimates of beach visitation and surveys of beach visitors to assist in estimating tourism, external and local visitor value;
- an assessment of the effect of proximity to the beach on property values as well as the identification of any links between beach quality (beach width, useability etc.) and local property value;
- assessment of the beach's contribution to local business revenue, for example by assessing seasonal trends in turnover;
- assessment of the economic value of the environmental functions of the beach and foreshore; and
- identification of existing beneficiaries and the level to which they benefit from the natural assets.

A critical information gap existing at present, that is required to inform a proper cost-benefit analysis of future adaptation options, is an estimate of the economic value/productivity of beaches and other natural assets. This input is required to establish a 'base case' for economic analysis, against which costs and benefits can be assessed. This will be required to inform detailed options assessments, such as those recommended in Section 5.4. It will also be important to inform the next CHRMAP review.

Action 3: Investigate and establish a fund for Coastal Hazard Management and Adaptation and allocate funding sources.

The estimated long term management cost by 2100 will ultimately vary depending on the triggers reached and where the City chooses to protect and/or retreat. Regardless, the cost is likely to be considerably greater than the City's current expenditure on coastal management.

The City will continue to advocate for part funding from the Federal and State Governments, however, must also establish funding arrangements to ensure the City is well placed in the future to make the most appropriate decisions for the community and stakeholders, when the time comes.

As such, the City will establish a fund for management of coastal hazards. Funding may need to be directed towards a combination of interim protection, to hold the shoreline in place, or compensation for affected landholders to implement managed retreat and allow the shoreline to recede.

Levels of funding required should be informed by economic values presented in this CHRMAP and more detailed economic analyses performed through the proposed detailed options assessments.

There is a range of potential revenue raising mechanisms which could be used to establish a Coastal Adaptation and Management cash reserve, such as applying:

- a percentage increase to all rates (i.e. additional 1% per year), acknowledging that the coastline is a public asset to the whole community, not only those who live in close proximity to the coast.
- a specified area rate to apportion funding contributions, aligning them with the level of benefit that certain rate payers will receive as a result of management.
- A differential area rate based on TPS2 zoning and land use
- the requirement for developer contributions. Such contributions would be required where a development is set to benefit from its proximity to the coast and, therefore, the management of the coast in the area.
- a user pays principle, collecting revenue from paid parking at the foreshore and boat ramps. Sourcing funding in this way would need to be carefully approached, given that the intent of the CHRMAP is to ensure the beach and coastal foreshore reserve is a public asset that should be available to all members of the community.

Further investigations are required prior to collecting revenue specifically for a Coastal Hazard Management and Adaptation fund. An associated policy framework would also be required to guide future allocation of this funding.

For now, it is proposed that modest annual inputs be allocated into a cash reserve for coastal adaptation through existing budgeting processes, relative to other priorities.

Identification of targeted revenue raising mechanisms, preparation of a Coastal Adaptation Costing Plan to inform potential rate increases and investigation of a DCP for protection areas would then await the next CHRMAP review (10 years), so that these items can take into account:

- The proposed coastal monitoring dataset;

- Revised IPCC sea level rise projections;

- Revised SPP 2.6; and

- More informed adaptation cost estimates.

Following revision of the hazard lines with the next CHRMAP review, a Coastal Adaptation Costing Plan document could operate in a similar manner to the Community Infrastructure Plan, providing a robust foundation for collection of funding specifically for a Coastal Hazard Management and Adaptation fund.

Future advocacy for State and Federal Government funding should aim to be specific, with the cost of proposed actions well justified in response to triggers, community values and comprehensive coastal planning.

## 9.3 Land use planning

Western Australia's preference for addressing coastal hazards by way of a State Planning Policy is a less stringent framework than the legislative approach by other states. It requires that local authorities have due regard to the policy when preparing or modifying schemes and assessing development proposals.

The following planning instruments are generally consistent with those outlined in CHRMAP Guidelines (WAPC, 2019) and have varying applicability in the context of the City.

**Structure Planning**
In areas where development or redevelopment of coastal land is proposed, all local structure plans should properly incorporate the requirements of the City's CHRMAP, to account for coastal hazard risks and ensure an appropriate coastal foreshore reserve is included. This instrument will have limited effect in the context of the City, given much of the land identified as vulnerable is already developed.

**Special Control Areas (SCA)**
To ensure discretion over any further development proposed in coastal hazard areas and to identify areas likely to require eventual managed retreat. The SCA would be based on the coastal hazard mapping (a SCA for inundation and a SCA for erosion) in this CHRMAP and be reflected in TPS2, as required by the P&D Regulations, Schedule 1, Part 5. The SCA would require planning approval for normally exempt development to ensure coastal hazards are considered in the decision making process and enable the application of notifications on titles.

It is noted that some forms of development cannot be controlled by a SCA, such as works carried out by the State Government under the Public Works Act 1902. Inbuilt flexibility would be required to permit certain public infrastructure on land prone to coastal processes, where deemed necessary and appropriate.

The City should liaise with the State regarding such development, to ensure it is not incongruous with the long term pathway set out for the area.

**Local Planning Policy (LPP)**
IA LPP would be linked to the SCA under TPS2 and provide guidance for applicants and decision-makers in relation to assessment procedures and development standards on land prone to coastal hazards. The LPP could outline coastal adaptation options from the CHRMAP, include 'as-of-right' criteria and performance-based criteria for achieving compliance with TPS2 provisions, refer to design guidelines where applicable and establish procedures to manage risk when approving development in coastal hazards areas.

**Scheme Amendment**
An amendment to TPS2 would be required to reference the SCA, Local Planning Policy and associated hazard mapping, to identify the permissibility of uses on land subject to coastal hazards and to permit temporary approvals (time limited) where appropriate.

**Design Guidelines**
Design Guidelines would be referenced in the LPP and might specify appropriate design responses for individual development proposals (e.g. relocatable dwellings, prescribed setbacks, finished floor levels) and outline preferred options in an 'as-of-right' approval arrangement in compliance with the accompanying Local Planning Policy.

**Notifications on Title**
Require the provision of a Section 70A notification on the Title 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.

**Time Limited Planning Consent Conditions**
To allow, where appropriate, the temporary use of land in hazard areas until hazards materialise, while ensuring that the City maintains a level of discretion over development in these areas. Time limits on development approvals could be set using coastal hazard mapping projections. If the approval expires before hazards materialise, the proponent may apply for an extension to the approval. If hazards materialise before the time limit expires, the City would consider requiring the demolition or removal of compromised structures under relevant legislative provisions.

Event-based triggers can also be used, but are not preferred due to the inherent uncertainty around defining coastal hazard events in the coastal environment and the ability to respond in a timely manner.

Where development is proposed behind a protected coastline, the lifecycle of the protection mechanism should determine the time limit permitted on planning consents. Maintenance and capital costs of any protection should be funded by the beneficiaries of the protection.

**Development applications for subdivision and zoning**
Beyond existing scheme allowances, application for further subdivision should not be permitted within coastal hazard areas, except where a strategy for long term protection is adopted in key locations. If a long term strategy for protection is in place then further development can be supported, provided developer contribution requirements or specialised area rates are in place to enable collection of funds for the construction, maintenance and upkeep of the seawall in the future.

**Other instruments**
There are a range of other instruments, including 'transferable development rights', 'leaseback of land', 'land swaps' and 'rolling easements'. These instruments remain conceptual in the WA planning context and are not provided for under the State's planning framework at present. These concepts require more research to determine how they would be practically implemented, but may be considered by the City in future.

### 9.3.1 Planning recommendations

In light of the above, instruments available to address coastal hazards have been considered by the CHRMAP and the following actions are recommended.

> Action 4: Existing and proposed structure plans should be reviewed to ensure they adhere to SPP2.6 and account for the risks identified in this CHRMAP.

All structure planning should account for the hazards identified in this CHRMAP and the requirements of SPP2.6. The primary mechanism for achieving this through structure planning will be the allocation of a suitable portion of land as coastal foreshore reserve. This foreshore reserve should be of adequate width to account for the 2110 coastal erosion hazard line, and also ensure a functional foreshore area will remain should this hazard extent be realised in the future.

> Action 5: TPS2 should be amended to incorporate SPP2.6 and include vulnerable areas as Special Control Areas (SCA).

It is recommended that TPS2 be amended to directly reference SPP2.6. Wording and placement of this reference is specified in the CHRMAP Guidelines (WAPC 2019). It is also recommended that TPS2 be amended to incorporate areas lying within the 2110 coastal erosion and inundation extents as SCAs. Two SCA's will be required, as different controls will be required in areas prone to erosion, compared to areas prone to inundation. The SCA for erosion is likely to exhibit a greater level of control and should, therefore, prevail in areas of both erosion and inundation hazard. The SCA classification should be used to facilitate land use changes and ensure development control over the identified areas. The nature of the SCA would be distinct for areas at risk of erosion, compared to those at risk from inundation. They should function as follows:

- The SCA for coastal erosion should be based on the 2110 hazard extent, plus an additional allowance for future foreshore amenity;
- The SCA for coastal erosion should establish the intent to eventually retreat from the identified area, where this is identified as the priority long term pathway;
- Both SCA's should require that all development in the area requires approval, allowing the City to control development and ensure it aligns with the long-term pathways for the area;
- SCA's should not extend over areas zoned such that development is already prohibited, such as Parks and Recreation Reserve.

