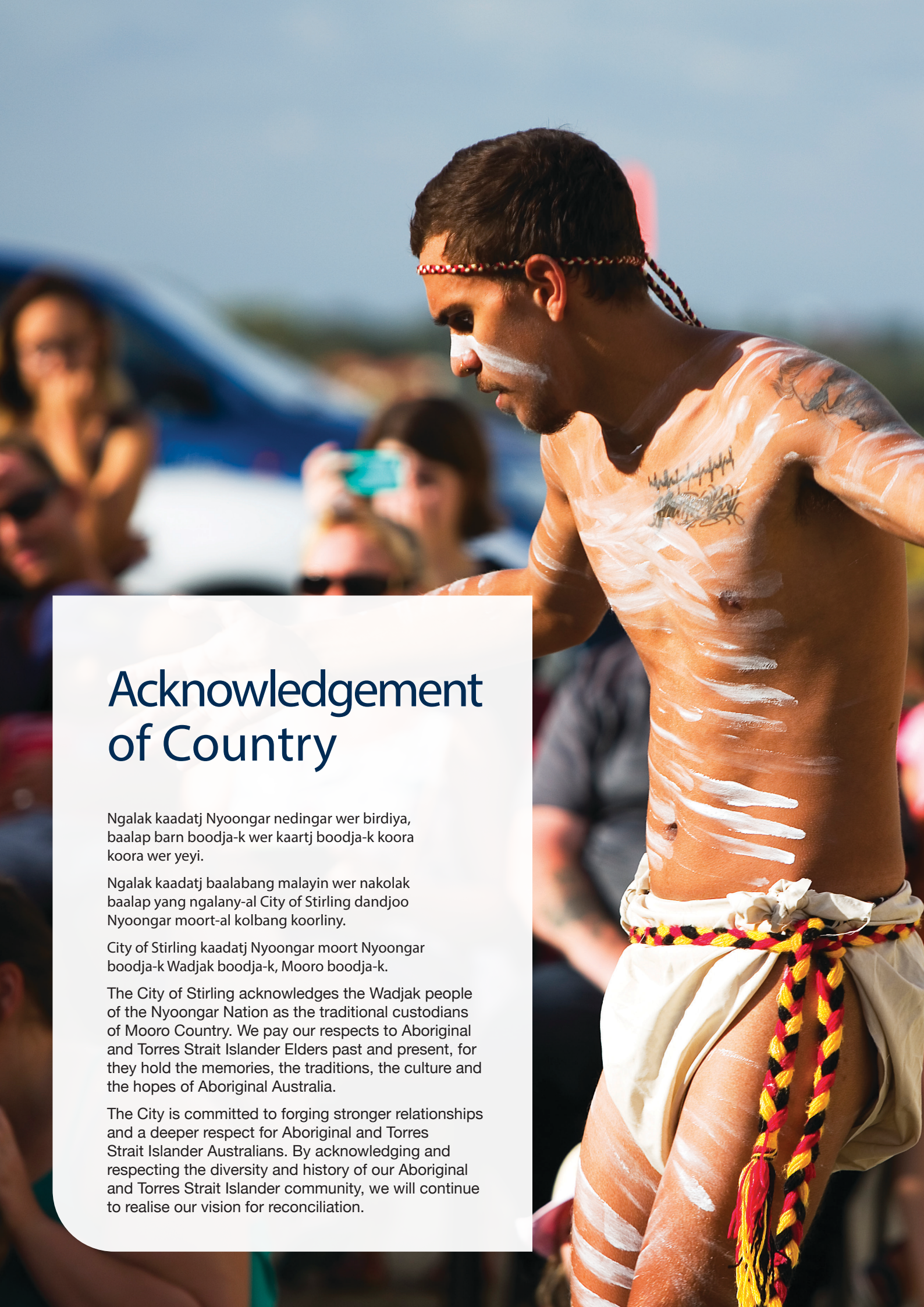




Coastal Hazard Risk Management and Adaptation Planning



A man in traditional Nyoongar attire is shown in profile, facing left. He has white body paint applied in horizontal stripes across his chest, abdomen, and arms. He wears a beaded headband and a white loincloth with a yellow and black braided cord. The background is blurred, showing a crowd of people at an outdoor event.

Acknowledgement of Country

Ngalak kaadatj Nyoongar nedingar wer birdiya, baalap barn boodja-k wer kaartj boodja-k koora koora wer yeyi.

Ngalak kaadatj baalabang malayin wer nakolak baalap yang ngalany-al City of Stirling dandjoo Nyoongar moort-al kolbang koorliny.

City of Stirling kaadatj Nyoongar moort Nyoongar boodja-k Wadjak boodja-k, Mooro boodja-k.

The City of Stirling acknowledges the Wadjak people of the Nyoongar Nation as the traditional custodians of Mooro Country. We pay our respects to Aboriginal and Torres Strait Islander Elders past and present, for they hold the memories, the traditions, the culture and the hopes of Aboriginal Australia.

The City is committed to forging stronger relationships and a deeper respect for Aboriginal and Torres Strait Islander Australians. By acknowledging and respecting the diversity and history of our Aboriginal and Torres Strait Islander community, we will continue to realise our vision for reconciliation.

Contents

Acknowledgement of Country	ii	How to best manage the City of Stirling coastline	45
Introduction	1	Community and stakeholder preferences	45
What is a CHRMAP?	1	Multi-criteria assessment	45
Purpose and objectives	2	Cost-benefit analysis	46
Study area	2	Adaptation pathways	47
Project staging	4	Implementing the CHRMAP and gaining a better understanding of coastal hazard risk	55
Glossary	5	Short-term implementation (next 25 years)	55
How to read this document	5	Monitoring and further investigation	57
CHRMAP Context	7	Medium and long-term implementation	57
Environmental setting	7	Key recommendations	58
Coastal controls	8	Reference list	59
Coastal assets	9	Appendix A: Asset classification list	61
Community and stakeholder input	16	Appendix B: Erosion risk assessment outcomes	63
Success criteria	16	Appendix C: Multi-criteria analysis	67
Coastal hazards	17		
What are the coastal hazards?	17		
Coastal hazard assessment	17		
How vulnerable is our coastline?	35		
Approach to vulnerability analysis	35		
Effect of coastal controls	36		
Management units	36		
Prioritising vulnerable areas for adaptation	37		
Key outcomes of vulnerability analysis	37		
What are the management options for coastal hazards?	38		
Whose responsibility is it to manage the coastline?	38		
Equity explained	39		
Adaptation hierarchy	39		
Management options	41		
Triggers to respond	42		



Introduction

The City of Stirling has a population of 226,369 (based on 2021 Census data) and a rich, diverse natural and physical landscape covering approximately 104 km², including 6.5 km of coastline.

The City of Stirling's foreshore boasts sandy beaches, rock pools, open space, parks and reserves, shopping, recreation and leisure centres, scenic drives and waterfront property. This diverse foreshore is well loved by local residents and those residing in surrounding areas of Perth's western suburbs, as well as tourists who travel from outside the City and abroad to enjoy them.