> Action 6: Landholders that may be affected by coastal hazards by 2110 should be notified directly and by the application of notification on Certificates of Title where possible.

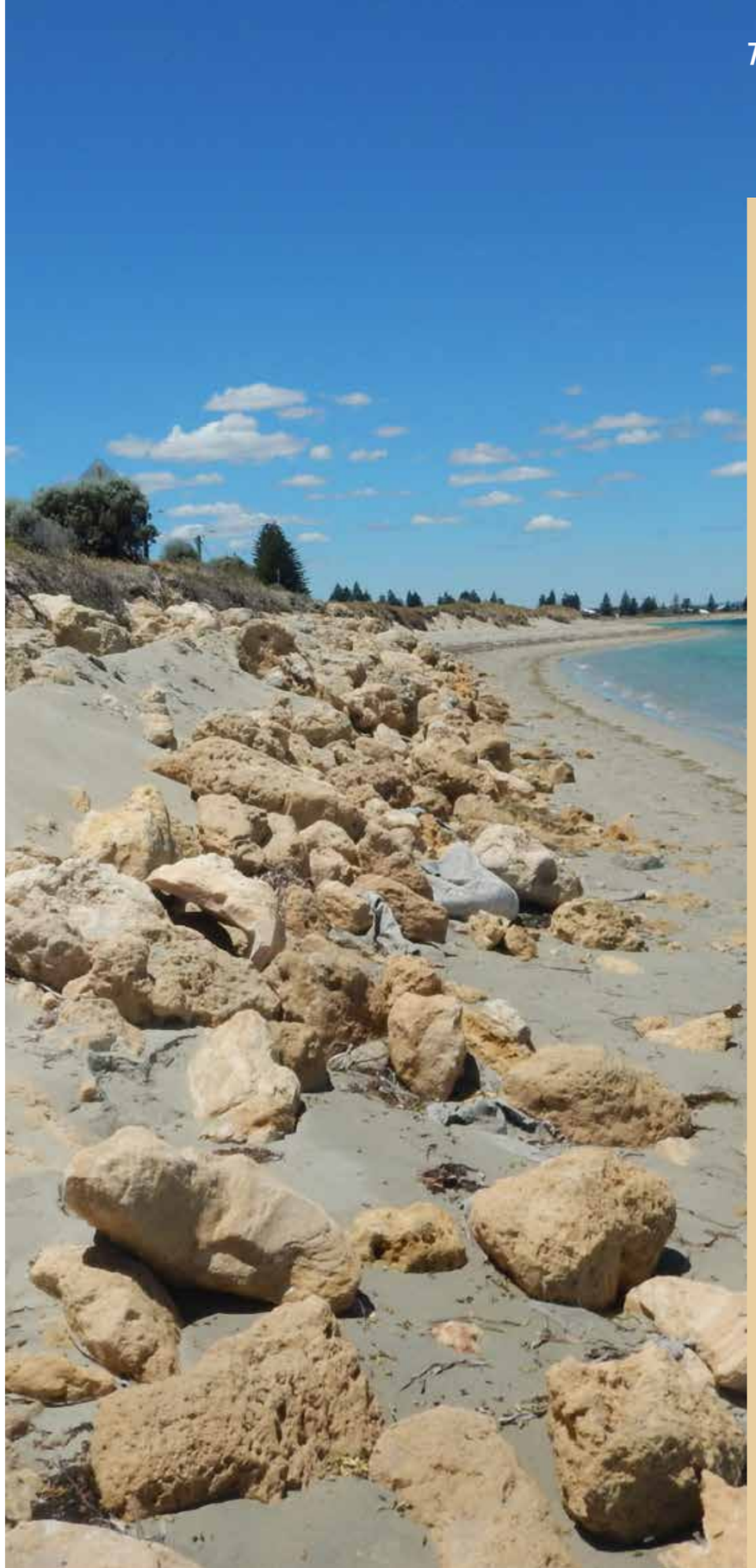
It is important that the City notify the community and potentially affected landholders and stakeholders of the results of the CHRMAP and the extents of potential coastal hazards. The City will notify owners of land situated within the mapped 100 year erosion and inundation extents directly, via mail or email. There are also mechanisms to apply notification of the potential hazards to Certificates of Title and these should be implemented where possible.

### 9.3.2 Leases

Where the City leases facilities on land vulnerable to coastal hazards short term measures would include:

- notifying all affected leasees of potential coastal hazards
- reviewing the suitability of lease arrangements relative to the CHRMAP at such time that new leases are applied for or existing leases are due for renewal
- if leases are in an area identified for protection or with hazards not likely to be realised until 2070, then renewing for a term up to 20 years may be appropriate
- if leases are in an area likely to be vulnerable in the short term, consider not leasing, or leasing with a reduced term or event-limited arrangement.

The suitably of leases in the future would need to be investigated relative to the findings of future CHRMAPs and long term adaptation pathways selected.



## 9.4 Managing Short Term Hotspots

### 9.4.1 Ongoing protection

Action 7: Initiate/continue targeted beach nourishment in vulnerable areas.

In the short term, beach nourishment should continue to be employed to manage coastal erosion hazards along the City's coastline. With predicted sea level rise, the volume of sand required is likely to increase and it will be important to allocate nourishment effort as effectively as possible. Nourishment activities are often reactive and are in response to threats to individual assets or isolated areas. While this may seem necessary, it could be an inappropriate allocation of resources.

The City will review past nourishment activities and plan future activities in light of the results of hazard modelling undertaken as part of the CHRMAP. Nourishment should target areas with the highest overall vulnerability and also consider where the most value can be added through the activity, such as by improving beach amenity at popular beaches. Areas where nourishment should be considered/continued include:

- along Rockingham Beach between Catalpa Park and The Cruising Yacht Club due to the vulnerability of landward assets, the potential for event-based erosion and the opportunity to improve beach amenity;
- to the north of Shoalwater Foreshore Park due to the vulnerability of landward assets, the potential for event-based erosion and the opportunity to improve beach amenity;
- along the southern side of Mersey Point due to the vulnerability of landward assets;
- to the west of Safety Bay Foreshore Park due to the vulnerability of landward assets, the potential for event-based erosion and the opportunity to improve beach amenity; and
- in front of vulnerable infrastructure (predominantly carparks) due to the vulnerability of landward assets, the potential for event-based erosion and the opportunity to improve beach amenity.

Effective beach nourishment programs should consider the various components that increase success and the longevity of protection. These include:

- selecting the appropriate location for placement;
- using the most effective placement volume, footprint and profile;
- selecting appropriate sand in terms of grain size and colour; and
- timing nourishment for greatest effect.

Specific criteria for when and where nourishment should be placed can be developed and refined through data collected during ongoing shoreline monitoring (R11), as well as through other specialist investigations including sediment transport analysis (R13), detailed management options assessments (R8, R9) and even community engagement (R1) and economic assessment (R2) - to identify where nourishment would be most beneficial from a social perspective.

### 9.4.2 Sector 3 Vulnerability

Action 8: Undertake a detailed options assessment for management of coastal vulnerability in Sector 3 with a particular focus on ongoing erosion issues at Mersey Point.

The City will undertake a detailed options assessment of potential mitigation measures for vulnerable areas in Sector 3. The study should consider the implementation of managed retreat, groynes, offshore breakwaters, seawall(s) and nourishment, in isolation or as a combination. The detailed assessment should consider the methodology outlined in Coastal Management - Local Coastal Hazard Assessment (Department of Transport 2018).
Mersey Point is currently experiencing erosion issues and this should be an area of priority for the treatment options. A detailed options assessment should include the following:

- detailed engineering feasibility of coastal protection structures;
- sediment transport modelling to estimate the future changes to the shoreline, with the installation of structures or without management; and
- detailed costings of the management options and a detailed cost-benefit analysis, assessing the full lifecycle of each prospective option and determining the value of natural assets involved.

Interim protection should still aim to achieve as natural looking and feeling beaches as possible, reflective of the community value placed on these attributes.

It should be noted that to properly assess and implement major management options, R13 will require implementation. Ideally R1 would also be undertaken to inform the assessment, if possible.

### 9.4.3 Sector 2A Vulnerability

Action 9: Undertake a detailed options assessment for management of coastal vulnerability in Sector 2A, with a focus on the area near Hymus Street.

The City will undertake a detailed options assessment of potential mitigation measures for vulnerable areas in Sector 2A. The study should consider the implementation of managed retreat, groynes, offshore breakwaters, seawall(s) and nourishment, in isolation or as a combination. The assessment should consider the methodology outlined in Coastal Management - Local Coastal Hazard Assessment (Department of Transport 2018). A detailed options assessment should include the following:

- detailed engineering feasibility of coastal protection structures;
- sediment transport modelling to estimate the future changes to the shoreline, with the installation of structures or without management; and
- detailed costings of the management options and a detailed cost-benefit analysis, assessing the full lifecycle of each prospective option and determining the value of natural assets involved.