Following a series of storms in 2009 that significantly impacted coastal infrastructure at Watermans Bay, the City commissioned a Strategic Coastal Processes Study (BMT JFA, 2016). This study allowed the City to better understand the coastal processes, determine which areas of the coastline were most at risk and identify what those risks were, over a 100-year planning timeframe.

In 2019, Watermans Bay and Mettams Pool were identified as two of the 55 coastal erosion hotspots in the Assessment of Coastal Erosion Hotspots in Western Australia (prepared by the Department of Planning, Lands and Heritage and the Department of Transport). A range of public foreshore amenities were found to be prone to erosion hazard in the near to medium term (within zero to 25 years), while large sections of public infrastructure assets such as dual-use paths, sections of West Coast Drive and associated services (gas, power, water) were found to be at high risk due to coastal erosion in the medium to long term (as early as 2045).

The City commissioned several Geophysical Subsurface Investigations (GBGMAPS, 2016-18) to determine the rock profile between Trigg Island and Watermans Bay, Mettams Pool (between Lynn Street and Hamersley Street) and North Beach (between Malcolm Street and James Street). The degree of erosion and inundation hazard protection afforded by the ground condition findings remains to be interpreted in the context of coastal hazards mapping refinements and encapsulated in an appropriate risk management process compliant with the State Planning Policy 2.6 - State Coastal Planning (SPP2.6).

As such, this Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) has been prepared for the study area in accordance with the CHRMAP Guidelines and SPP2.6.

What is a CHRMAP?

A Coastal Hazard Risk Management and Adaptation Plan, also known as a CHRMAP, is a strategic, long-term plan that guides the response to existing and potential future risk of impact from coastal hazards. It assesses risk levels at specific planning timeframes 10, 25, 50 and 100 years into the future. It then outlines adaptation pathways to be pursued in order to minimise risk and vulnerability across these timeframes. CHRMAPs are prepared in accordance with the CHRMAP guidelines (WAPC, 2019) and State Planning Policy No. 2.6 – State Coastal Planning Policy (WAPC, 2013) and associated guidelines and studies.

Purpose and objectives

The objectives of the CHRMAP are to:

- Improve understanding of coastal features, processes and hazards in the study area
- Identify significant vulnerability trigger points and respective timeframes for the relevant management units to mark the need for immediate or medium-term risk management measures
- Identify assets (natural and built) and the services and functions they provide within the coastal zone
- Gain an understanding of asset vulnerability
- Identify the economic values of the assets that are vulnerable to adverse impacts from coastal hazards
- Identify the values that community and stakeholders place on the various coastal assets throughout the City

- Determine the consequence and likelihood of coastal hazards on the assets, and assign a level of risk
- Identify possible (effective) risk management measures (or actions) and how these can be incorporated into short and longer-term decision making
- Engage stakeholders and the community in planning, decision making and the overall CHRMAP process.

Study area

The study area for the CHRMAP captures the entire City of Stirling coastline and the affected land adjacent to the coast. As the study area encompasses such a large area, seven map zones have been delineated, shown in Figure 1. Note that map zones differ from management units, which are introduced on page 36.

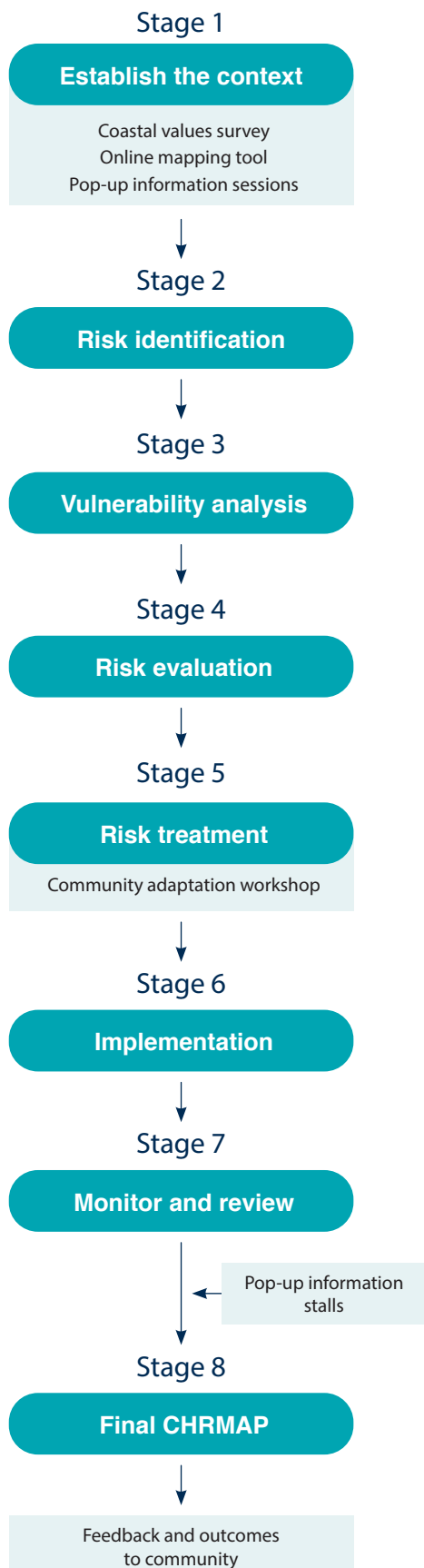




Figure 1: Study area boundary

Project staging

The CHRMAP project began in September 2021 and was undertaken in eight stages, which are outlined below.



Stage 1	- Establish the context - Background review of study area, previous studies and project structure - Identification of existing legislative and planning controls and physical controls - Community and Stakeholder Engagement Plan
Stage 2	- Risk identification - Hazard identification for both erosion and inundation hazards at present day and future planning timeframes (10, 25, 50 and 100 years into the future) - Detailed hazard mapping to delineate present and future hazard extents - Identification, characterisation and valuation of assets within the present and future hazard extents, to inform risk assessment
Stage 3	- Vulnerability analysis - Interpretation of coastal hazard risk modelling, to assess the risk and vulnerability of assets along the City's coastline
Stage 4	- Risk evaluation - Identification of priority areas of risk and vulnerability for the City, allowing adaptation options to be assessed for these areas
Stage 5	- Risk treatment - Identification of potential adaptation options for the prioritised list of assets at risk of coastal hazards, developed during the vulnerability analysis and risk evaluation stages
Stage 6	- Implementation Plan - Recommendation of specific coastal hazard risk management measures to be undertaken within the next 25 years (short term) - Further investigations required to inform management and adaptation are also recommended - Strategic guidance for the 25-50 year (medium-term) and 50-100 year (long-term) timeframes
Stage 7	- Monitoring and review - Details the monitoring to be undertaken to understand ongoing coastal hazard risk and inform the triggering of reactive management measures
Stage 8	- Draft then final CHRMAP - Compilation of chapter reports into a reader-friendly format

Glossary

AC	Accommodate
Adaptive capacity	The ability for an asset to adapt, or be adapted, to changing coastal hazards
Assets	Physical elements of the coastal zone (natural or built) that have value (economic or otherwise)
AV	Avoid
Coastal hazards	Actions in the coastal zone that can impact assets - the main hazards are erosion of coastal land and inundation (flooding) of coastal land
DN	Do nothing
Erosion	Permanent or temporary removal of sediment from the coastal zone due to coastal hazards
Exposure	The likelihood of coastal hazards causing impact (that is, to an asset or area)
GSC	Geotextile Sand Container
Horizontal shoreline datum (HSD)	Defines the limit of the shoreline under storm activity
Inundation	The flooding of the coastal zone due to elevated sea levels
Management Unit (MU)	Defined section of coastline for assessing risk and recommending treatment
Planning horizon	The amount of time into the future for which plans are made - this CHRMAP considers planning horizons of 10, 25, 50 and 100 years
PMR	Planned/managed retreat
PR	Protect
Risk	The combination of likelihood (exposure) and consequence (sensitivity) of hazard impact for an asset or area
Sensitivity	The consequence for an asset or area if an impact occurs
SLR	Sea level rise
SPP2.6	The State Planning Policy No. 2.6 – State Coastal Planning Policy
Vulnerability	The combination of risk to an asset and its adaptive capacity. For example, if an asset is at high risk, but can be easily adapted, its vulnerability is relatively low

How to read this document

This report has been designed as a reader-friendly version of the five technical chapter reports. If you require further information about this report, you can refer to the technical chapter reports on the City of Stirling's website: www.stirling.wa.gov.au/your-city/shaping-our-city/search-all-projects/coastal-hazard-risk-management-and-adaptation-plan



CHRMAP context

Environmental setting

Traditional land use

The traditional custodians of the City's lands and coastline are the Wadjak people of the Nyoongar Nation. The Nyoongar people occupied and preserved the land in the south-west corner of Western Australia for over 40,000 years, and possibly up to 60,000 years, prior to the area being colonised by the British. Coastal areas have always held specific significance for Nyoongar people. Hunting and gathering from marine waters provided a large portion of the food for coastal tribes. Certain coastal plants were used as food and medicine and for ceremonial purposes. Coastal dunes were also common places of burial.

Coastal geology and geomorphology

The City's coastline consists of white sandy beaches south of Trigg Island and bluff-dominated shoreline with perched beaches, nearshore calcarenite reefs and headlands in the north. Geophysical investigations were undertaken over a section of coastal dune systems parallel to West Coast Drive, between Beach Road and the Trigg Beach South carpark to determine the rock profile. Rock was found to be present at varying levels, affording a significant portion of the City's northern coastline a level of protection. Prevailing coastal conditions generally result in the net annual transport of sand in a northerly direction.

Sediment cells are spatially discrete areas of the coast within which marine and terrestrial landforms are likely to be connected through processes of sediment exchange, often described using sediment budgets. Each includes areas of sediment supply (sources) and loss (sinks), and areas through which sediment is moved between sources and sinks (pathways) (Stut et al 2015). Stul et al (2015) mapped sediment cell boundaries at three spatiotemporal scales (occurring in both space and time) along the Western Australian coastline between Cape Naturalist and Moore River.

The three scales are listed below.

- Primary cells are related to large landforms or land systems over longer coastal management timescales of more than 50 years. The study area falls in primary cell R06F, which spans from the engineered section of the coast at Fremantle to Pinnaroo Point.
- Secondary cells incorporate contemporary sediment movement on the shoreface and potential landform responses to inter-decadal changes in coastal processes. The study area falls in two secondary cells:
 - Secondary cell 26, which comprises a sandy stretch of coastline bound by rocky outcrops at Mudurup Rocks in Cottesloe and Trigg Point which interrupt sediment transport along the coastline
 - Secondary cell 27, which comprises a mixed rocky/sandy stretch of coastline bound by rocky outcrops at Trigg Point and Pinnaroo Point.
- Tertiary cells are defined by the reworking and movement of sediment in the nearshore and are the most relevant for seasonal to inter-annual changes to the beach face. The study area is spread across cells 26c,d and cell 27a, where:
 - Cell 26c spans from Empire Avenue, City Beach to Brighton Road, Scarborough
 - Cell 26d spans from Brighton Road, Scarborough to Trigg Island, Trigg
 - Cell 27a spans from Trigg Island, Trigg to Bettles Street, Marmion.

Coastal controls

A number of physical controls have been identified in the study area, including natural controls, 'hard' engineering controls and 'soft' coastal management measures.

Control	Location(s)	Purpose	Year implemented
Hard engineering controls			
Watermans Bay GSC seawall revetment (see Figure 2)	Watermans Bay	Defend landside infrastructure	2010
North Beach Jetty cliff top rock capping	North Beach Jetty	Protection of, and access to, North Beach Jetty	1922 (restored in 2018)
Mettams Pool temporary GSC seawall revetment and beach nourishment	Mettams Pool	Protect/support of access ramp/replenish sand on beach	2021
Scarborough Beach amphitheatre retaining walls	Scarborough Beach	Land stabilisation	2006
West Coast Drive retaining walls	Various locations along West Coast Drive	Land stabilisation	Various
Drain outlets	Various locations along the City's coastline	Discharge of stormwater	Various
Soft engineering controls			
Dune management	Various locations along the City's coastline	Promote coastal dune restoration	Ongoing
Coastal revegetation	Various locations along the City's coastline	Promote long term survival of native flora, fauna and dune systems	Ongoing
Natural engineering controls			
Rocky foreshore and elevated bedrock formation	North of Trigg Point	Reduction of wave energy	-
Sand dunes	South of Trigg Point	Erosion buffer	-
Foreshore reserves	City of Stirling coastline	Erosion buffer	-

Figure 2: GSC seawall at Watermans Bay



Coastal assets

It is necessary to identify all assets (built and natural) together with their function, services and values to help identify the consequences of coastal hazards. The City's foreshore reserves support a variety of recreation, conservation and commercial land uses, including substantial built infrastructure situated in proximity to the shoreline.

Such infrastructure includes West Coast Drive, Trigg and Scarboro Life Saving Clubs, cafes, playgrounds, footpaths and several carparks,

which may be subject to the impacts of coastal hazards at present or in the future. A total of 56 key assets have been identified as being at risk over the next 100 years, including:

- 21 natural assets such as beaches and dune systems, including Bush Forever sites
- 35 built assets including one protective asset and one heritage listed asset.

Minor assets such as access paths, showers and benches have been grouped together for assessment and management.

For a full list of assets, refer to Appendix A.