Interim protection should still aim to achieve as natural looking and feeling beaches as possible, reflective of the community value placed on these attributes.

It should be noted that to properly assess and implement major management options, R13 will require implementation. Ideally R1 would also be undertaken to inform the assessment, if possible.

### 9.4.4 Emergency Hazard Response

Action 10: Update the existing asset inventory to identify vulnerable assets and prepare an emergency/ damage response plan to respond to potential coastal impacts.

The City will use the hazard extents derived through the CHRMAP, specifically those for the present day and 2030 planning timeframes, to create an inventory of assets that could be impacted, further to the existing asset database on Intramaps.

With the identification of vulnerable assets, the possible result of impacts shall be assessed and any potential risks to public safety identified (flooding, unsafe/unstable infrastructure etc.). The City will develop a plan to respond to hazardous events, and the asset damage and scenarios that could be associated with them. This plan might involve the rapid installation of signage and access prevention, the timely removal of damaged assets and response plans for emergency situations.

## 9.5 Monitoring and further investigation

Monitoring and further investigation is recommended with respect to the CHRMAP process and has been defined to better inform future iterations of the City's CHRMAP. Further investigation that will refine estimated risk levels and inform management beyond the CHRMAP process has also been recommended.

### 9.5.1 Long-term coastal monitoring (S2, S3)

Action 11: Initiate a long term coastal monitoring program, incorporating ad hoc storm and metocean monitoring, and coastal asset condition assessments.

Long term estimates of recession are typically derived using historic high resolution aerial imagery. This provides a useful indication of how the shoreline has moved in the past. Due to the difficulties in defining shoreline positions from aerial imagery, it is common practice to use the vegetation line as an indicator of shoreline movement. Whilst this is a useful analysis to estimate historic long term trends, it is emphasised that the vegetation line does not necessarily move at the same rate as the shoreline.

This is further complicated in the assumption that the shoreline will erode due to rising sea levels. Noting that sea levels have risen in the past, the sea level rise component (S3) of historic erosion is typically (conservatively) assumed to be negligible. Moving forward, sea level rise is predicted to accelerate, so any future updates to the CHRMAP process may need to split historic erosion rates into an underlying erosion rate and a rate due to sea level rise.

To inform future revisions of the CHRMAP and to identify the current position of the HSD, the City will implement regular monitoring, in addition to analysis of collected aerial imagery. The City already undertakes coastal monitoring through the Peron Naturaliste Partnership.

The existing program will be assessed alongside the recommendations in this report, to achieve efficiencies, improvements and collaboration where possible, and avoid unnecessary repetition of monitoring activities. In view of this CHRMAP, the monitoring program should include:

- regular analysis of aerial images, vegetation lines, and creation of GIS layers to describe them. i.e. digital tracing of vegetation lines and shorelines (at least in key vulnerable areas) in a GIS format, to allow analysis and comparison over time;
- 6 monthly beach profile monitoring at set transect locations, spaced at 50 to 100 metre intervals, depending on the change in orientation of the shoreline (i.e. long straight beaches can have surveys wider apart). The surveying should prioritise areas with the highest vulnerability at present. Ideally, all of Sector's 1, 2 and 3 should have surveying commence as soon as possible, to ensure the longest dataset possible is available to inform future management. These should be timed to occur in the intervals between the Perth seasonal summer and winter (approximately April and October/November, respectively);
- nearshore bathymetric surveys on an annual basis (or 6 monthly in association with beach profiles if feasible);
- sediment sampling at beach profile locations (6 monthly). Ideally, samples would be analysed for particle size distribution by a laboratory. Lab analysis can be expensive and other options are available, such as analysing with sediment sizing cards, and/or the collection and storage of sediment samples for future analysis if/when required;
- installation of remote imagery cameras - As well as providing ongoing information on the state of beaches, cameras also capture a range of other data, including storm effects, beach visitation, coastal inundation extents and seasonal variations that could be missed by beach profile surveys;
- storm monitoring and metocean data collection as described below (Section 9.5.2);
- regular analysis of collected data (every 2-5 years as required) alongside wind data collected by the Bureau of Meteorology, and water level and wave data collected by the DoT.

The City shall engage a specialist coastal monitoring consultant to review and formalise the monitoring program for the entire coastline. This would include development of a monitoring manual, which also includes instruction around storm monitoring.

### 9.5.2 Storm and metocean monitoring (S1)

The collection of data around storm events will be valuable in refining estimates of how vulnerable beaches within the City are to storm-based erosion. The collected data can be used to validate the modelled erosion extents. These extents are critical to adaptation planning because they are used as a trigger distance to initiate a change in the management pathway, such as a shift to managed retreat.

As such, the City will seek to incorporate ad hoc storm monitoring in key vulnerable areas into the recommended long-term coastal monitoring program. The key components of the program would be shoreline profiling and sediment sampling, targeting vulnerable sections of coastline before and after storm events. Sampling should target the most severe storm events, or those with the greatest potential to lead to shoreline impact.

Predicting the duration and intensity of forecast storms is difficult and, furthermore, predicting their ability to impact the shoreline is impossible. Notwithstanding this, there are several key factors that should be assessed when selecting a storm to monitor. These are as follows:

- Predicted wave height, period and direction (forecast of these is available at websites such as Seabreeze and Willy Weather). Higher wave height and longer wave period means higher wave energy and greater ability to erode the coastline. A wave direction that is less obstructed by offshore island and reefs is also preferred;
- Predicted tide / water level (available at the websites above or from the Bureau of Meteorology website). Water level is highly important in a storm's ability to impact the coastline. Storms should be chosen where the peak of the storm is predicted to occur at high tide, ideally during spring tides; and
- Predicted storm duration. Generally, storms with a longer duration will have higher impact on the coast. Longer duration also means there is the potential for storm peak(s) to occur during elevated water levels.

Once a storm has been selected for measurement, data should be collected as close to the start and finish of storm conditions as practicable.

Profiling is critical for assessing changes in the shoreline and estimating changes in volume of sand on the beach. It is important to note that the shoreline is constantly changing and profiling provides a 'snapshot' in time of the beach cross section. The dynamic nature of the shoreline means it is important to profile as close to before and after a storm as possible, to avoid detecting changes that might be associated with other processes. Profiling protocols for storm monitoring should be consistent with those outlined in 5.5.1, and the same profile locations as the overall monitoring program should be used where possible.

Sediment sampling is important to assess the change in composition of beach sand, associated with storm impact. Generally smaller grain sizes are taken away more easily, leaving large sand particles after a storm event. Sediment data will be useful for informing renourishment and shoreline protection activities, where the characteristics of imported sand are critical. Sediment sampling protocols for storm monitoring should be consistent with those outlined in Section 5.5.1, and the same sample locations as the overall monitoring program should be used where possible.

Ideally, metocean data such as water level, wave and current conditions should also be measured during storm monitoring. This data can help define the nature of the sampled storm event, including its severity and duration. This type of data collection is relatively expensive and would be difficult to implement alongside each storm sampling exercise. Targeted metocean data collection campaigns (during the winter period for example) should, however, be incorporated into the City's coastal monitoring program where feasible. Metocean data has significant value and provides information for a range of applications. These include: validating wave and hydrodynamic modelling, informing sediment transport analysis and modelling, informing detailed management options assessments and informing the design of coastal structures.

### 9.5.3 Existing Coastal Infrastructure - Condition Assessment

Some built assets necessarily reside within coastal hazard areas because of their purpose. These assets include boat ramps, jetties, groynes, seawalls, breakwaters and associated access infrastructure, like carparks and access ways. An example is the Point Peron Boat Ramp and associated parking and access. Such assets are generally designed to be sufficiently strong to withstand coastal hazards in their own right, or accompanied by protection against coastal hazards.

As mean sea level has already been rising and climate change is expected to bring further changes to water levels and storm intensity, it is possible that existing coastal assets have been under-designed for present and/or future coastal conditions. Assets like boat ramps, protection structures and access ways can also lose functionality as conditions change and the shoreline is altered. This is always a challenge when placing fixed infrastructure at a dynamic shoreline.

As unprecedented changes and coastal conditions are predicted to occur, more regular condition assessment of coastal infrastructure shall be undertaken by the City. For significant infrastructure, assessments should be carried out by an experienced coastal or maritime structural engineer. Formal inspection frequency should be approximately every 5 to 10 years, but this should be flexible based on the outcomes of previous assessments and observations from informal assessments. There should also be the capacity to inspect infrastructure after major storm events, to identify any critical damage.

### 9.5.4 Water level/ inundation (S4)

Action 12: Undertake a local water level and sea level rise analysis.