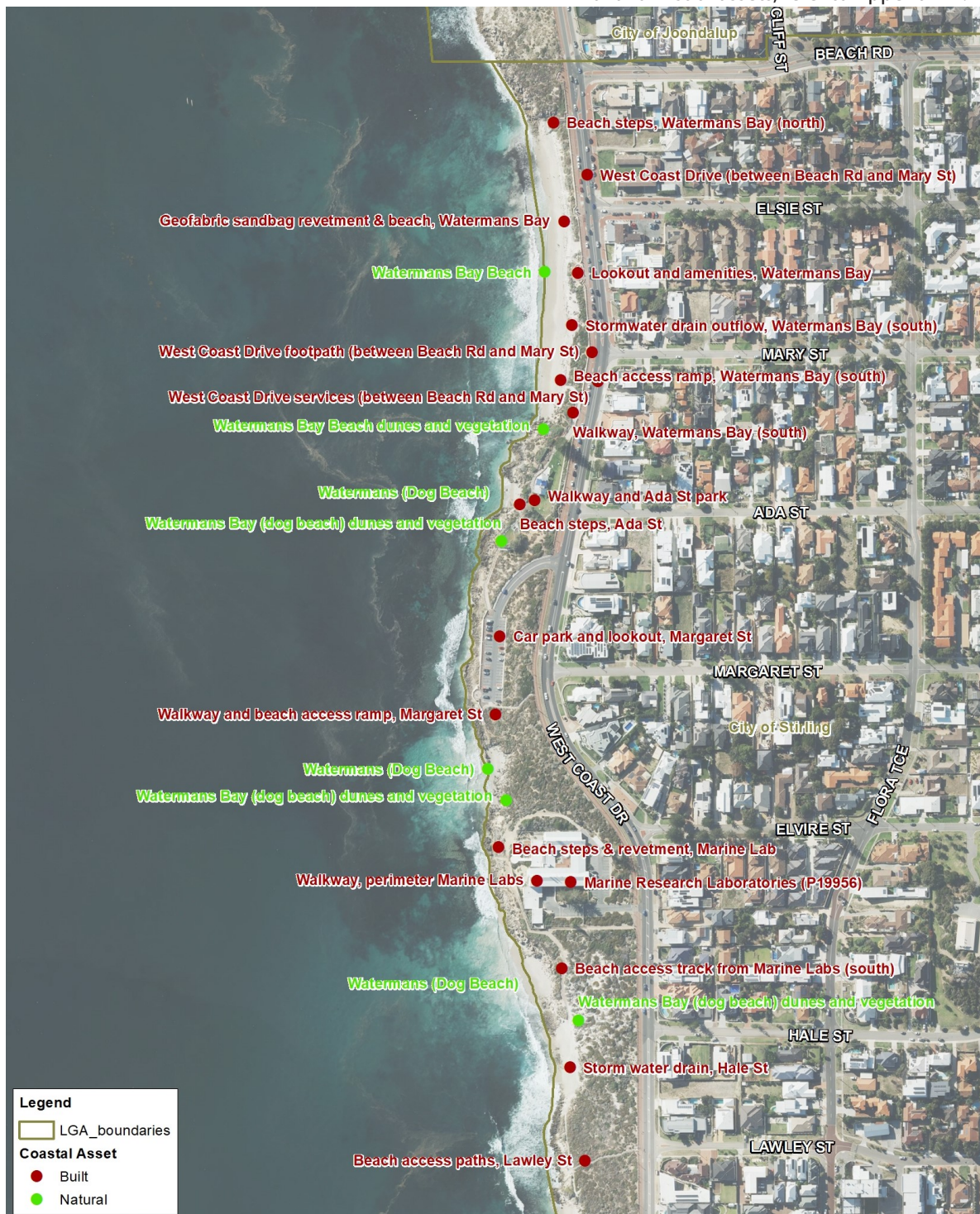


Figure 3a: Zone 1 asset locality plan



Figure 3b: Zone 2 asset locality plan



Figure 3c: Zone 3 asset locality plan



Figure 3d: Zone 4 asset locality plan



Figure 3e: Zone 5 asset locality plan

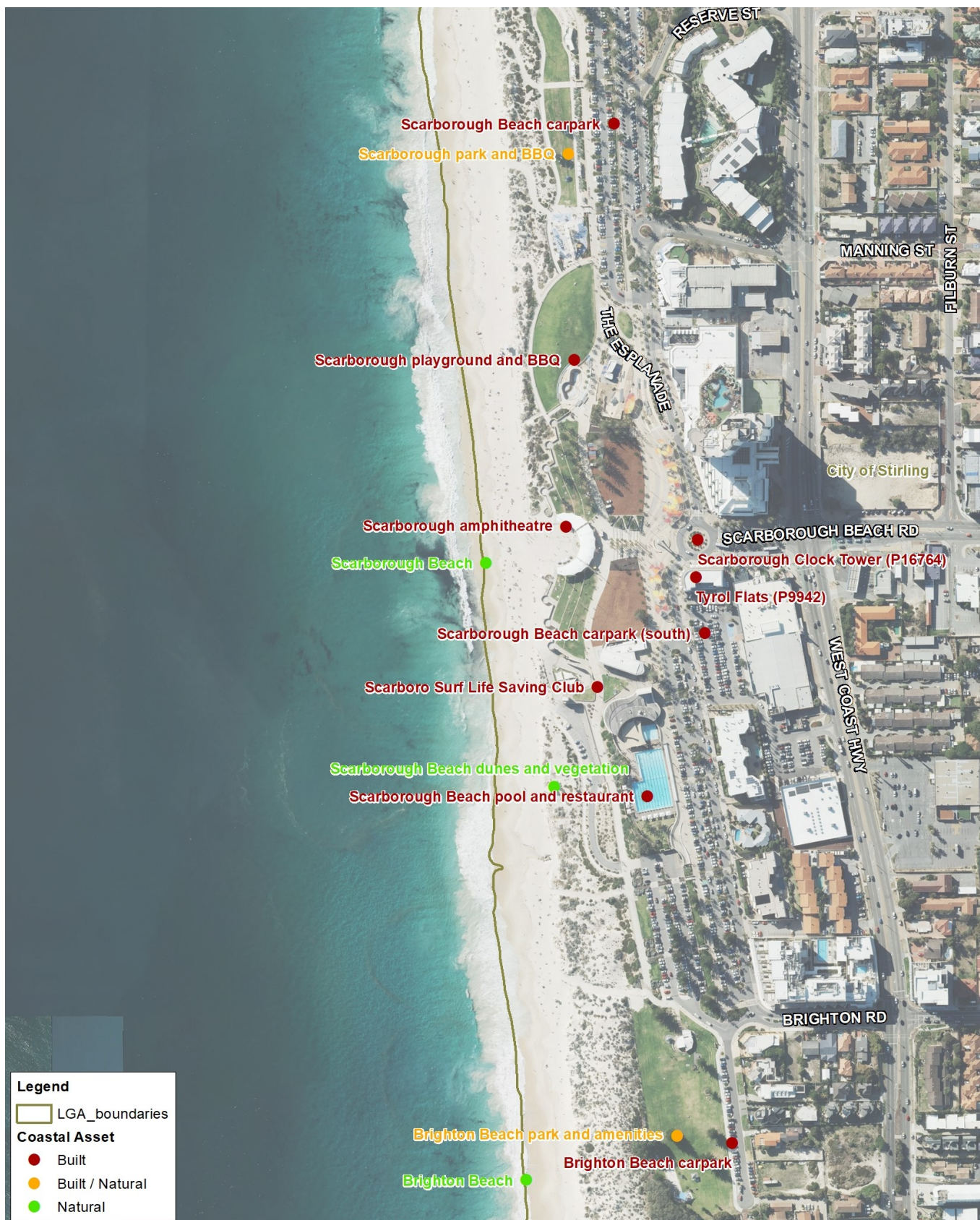


Figure 3f: Zone 6 asset locality plan



Figure 3g: Zone 7 asset locality plan

Community and stakeholder input

An important part of creating a CHRMAP is bringing interested community members and key stakeholders on the planning journey to ensure the coastal values and adaptation pathways are acceptable to the community and people who interact with the coast and key assets along the coastline. The following engagement and communications methods were used to encourage community and stakeholder input.

230 respondents

Online coastal values survey – to understand the way that people use and value the coastline

29 comments

Online asset mapping tool – to understand where and what the key assets are that the community value along the coastline and why they value those assets



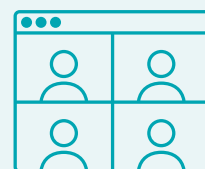
22 attendees

Pop-up information session – to help share knowledge about the CHRMAP process and receive feedback from the community about coastal values



6 attendees and 2 additional feedback forms completed

Two online adaptation scenario workshops* – to involve the community and stakeholders in the process of determining the preferred adaptation and mitigation strategies for key assets along the coastline



270+ attendees and over 4 locations

Pop-up information stalls – to further raise awareness of the project and seek final feedback on the acceptability of the proposed adaptation options



Workshop webinar

Workshop webinar – a webinar of the workshop was made available on the project webpage for those wanting to learn more about the project

* Due to COVID-19 within the community, the decision was made to reschedule the face-to-face workshops to online in February 2023

Success criteria

1	Preserve the function and opportunity for recreation activities along the coastline (such as walking/ running, swimming and surfing).
2	Preserve the existing hospitality venues along the coastline and access to them.
3	Ensure the natural environment is protected and sustained in its current condition or an improved condition (concerning the dunes and flora and fauna).
4	Develop solutions to coastal processes that are sustainable (financially, socially and built form) and locally responsive.
5	Revisit regularly with community and key stakeholders their values in relation to development adjacent the coastline.
6	Maintain services that maximise community benefit for all.
7	Ensure the coastline is safe and accessible to all.
8	Achieve a balance between access needs and environmental sensitivities.

Refer to Chapter Report 1: Establish the Context for further detail.

Coastal hazards

What are the coastal hazards?

Coastal hazards are associated with the natural variability of the ocean and have the potential to impact coastal areas and assets. Coastal hazards are not solely associated with climate change; they have always existed along our coastlines.

The impact of sea level rise, associated with climate change, is considered in the CHRMAP over the next 100 years. Its influence is based on the projection that the sea level is projected to be nearly 1m higher by 2122. Sea level rise will likely increase the risk associated with coastal hazards due to erosion and inundation, which are the two primary coastal hazards that are examined in the CHRMAP study.



Erosion – Erosion can occur in a short period - for example due to a storm event, or over a longer period – as the shoreline gradually retreats due to rising mean sea level or changes/variability in local coastal

process. If erosion occurs where assets exist, the damage is generally permanent. Erosion, however, is not necessarily permanent, with sandy beaches often eroding and recovering seasonally.



Inundation – Inundation can occur due to tidal variation, sea level rise and coastal storm surge, occurring when the ocean water level exceeds the land level and leading to

flooding of these areas. When assets exist in these areas, they can be temporarily impacted, which may lead to permanent damage.

Coastal hazard assessment

Coastal hazard modelling was undertaken in accordance with the State Coastal Planning Policy (SPP2.6), which specifies the calculation of the following components of erosion and inundation:

- **S1 Erosion** – allowance for the current risk of storm erosion
- **S2 Erosion** – allowance for historic shoreline movement trends
- **S3 Erosion** – allowance for erosion caused by future sea level rise
- **S4 Inundation** – allowance for the risk of storm surge inundation for current topography.

The sum of each of the components for erosion (S1, S2 and S3) and inundation (S4) were used to derive hazard lines for present day, 2030, 2045, 2070 and 2122 timeframes. Hazard lines depict the active limit for each coastal hazard at a given timeframe and are used to identify at-risk areas and assets along the City's coastline. 'Uncontrolled' maps have also been included for sections of the City's coastline containing coastal controls. The maps display erosion hazard lines without the effects of coastal controls, as per the guidance of SPP2.6. For further information, refer to Figure 4a-p.

A key outcome of the coastal hazard assessment was the confirmation that coastal erosion is the prevailing coastal hazard for the City's coastline. Calculated inundation extents show water levels do not surpass the City's steep dune systems and will not impact built assets over the 100-year timeframe. Erosion hazard extents will be interpreted to assess risk and guide adaptation planning for the CHRMAP. These extents have been calculated both with and without the effect of coastal controls, like the GSC seawall at Watermans Bay.

Refer to Chapter Report 2: Risk Identification for further detail.