A key component of this CHRMAP involved analysis of water level records to estimate peak water levels during extreme events. Due to the length and reliability of the data set, the tide record from Fremantle Fishing Boat Harbour was analysed to define design water levels for various ARI events. Water level can change considerably with location (even when nearby). To better inform risk levels prior to the next CHRMAP revision, the City will undertake a local assessment of water levels, adjacent to its coastline. The assessment should include:

- collection of water level data (during storm events if possible) for analysis/comparison through the deployment of instrumentation at a selected offshore location. A specialist consultant would be required to carry out this data collection;
- an analysis of water level records (including historical) at nearby locations, including Fremantle, Mangles Bay and Mandurah, to establish relationships between the datasets and identify historical sea level rise trends specific to Rockingham; and
- visual inspections (or remote imagery capture) of inundation extents during storm activity, to assess against modelled hazard extents.

## 9.6 Further Investigation

Action 13: Undertake a detailed sediment transport analysis to establish a detailed sediment budget for the City focusing on Sectors 2 and 3.

**9.6.1 Sediment Transport Analysis**

Coastal erosion hazards, as estimated through the CHRMAP process, are based on a number of simplified assumptions. One of the key assumptions made in defining hazard extents is that the historical rate of shoreline recession will continue at the same rate into the future. In reality, the rate of recession is governed by a number of factors including wave conditions, bathymetry, availability and size of sediment and the orientation of the shoreline.

This CHRMAP assessment has identified a number of assets which are potentially at risk of erosion hazards now, or in the future. To further qualify the risk levels, a detailed sediment transport analysis shall be undertaken to quantify expected erosion and accretion rates in the future. Key outcomes of the study should include:

- development of a (or multiple) validated numerical sediment transport and shoreline response model(s) of the Rockingham shoreline;
- quantification of gross and net transport rates along the Rockingham foreshore under current and future climatic conditions;
- further quantification and refinement of future erosion hazards to be incorporated into the next CHRMAP revision; and
- assessment and further development of any proposed shoreline protection options (such as groynes, breakwaters, seawalls, nourishment programs etc.), and their impacts on the shoreline.

The CHRMAP process has identified that the most vulnerable sections of coastline lie within Sectors 2 and 3, therefore the sediment transport assessment should focus on these areas.

**9.6.2 Nourishment Sand Source Investigation**

Action 14: Undertake an investigation to identify suitable sediment sources and determine available volumes for use in ongoing beach nourishment.

The preferred management scheme for vulnerable areas in the short term is to continue the City's beach nourishment activities. This management technique provides temporary protection, generally improves beach amenity and maintains a flexible adaptation pathway for the future. As sea levels rise, the volume of sand needing to be added to the beach will increase. In anticipation of the increased nourishment volumes, beyond the volume available at the Point Peron sand trap, it is prudent that the City identifies suitable sediment sources for use in the future. This could include identification of sources such as:

- stripping sand from the City's beaches where accretion is occurring or in areas not considered to be vulnerable;
- investigation of the existing sand trap, and investigating ways to increase the trapping efficiency of this operation;
- sourcing sand from developments close to the coast where excavation in good quality sand (for example basement excavation) is proposed; and
- identification of nearshore sand sources that could be sourced using dredging operations.

**9.6.3 Geophysical Investigations**

Geophysical investigations can be useful in identifying the depth of erodible material below the ground surface. Noting that managed retreat is a potential adaptation option in the future, geophysical investigations may be more beneficial prior to major built infrastructure being removed. The geophysical investigation could inform the managed retreat decision, ensuring assets are not removed unnecessarily.

Geophysical investigation generally involves transect and point measurements to identify layers and hardness of material below the surface. For this purpose, they would be used to identify if there is a continuous, alongshore rock barrier located below the ground surface (e.g. within a sand dune), that has sufficient strength and height to prevent coastal hazards impacting assets on its landward side. Such investigations are carried out by geologists using specialised equipment.

Given the generally low lying nature of the City's coastal areas and the general lack of exposed hard rock in these areas, a geophysical investigation is not expected to add significant value to future revisions of the CHRMAP.

**9.6.4 Stormwater and Drainage Asset Management and Maintenance Program**

Action 15: Update the City's Asset Management Plan and Drainage Maintenance Program to reflect adaptive measures selected by the City and develop a priority matrix to ensure assets nearer to the foreshore area are performing as expected.

*Asset Management*

When drainage assets become due for upgrade or renewal the City will need to consider the adaptation options proposed for each section of coastline, be it long term protection or managed retreat. These options, along with critical failure mode analysis, need to be considered when developing and determining renewal and upgrade intervention levels and their subsequent treatments. This information will need to be included in drainage asset deterioration modelling to ensure future funding requirements are factored into the Infrastructure Asset Management Plan and the City's 10 Year Business Plan.

Subsequently, the adaptation options will inform drainage asset levels of service; and determine maintenance strategies and programs.

*Drainage Maintenance Program*

It will be important that maintenance is proactive as opposed to reactive. A proactive maintenance regime could substantially prolong the useful life of the stormwater and drainage assets, and improve performance.

It is suggested that a priority matrix be developed that assesses maintenance of assets nearer to the foreshore areas in line with the potential impacts of erosion and inundation. This is to ensure that the assets in these vulnerable locations are performing as expected and are not hindered by blockages or other obstructions.

Operational and maintenance activities may be targeted to mitigate critical asset failure and maintain agreed service levels. These activities may include increased inspection frequency and higher maintenance intervention levels.

Identification of critical stormwater assets and their failure modes will be necessary to minimise risk and inform the City's asset management plan. For example, critical stormwater assets are likely to include:

- drainage structures under main roads;
- drainage structures under roads with no nearby alternative routes;
- drainage structures near schools, aged care and childcare facilities;
- drainage structures protecting emergency services sites; and
- flood mitigation structures protecting residential land.

Any reported drainage or flooding issues should be reviewed and assessed to identify if the issues are related to coastal processes or hazards.

Through the implementation of updates to stormwater and drainage information on the City's mapping system (Intramaps), assets noted as critical can be identified and linked to a specific maintenance regime, to address known issues. This will help develop maintenance planning for predicted sea level rise and increased inundation. Maintenance regimes will need to be reviewed and a gap analysis performed to ensure that maintenance planning will address future adaptation pathways identified by the City.

### 9.6.5 Stormwater Modelling

Action 16: Stormwater and drainage system be reviewed for functional capacity should issues be reported.

As the City has over 40 drainage outlets discharging to the ocean, understanding the capacity of the drainage network will provide an indication of which catchments will be prone to failure due to coastal processes.

Up to 2030, should drainage assets be identified as underperforming, the drainage system should be reviewed for functional capacity and retrofication works undertaken to ensure performance is maintained.

Beyond 2030, the City shall seek to undertake direct rainfall modelling of the coastal area. This assessment will provide the City with an understanding of the areas most prone to inundation due to rainfall. This modelling should be used to determine the impact of elevated water levels on the efficiency of the drainage network as part of the adaption measures assessment.

Direct rainfall modelling applies an excess rainfall volume directly to a hydraulic model, thereby considering both flow capacity and volumetric storage. This is particularly important in considering drainage networks that flow to tidal boundaries, as exist in the City, as the capacity of the outlet can be constrained under high tidal levels, due to sea level rise or ocean inundation events, leading to the ponding of water in flood storage areas. These areas include low lying areas behind dunes and local depression storages that would normally flow under low tide conditions via the underground drainage network.

As part of the direct rainfall modelling, consideration should be given to include a joint-probability analysis of both coastal events and pluvial flooding along the entire coast line.

### 9.6.6 Lake Richmond

Action 17: Continue to undertake environmental surveys and monitor TDS levels for Lake Richmond.

The City currently undertakes environmental surveys and water quality monitoring to collect baseline information on the health of Lake Richmond. This shall be continued to ensure future adaptive measures will preserve the important economic, environmental and social values of the lake.

Once substantial baseline data is collected (i.e. five years), trigger values and contingency measures should be derived. Should trigger values be exceeded the identified contingency measures shall be implemented. It is suggested trigger values are based on increases in Total Dissolved Solids (TDS) levels, an indication of salinity, based on a review of the ability of flora, fauna and microbialite communities to adapt to changes in salinity.

### 9.6.7 CHRMAP Revision

Action 18: Undertake a full revision of the City's hazard extents and CHRMAP identifying and incorporating relevant new information.

As noted in the CHRMAP guidelines, the CHRMAP should be a living document and undergo regular revisions and monitoring.