Figure 4a: Coastal erosion lines zone 1

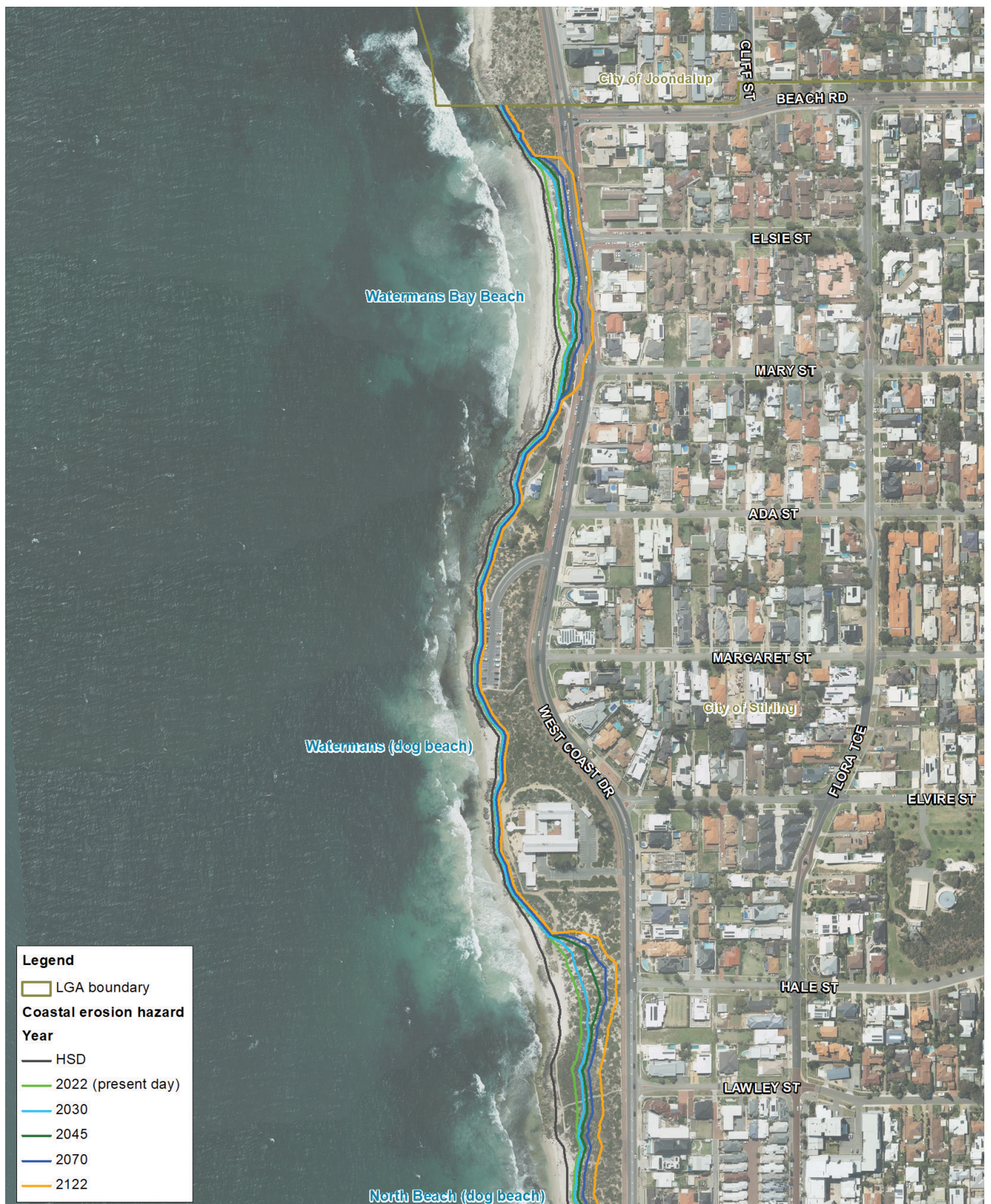


Figure 4b: Coastal erosion lines zone 1 uncontrolled



Figure 4c: Coastal erosion lines zone 2

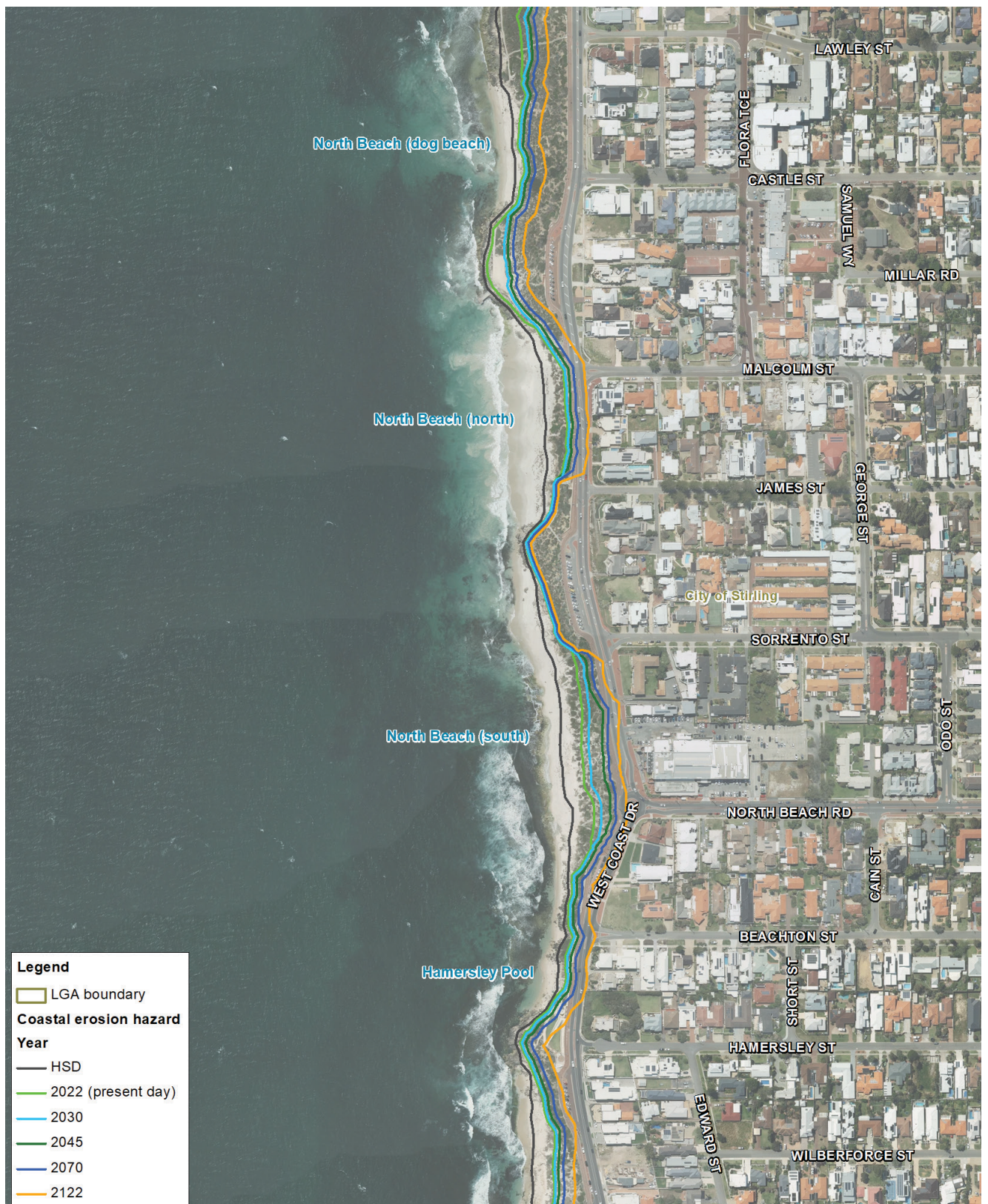


Figure 4d: Coastal erosion lines zone 2 uncontrolled

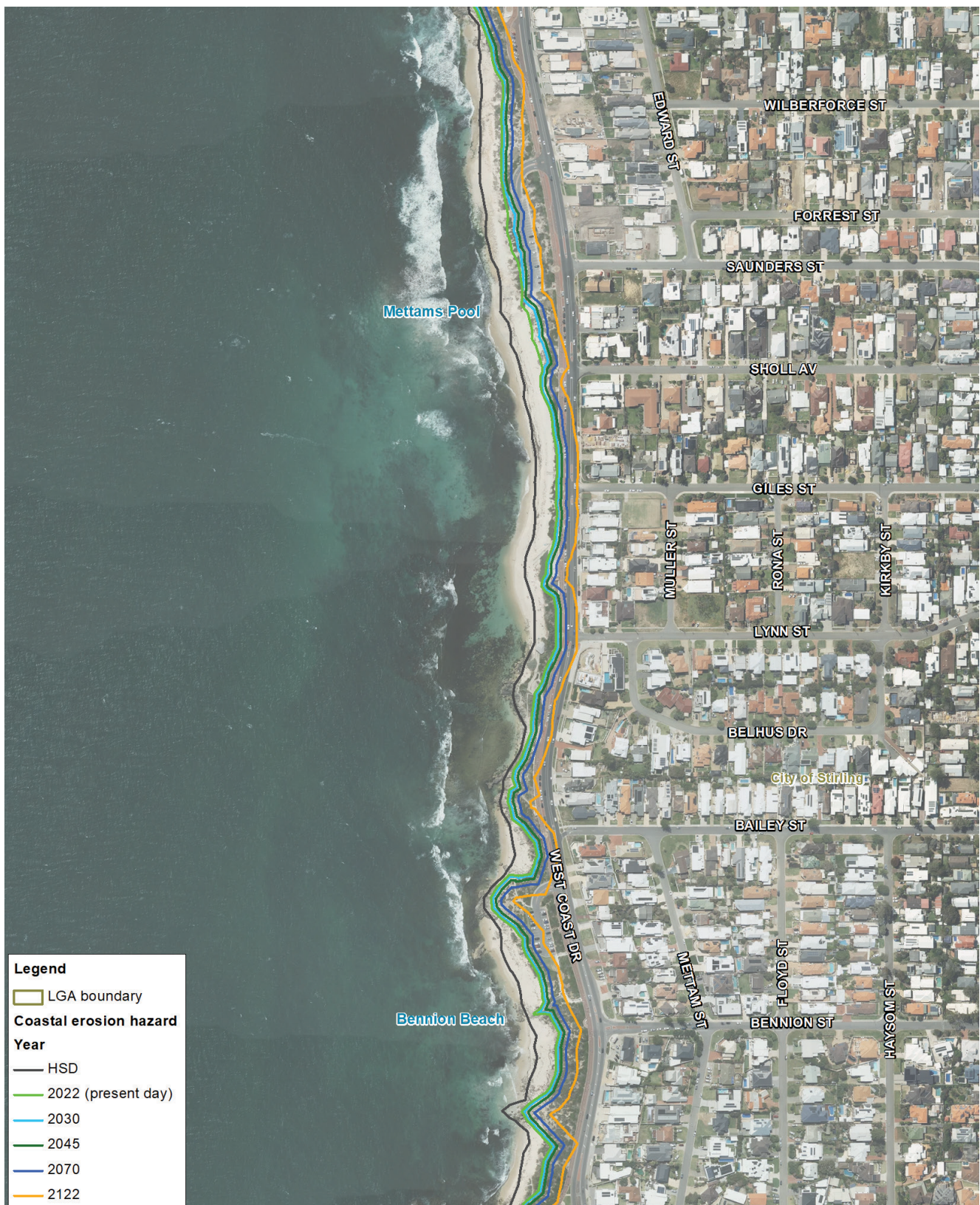


Figure 4e: Coastal erosion lines zone 3



Figure 4f: Coastal erosion lines zone 4



Figure 4g: Coastal erosion lines zone 5



Figure 4h: Coastal erosion lines zone 6

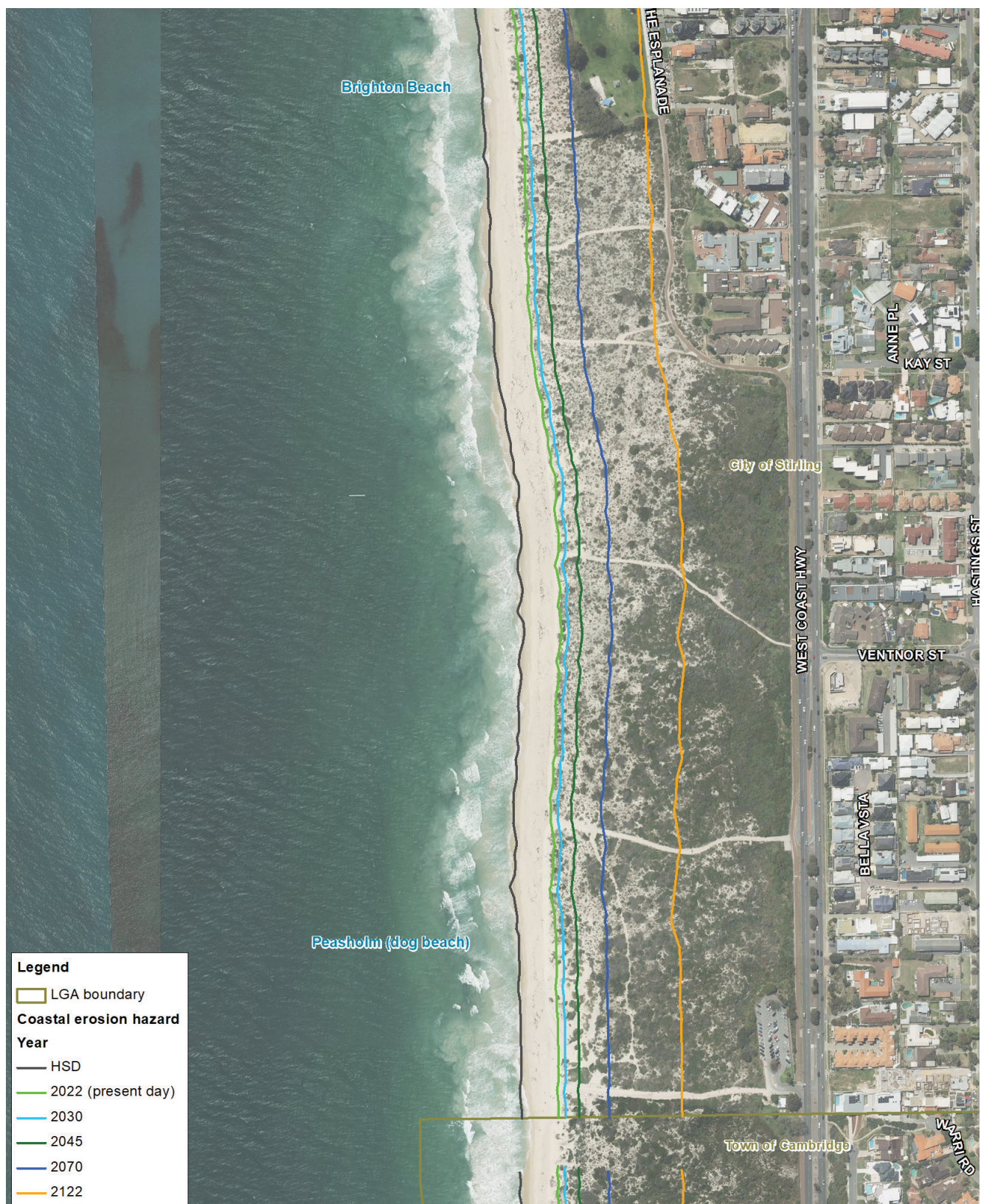


Figure 4i: Coastal erosion lines zone 7



Figure 4j: Coastal inundation lines zone 1



Figure 4k: Coastal inundation lines zone 2



Figure 4l: Coastal inundation lines zone 3



Figure 4m: Coastal inundation lines zone 4



Figure 4n: Coastal inundation lines zone 5



Figure 4o: Coastal inundation lines zone 6



Figure 4p: Coastal inundation lines zone 7



Mentana's Pool
SUPPLY AREA
NO FISHING
IN THIS POOL AREA

How vulnerable is our coastline?

Approach to vulnerability analysis

The vulnerability analysis 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 likelihood and consequence. Likelihood was assigned using the results of the coastal hazard assessment. Consequence ratings were informed by a combination of environmental, social and economic values and additional values determined through community consultation, economic assessment and experience with similar assets along the WA coastline. Risk ratings were then combined with an asset's adaptive capacity to assign assets a rating for vulnerability over each planning horizon.