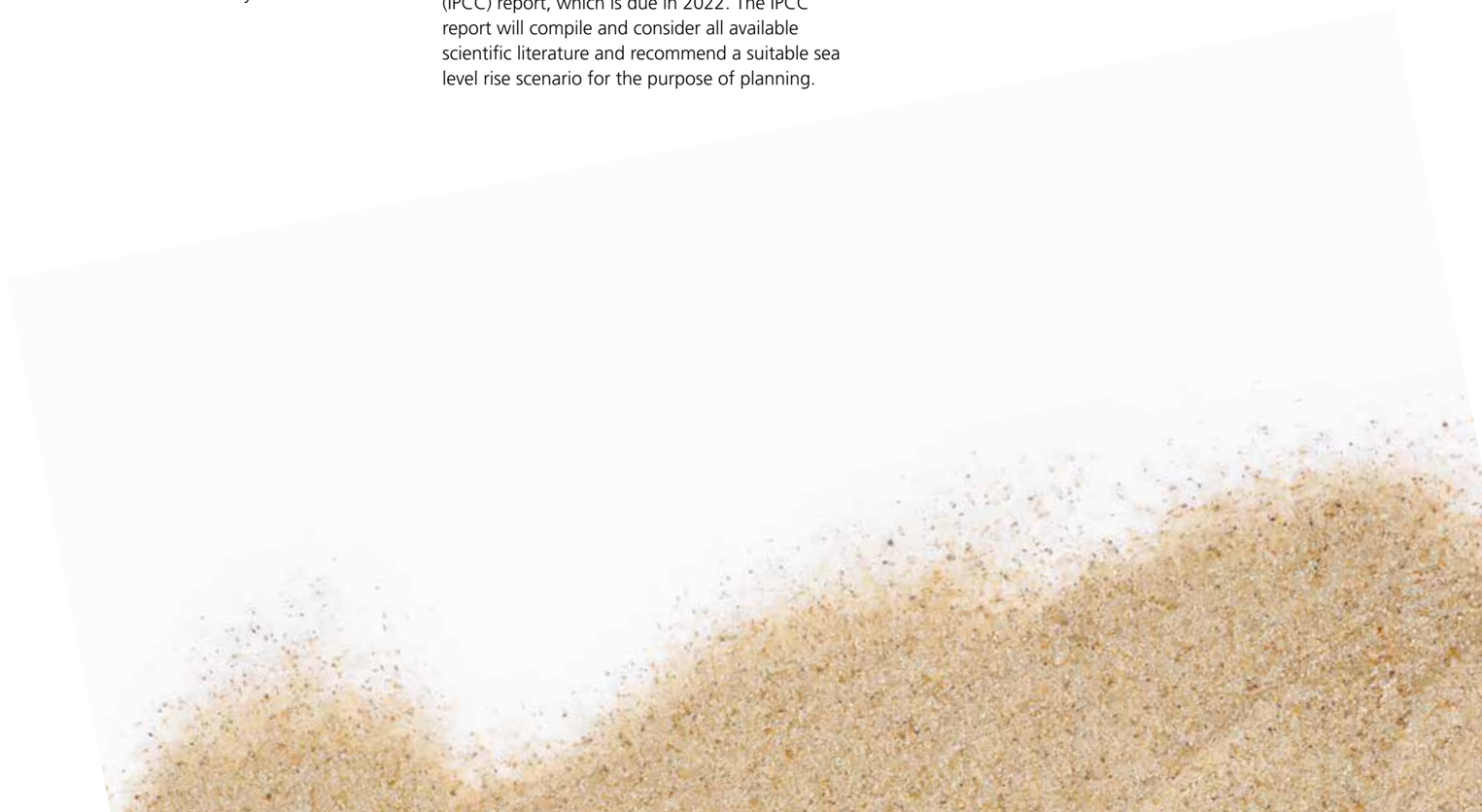
*"…risks arising from coastal hazards rarely remain static, especially as our understanding of coastal processes is improving and given the long timeframes associated with some types of coastal processes and types of land use and development in the coastal zone. It is also impacted by uncertainty on the degree of future climate change (i.e. what the future global greenhouse emissions will be), and climate change projections that are used in the vulnerability assessments.*

*Monitoring and reviewing the CHRMAP ensure the management and adaptation to reduce risks, their likelihood and consequences and the risk priorities, remain the most suitable and effective, and timing and cost appropriate. Where possible principles of adaptive management should be applied which involves small, flexible, incremental changes based on regular monitoring and revision of plans based on the best information available at the time."*

The key changes to any future revisions of the CHRMAP should include an update of hazard estimates using more recent information, the findings of specialist investigations undertaken, changes to projected sea level rise, climate change effects and any changes to the use of the foreshore.

The CHRMAP will be reviewed in 10 years or when SPP 2.6 is reviewed, whichever comes first.

SPP 2.6 is proposed to be revised following the next Intergovernmental Panel on Climate Change (IPCC) report, which is due in 2022. The IPCC report will compile and consider all available scientific literature and recommend a suitable sea level rise scenario for the purpose of planning.



## 9.7 Summary of short term recommendations (to 2030)

The recommended short term actions discussed in the previous section are collated and summarised in the table below. These actions generally focus on actions that will or may require implementation prior to 2030. Recommendations for management actions beyond 2030 will be better informed by investigations undertaken and information collected over the next decade, which will be highlighted in the next review of the CHRMAP.

| | Action | | Action |
|---|---|---|---|
| 1 | Engage the community to present the results of this CHRMAP and collect their feedback on the acceptability of adaptation options and pathways. | 10 | Update the existing asset inventory to identify vulnerable assets and prepare an emergency/damage response plan to respond to potential coastal impacts. |
| 2 | A detailed economic assessment should be undertaken to establish the economic value/contribution of natural assets in key vulnerable areas. | 11 | Initiate a long-term coastal monitoring program, incorporating ad hoc storm and metocean monitoring, and coastal asset condition assessments. |
| 3 | Investigate and establish a fund for ongoing coastal adaptation and management, and allocate funding sources. | 12 | Undertake a local water level and sea level rise analysis. |
| 4 | Existing and proposed structure plans should be reviewed to ensure they adhere to SPP2.6 and account for the risks identified in this CHRMAP. | 13 | Undertake a detailed sediment transport analysis to establish a detailed sediment budget for the City, focusing on Sectors 2 and 3. |
| 5 | TPS2 should be amended to incorporate SPP2.6 and include vulnerable areas as SCAs. | 14 | Undertake an investigation to identify suitable sediment sources and determine available volumes for use in ongoing beach nourishment. |
| 6 | Landholders that may be affected by coastal hazards by 2110 should be notified directly and by the application of notification on Certificates of Title, where possible. | 15 | Update the City's Asset Management Plan and Drainage Maintenance Program to reflect adaptive measures selected by the City and develop a priority matrix to ensure assets nearer to the foreshore area are performing as expected. |
| 7 | Initiate/continue targeted beach nourishment in vulnerable areas. | 16 | Stormwater and drainage system be reviewed for functional capacity should issues be reported. |
| 8 | Undertake a detailed options assessment for management of coastal vulnerability in Sector 3, with a particular focus on ongoing erosion issues at Mersey Point. | 17 | Continue to undertake environmental surveys and monitor TDS levels for Lake Richmond. |
| 9 | Undertake a detailed options assessment for management of coastal vulnerability in Sector 2A, with a focus on Hymus Street. | 18 | Undertake a full revision of the City's hazard extents and CHRMAP, identifying and incorporating relevant new information. |

# 10 Short Term Implementation Plan to 2030

This table describes actions recommended for implementation by 2030, their estimated costs, responsible divisions and suggestions for timing. It is noted that the costs in the table are estimates only, and the relevant teams should undertake a more detailed cost estimate at such time the action is due to be budgeted for and implemented.

| Component | Responsible | Annual cost estimate | Total cost estimate (to 2030) | Timing |
|---|---|---|---|---|
| **Planning** | | | | |
| Review existing Structure Plans | SPE | O | O | 2019/20 |
| Amend TPS2 | SP | O | O | 2019/20 |
| Directly notify affected landholders | SP | O | O | 2019/20 |
| Apply notification to title for new Development and Subdivision Approvals, as per SPP 2.6 requirements | SP | O | TBD | From 2019 |
| **Monitoring** | | | | |
| Shoreline monitoring manual | SPE | $25,000 | $25,000 | From 2019 |
| Ongoing aerial imagery analysis | SPE | $5,000 | $60,000 | From 2019 |
| Ongoing shoreline monitoring | SPE | $40,000 | $480,000 | From 2019 |
| Storm monitoring | SPE | $15,000 | $180,000 | From 2019 |
| Coastal asset condition assessments | ES | $15,000 | $180,000 | From 2020 |
| Metocean data collection | SPE | $25,000 | $300,000 | From 2019 |
| | **Sub-total** | | **$1,225,000** | |
| **Implementation/ Management** | | | | |
| CHRMAP community engagement | SPE | - | $25,000 | 2019 |
| Ongoing community engagement | SPE | $10,000 | $60,000 | From 2019 |
| Undertake detailed investigations and establish a coastal adaptation fund | FS | - | - | 2019/20 |
| Ongoing beach nourishment | ES | $250,000 | $3,000,000 | From 2019 |
| Coastal asset inventory update | AS | - | $10,000 | 2020/21 |
| Asset management plan update | AS | - | $15,000 | 2020/21 |
| Drainage Maintenance Program update | ES | - | - | From 2019 |
| Hazard response preparation | CS | - | $15,000 | 2019/20 |
| Management at Mersey Point | ES | - | $500,000 | 2020-2025 |
| | **Sub-total** | | **$3,625,000** | |
| **Special Investigations** | | | | |
| Detailed economic assessment | SPE | - | $150,000 | By 2025 |
| Detailed options assessment for Sector 3 | ES | - | $100,000 | By 2020 |
| Detailed options assessment for Sector 2 | ES | - | $100,000 | By 2025 |
| Water level/sea level rise analysis | SPE | - | $50,000 | By 2030 |
| Detailed sediment transport investigation | ES | - | $120,000 | By 2020 |
| Nourishment sand source investigation | ES | - | $20,000 | By 2025 |
| Stormwater and drainage system review | ES | - | $100,000 | By 2030 |
| Hazard line and CHRMAP revision | SPE | - | $150,000 | By 2030 |
| | **Sub-total** | | **$790,000** | |
| | **Grand Total** | | **$5,640,000** | |

## LEGEND

**ES**: Engineering Services

**SP**: Statutory Planning

**SPE**: Strategic Planning and Environment

**AS**: Asset Services

**CS**: Community Safety

# 11 References


Cardno (2018). *Coastal Hazard Risk Management and Adaptation Plan - Technical Assessment*, Prepared for the City of Rockingham

CoastAdapt (2017). *Coastal Climate Change Infographics Series*. Available at https://coastadapt.com.au/infographics

Department of Transport (2010) *Sea Level Change in Western Australia Application to Coastal Planning*. Department of Transport, Perth, Western Australia.

Gittman, R. K., Scyphers, S. B., Smith, C. S., Neylan, I. P., & Grabowski, J. H. (2016). *Ecological Consequences of Shoreline Hardening: A Meta-Analysis*. Bioscience, 66(9), 763–773.

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* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

Ranasinghe R, Callaghan D, Roelvink D (2013) *Does a more sophisticated storm erosion model improve probabilistic erosion estimates*. Coastal Dynamics 2013

WAPC (2003) *Statement of Planning Policy No. 2: Environment and Natural Resources Policy*. Published by the Western Australian Planning Commission, Perth, Western Australia.

WAPC (2006) *Statement of Planning Policy No. 3: Urban Growth and Settlement*. Published by the Western Australian Planning Commission, Perth, Western Australia.

WAPC (2013a) *State Planning Policy No. 2.6. State Coastal Planning Policy*. Published by the Western Australian Planning Commission, Perth, Western Australia.

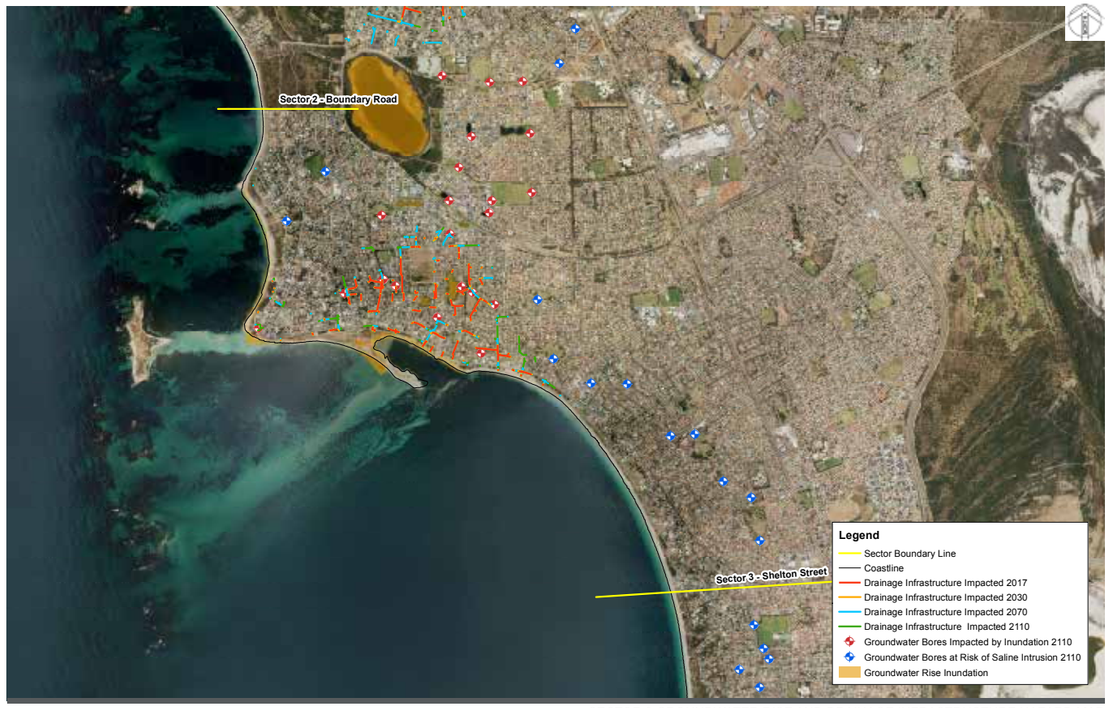
WAPC (2013b) *State Coastal Planning Policy Guidelines*. Published by the Western Australian Planning Commission, Perth, Western Australia.

WAPC. (2019) *Coastal Hazard Risk Management and Adaptation Planning Guidelines*. Published by the Western Australian Planning Commission, Perth, WA. Available at https://www.dplh.wa.gov.au/spp2-6-coastal-planning

# Appendix A Groundwater Rise Assessment


SECTOR 1 GROUNDWATER RISE AND DRAINAGE INFRASTRUCTURE HAZARD MAP


SECTOR 2 GROUNDWATER RISE AND DRAINAGE INFRASTRUCTURE HAZARD MAP



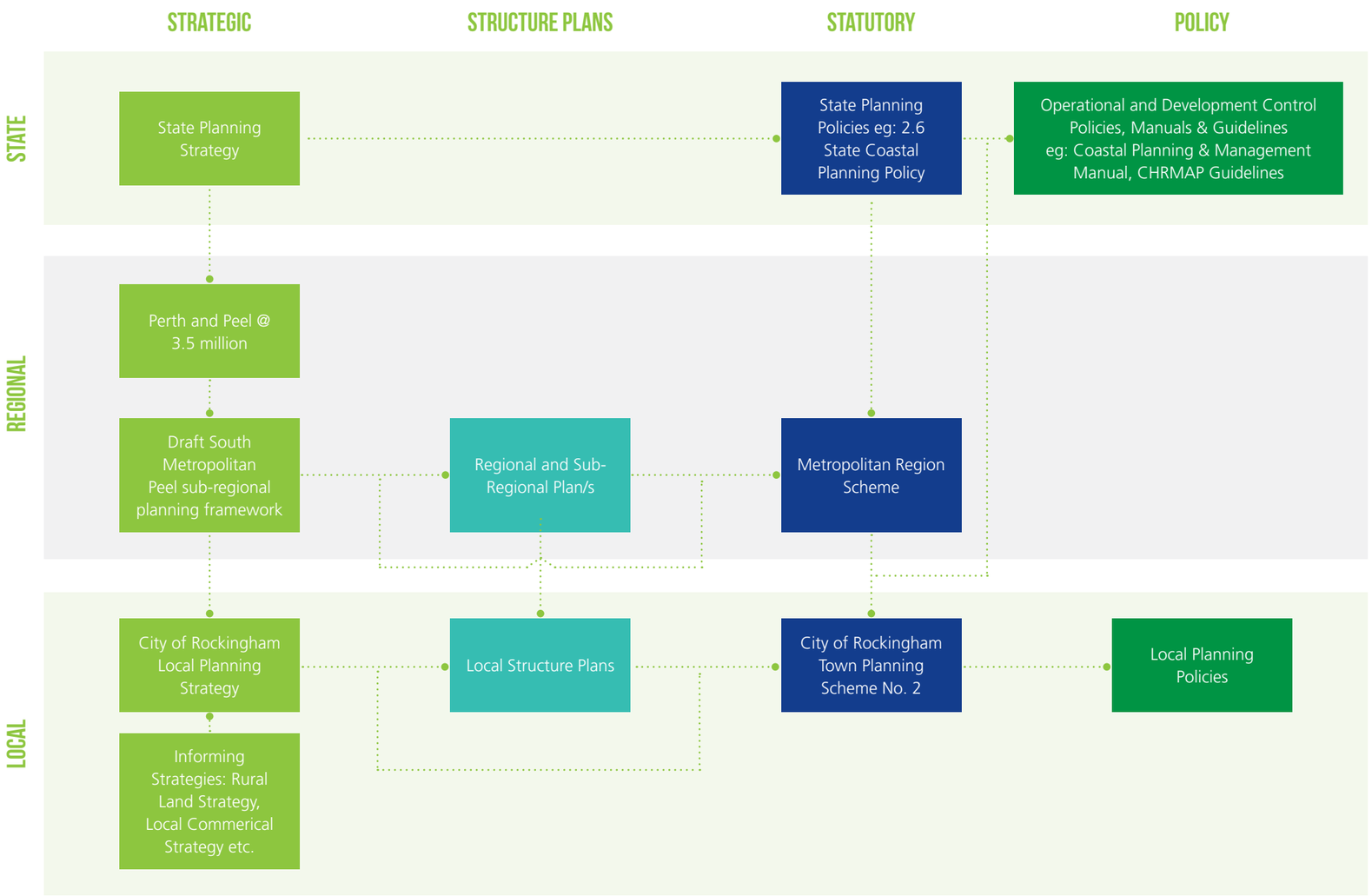

SECTOR 3 GROUNDWATER RISE AND DRAINAGE INFRASTRUCTURE HAZARD MAP


SECTOR 4 GROUNDWATER RISE AND DRAINAGE INFRASTRUCTURE HAZARD MAP


SECTOR 5 GROUNDWATER RISE AND DRAINAGE INFRASTRUCTURE HAZARD MAP


SECTOR 6 GROUNDWATER RISE AND DRAINAGE INFRASTRUCTURE HAZARD MAP

# Appendix B Planning Context



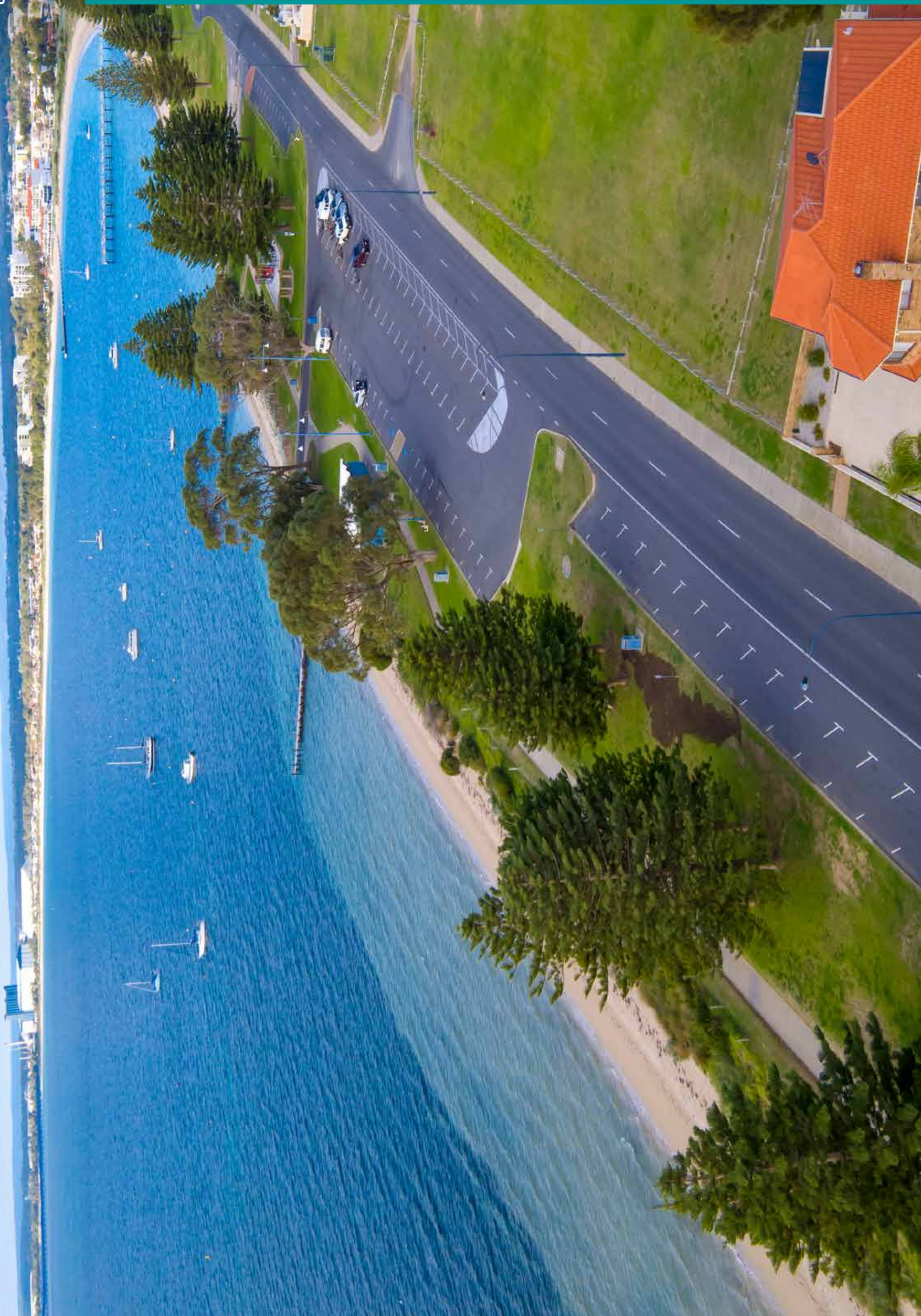

**Statutory Planning Framework**
This figure summarises the relevant planning framework. The key statutory planning document for the City is Town Planning Scheme No. 2 (TPS2). This applies zones and reserves to land within the City and outlines the permissibility of land uses, the requirements for development and the processes for seeking approval for proposed development. TPS2 was gazetted on 19 November 2004.

TPS2 was amended in September 2017, to be consistent with the Planning and Development (Local Planning Scheme) Regulations 2015 (the P&D Regulations, DoPLH, 2017a). Through the review of TPS2, the City identified any aspects of the document that were inconsistent with the intent of regional and state strategies, policies, and statutory requirements, including SPP2.6.

The general objectives of TPS2 are to:

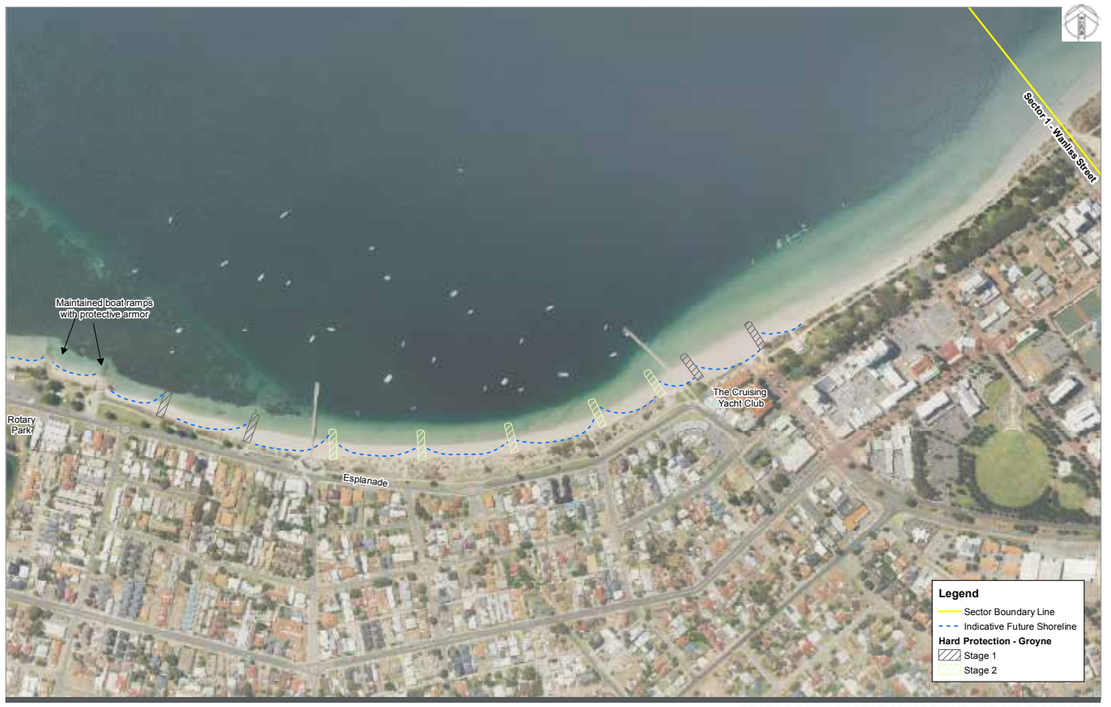
- Optimise the provision of services and facilities for the community;
- Establish the preferred use of land well in advance of development;
- Ensure the coordinated provision of adequate land for development;
- Conserve and enhance features of cultural, historical, environmental and natural significance; and
- Reconcile community needs and aspirations with appropriate land use and development.

State Planning Policies provide the highest level of planning policy control and guidance in Western Australia and are prepared under Part 3 of the *Planning and Development Act 2005* (DoPLH, 2017b). SPP2.6 is an environmental sector policy consistent with the higher order SPP 2 Environmental and Natural Resources Policy.



# Appendix C Hard Protection Adaptation Options - Feasibility Assessment Concept Designs


SECTOR 2A-1 ADAPTATION OPTIONS - BREAKWATER CONCEPT




SECTOR 2A-1 ADAPTATION OPTIONS - GROYNE CONCEPT


SECTOR 2A-1 ADAPTATION OPTIONS MAP - SEAWALL CONCEPT


SECTOR 3A-2 ADAPTATION OPTIONS - GROYNE CONCEPT


SECTOR 3A-2 ADAPTATION OPTIONS - SEAWALL CONCEPT


SECTOR 3B-1 ADAPTATION OPTIONS - BREAKWATER CONCEPT


SECTOR 3B-1 ADAPTATION OPTIONS - GROYNE CONCEPT


SECTOR 3B-1 ADAPTATION OPTIONS - SEAWALL CONCEPT


SECTOR 4B-1 ADAPTATION OPTIONS - BREAKWATER CONCEPT


SECTOR 2A-1 ADAPTATION OPTIONS - BREAKWATER CONCEPT


SECTOR 4B-1 ADAPTATION OPTIONS - SEAWALL CONCEPT

# Appendix D - Community Adaptation Workshop Summary

**Background**
The intent of the Community Adaptation Workshop was to inform dvelopment of the CHRMAP, which will outline key directions for coastal adaptation over a 100 year planning timeframe, in addition to prioritising management works over the next 10 years.

The workshop was held at the Gary Holland Community Centre on Wednesday 15 August 2018, from 5-7 pm. The workshop centred around a presentation on potential coastal hazards, adaptation options and costs. In the context of this information, 30 residents participated in a number of activities and engaged in valuable discussion.

**Activity One**

| Group | Participant suburbs | What is your favourite and/or most visited beach? | Name three things you value most about that beach? |
|---|---|---|---|
| 1 | • Shoalwater | • Shoalwater<br>• The Pond<br>• Rockingham Foreshore | • Water sports - kayaking, kitesurfing, diving<br>• Nature and wildlife<br>• Absence of pollution<br>• Cafes |
| 2 | • Shoalwater<br>• Safety Bay | • Shoalwater<br>• Safety Bay<br>• The Pond | • Clean and calm water<br>• Visiting the islands<br>• Exercising on the water<br>• The naturally maintained sand dunes<br>• Dog beach<br>• Easy access, boat ramp<br>• Swimming, kayaking, diving |
| 3 | • Shoalwater<br>• Warnbro<br>• Rockingham | • Point Peron<br>• Warnbro Dog Beach<br>• Shoalwater<br>• Palm Beach | • Clean quality of water<br>• Clean sandy beaches<br>• Dunes in Warnbro<br>• The islands |
| 4 | • Rockingham<br>• Baldivis<br>• Shoalwater | • Rockingham Foreshore<br>• Palm Beach<br>• Shoalwater Bay<br>• Safety Bay | • Parkland – family friendly, grass, trees, gazebos<br>• Pollution free - clean water and sand<br>• Easy access for boating |
| 5 | • Warnbro<br>• Golden Bay<br>• Port Kennedy<br>• Safety Bay | • Warnbro<br>• Rockingham Foreshore<br>• Secret Harbour<br>• Safety Bay | • Dog beach<br>• Dunes and native vegetation<br>• Quality of water and clean beaches<br>• Safe for swimming<br>• Family friendly, grassed picnic areas<br>• Native vegetation |
| 6 | • Rockingham | • Point Peron<br>• Rockingham Beach<br>• Palm Beach | • Calm, clean water<br>• North facing beach<br>• Boat ramps, jetties<br>• Restaurants, cafes<br>• Coastal views |

**Activity Two**

1. Generally speaking, would you favour protect or managed retreat, and why?

| Group responses: |
| --- |
| Likely favour protect at first, and then if this becomes no longer possible, managed retreat. Don't necessarily know enough about it to decide for sure. |
| Favour protection short term, with a view to carefully consider managed retreat long term. This would provide more time to manage as carefully as possible, due to level of unknowing. Perhaps it could be based on 'priority zones' for protection. |
| Combination of both, depending on the value of an area to the whole community. It is important to protect homes, but managed retreat will minimise costs long term. |
| Combination of both. Protection in some areas where there is high economic value or more vulnerable property, but managed retreat in other areas. Who pays for protection long term? |
| Important that the dunes are conserved and protected, with appropriate fencing, planting and signage. |
| Managed retreat. Protection is an ongoing expense with little net benefit in the long term. It allows for a buffer to be provided for the area. |
| Depends on personal circumstances. Property owners will favour protect, amenity users will favour managed retreat. The suspicion with managed retreat is woefully inadequate compensation for property owners. If there was more certainty around compensation, then managed retreat may be looked more favourably upon. |
| Protect, as our residence is on the front esplanade. |

2. If you could only keep three stretches of sandy beach (each 600 m long) which would they be?


A VARIETY OF SANDY BEACHES WERE SELECTED AND DID NOT NECESSARILY FAVOUR THOSE NEAREST TO THEM. FOR EXAMPLE, RESIDENTS FROM WARNBRO AND PORT KENNEDY SELECTED ROCKINGHAM BEACH AND POINT PERON, RESIDENTS FROM ROCKINGHAM SELECTED SHOALWATER BAY, AND A BALDIVIS RESIDENT SELECTED THE POND.

3. If you could only install three seawalls (each 600 m long) which areas of the coastline would you choose and why?


SELECTIONS GENERALLY ALIGNED WITH THOSE AREAS MORE VULNERABLE TO COASTAL HAZARDS. THERE WERE SOME AREAS IDENTIFIED FOR SEAWALLS, CONTRARY TO THOSE SAME AREAS BEING SELECTED FOR RETENTION OF THE NATURAL SANDY BEACH IN THE PREVIOUS ACTIVITY. HOWEVER, KEY DIFFERENCES CAN BE NOTED, INCLUDING MERSEY POINT BEING STRONGLY FAVOURED FOR PROTECTION, WITH ROCKINGHAM BEACH AND POINT PERON ALSO FAVOURED. BY COMPARISON, PALM BEACH, SHOALWATER BAY AND THE POND ALL RANKED HIGHER FOR RETENTION OF A SANDY BEACH AS OPPOSED A CONSTRUCTED SEAWALL COASTLINE. SOME RESIDENTS ALSO NOTED THE IMPORTANCE OF PROTECTING BOATING INFRASTRUCTURE WITH HIGH COMMUNITY VALUE, SUCH AS BENT STREET BOAT RAMP, WHILE STILL MAINTAINING SANDY BEACHES EITHER SIDE.

**Activity Three**

1. Who do you think should pay to manage coastal hazards in the future?

| Group responses: |
|---|
| Everyone |
| Federal, state and local governments; climate polluters; a carbon tax; tax on any other related externalities; Tony Abbott |
| Climate change is a global issue, all tiers of government have a role to play |
| All levels of government have some responsibility, but particularly state and local governments. In responding to coastal hazards it's important to work with neighbouring Councils to ensure continuity. |
| All levels of government, but local government in particular. |
| It is a whole community and state responsibility, but all three levels of government should contribute |
| It's a shared responsibility, all should contribute |

2. Do you think residents on the coast should pay more than those who live inland? Or should all residents pay equally?

| Group responses: |
|---|
| Everyone who drives, walks, swims and fishes in the area. We all fund parks, libraries, community centres and playing fields, but may never use them. This is just another thing that all of our rates should go towards managing. |
| Community should generally all pay, so long as public access remains to everyone can use it. |
| All should contribute through rates, which means that people on the coast will pay proportionately more anyway as their property values (GRV) are generally higher. |
| Everyone should pay the same |
| Everyone uses and enjoys the beach, so everyone should pay. Could also have a user pays component, where visitors coming to the area contribute to coastal management through parking fees. |
| Everyone should pay equally, people move houses over time too. |
| Waterfront properties already pay higher rates based on land value. Everyone should pay as everyone uses the beach and local facilities. Perhaps if certain properties are going to be particularly impacted that they pay proportionally more. |

3. Hypothetically, how much would you be willing to pay to manage coastal hazards on top of your rates? i.e. $20, $50, $100

| Group responses: |
|---|
| $50 |
| $20 - $100, or what is required |
| $100 or whatever is required based on best estimates. Not an open cheque book. |
| $50 - $100 |
| Unsure, depends what is necessary |
| A sliding scale based on CPI, not a set amount forever. It should be a small amount continually collected over time. |
| $100 |

4. Do you think it is reasonable to start putting money in a cash reserve now? Why?

| Group responses: |
|---|
| A sovereign wealth fund is always good |
| Yes, because it is better to act sooner and accrue interest |
| Yes, we don't want intergenerational inequity (whereby future generations are left paying more). Need to consider funding whole of life costs for asset management. |
| Yes, also important to protect the natural dunes now. |
| Yes, coastal management is not getting any cheaper. A cash reserve needs to be dedicated to coastal management and not redirected to other causes. |
| Yes, small amounts put away over time ensure sensible decisions can be made in times of need. |
| Yes, we need to plan ahead. There is going to be an impact, we just don't know when and how bad. |

* With respect to questions 3 and 4, a scenario was discussed whereby a 1% rate increase could be applied to all residents for a set period of time (i.e. 10 years) to establish a cash reserve for coastal hazards, which could then accrue interest over time.

In response, comments from the group expressed:

- The importance of establishing a cash reserve sooner rather than later to appropriately respond to coastal hazards when they occur.
- General support for a rate increase to establish a cash reserve, with 1% considered relatively acceptable (i.e. ~$20, depending on the property).
- That if a rate increase is applied, it would be better to continue collecting relatively small amounts indefinitely and not cease after a set term, acknowledging that management of coastal hazards is ongoing.
- The need for utmost certainty around the security of a cash reserve to only be used for future management of coastal hazards, and not for any other purpose.