Vulnerability ratings have been assigned both with and without the effect of the GSC seawall at Watermans Bay. The seawall has only been considered active for its anticipated design live.

Consequence	The severity of impact for an asset or area if an impacted by a coastal hazard
Likelihood	The chances of coastal hazards causing impact (that is, to an asset or area)
Planning horizon	The amount of time into the future for which plans are made. This CHRMAP considers planning horizons of 10, 25, 50 and 100 years
Risk	The combination of likelihood (exposure) and consequence (sensitivity) of hazard impact for an asset or area
Vulnerability	The combination of risk to an asset and its adaptive capacity; for example, if an asset is at high risk, but can be easily adapted, its vulnerability is relatively low

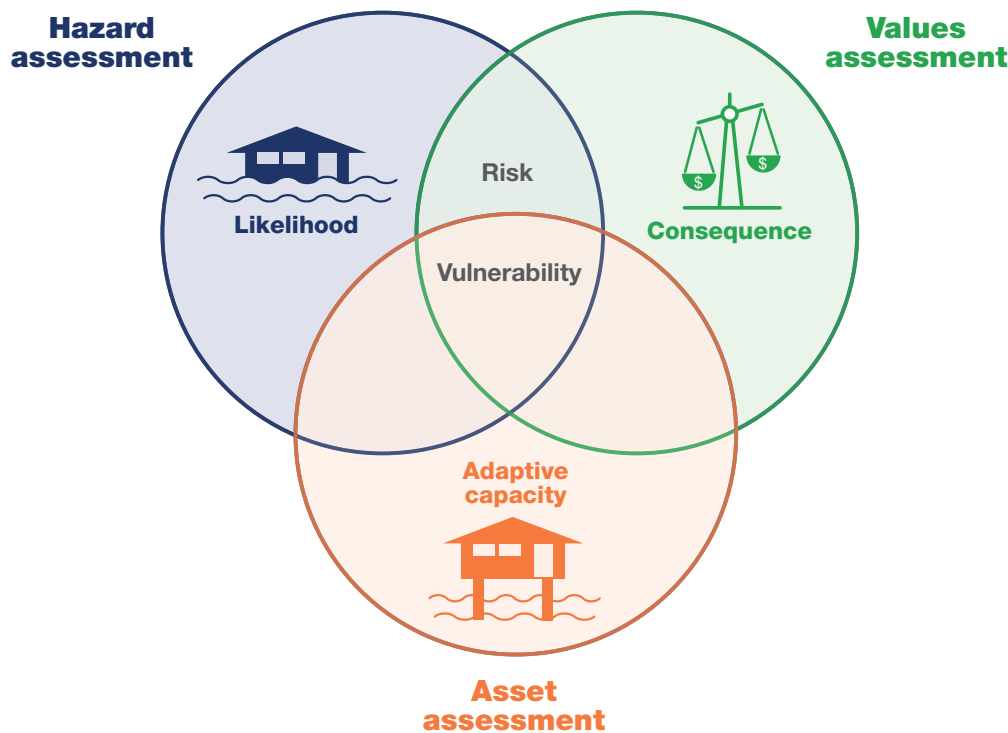


Figure 5: Conceptual relationship between risk assessment elements

Effect of coastal controls

Coastal controls that influence risk levels are the various revetments located in the north of the study area. The only one of these that is extensive enough to influence the risk assessment is the Watermans Bay GSC revetment. Hazard lines were developed in stage 2 for both controlled (GSC revetment is maintained until the end of its design life) and uncontrolled (all protective assets are assumed to be removed in the present-day planning horizon). While the complete removal of the GSC revetment (or other form of protection) is unlikely in the present day within the City's context, it does help illustrate the effect the existing controls have on the risk of assets (that is, the value they provide). This structure reduces the likelihood of impact to assets on its landward side, including vegetated dunes, a portion of West Coast Drive and the Watermans Bay lookout. This is useful when considering the management controls in the context of future adaptation options.

For the full table of erosion risk assessment outcomes, both with and without coastal controls, please see Appendix B.

Management units

Six management units (MU) were established along the City's coastline to assist with the evaluation of adaptation options. These MUs were selected based on the focused concentration of coastal hazard risk, as well as consideration for similar coastal features and shared sediment compartments.

MU1 – Watermans Bay

MU1 extends from the City's northern boundary (aligned with Beach Road) to the southern end of Watermans Bay dog beach (aligned with Hale Street).

MU2 – North Beach

MU2 extends from the northern end of North Beach dog beach (aligned with Hale Street) to the southern end of Hamersley Pool (aligned with Hamersley Street).

MU3 – Mettams Pool

MU3 extends from the northern (aligned with Hamersley Street) to the southern (aligned with Bailey Street) end of Mettams Pool.

MU4 – Trigg Beach North

MU4 extends from the northern end of Bennion Beach (aligned with Bailey Street) to Trigg Point/Island.

MU5 – Trigg Beach South

MU5 extends from Trigg Point/Island to the southern end of Trigg Beach.

MU6 – Scarborough Beach

MU6 extends from the northern end of Scarborough Beach to the southern extent of the City's boundary at Peasholm dog beach.

Prioritising vulnerable areas for adaptation

Based on the outcomes of the risk and vulnerability assessment, MUs have been classified as high or medium priority for treatment, as follows:

High priority, requiring further investigation in the immediate term and, depending on the outcomes, active management in the short term.

- MU1 – Watermans Bay
- MU3 – Mettams Pool.

Medium priority, requiring further investigation in the immediate to short term and, depending on the outcomes, active management in the short to medium term.

- MU2 – North Beach.
- MU4 – Trigg Beach North
- MU5 – Trigg Beach South
- MU6 – Scarborough Beach.

Key outcomes of vulnerability analysis

The following are key outcomes of the vulnerability analysis.

- The City's coastline is particularly vulnerable to coastal erosion and has a very low risk of coastal inundation.
- High priority MUs are those in the north of the study area, where highly valued beaches are vulnerable due to their inability to naturally adapt. Erosion in this area also creates risk for access infrastructure, with significant implications for reputation and service delivery.
- Assets located in MUs south of Trigg Island generally become vulnerable at later planning horizons than northern MUs due to wide sandy beaches and natural dune systems acting as a buffer between coastal hazards and assets.
- Vulnerability of natural assets such as beaches and dunes are controlled by the distance between the shoreline and built assets.

Refer to Chapter Report 3: Vulnerability Assessment and Risk Evaluation for further detail.



What are the management options for coastal hazards?

Whose responsibility is it to manage the coastline?

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.

State Planning Policy 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.

Knowing that any type of coastal adaptation will be expensive and that state and federal assistance is not guaranteed, 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 CHRMAP report will help the City to prioritise the savings fund.



Equity explained

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 from both inside and outside jurisdictional boundaries. It is critical that planning and management is as transparent and equitable as possible. Responsibility for coastal planning lies with both state and local governments, 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 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.

Adaptation hierarchy

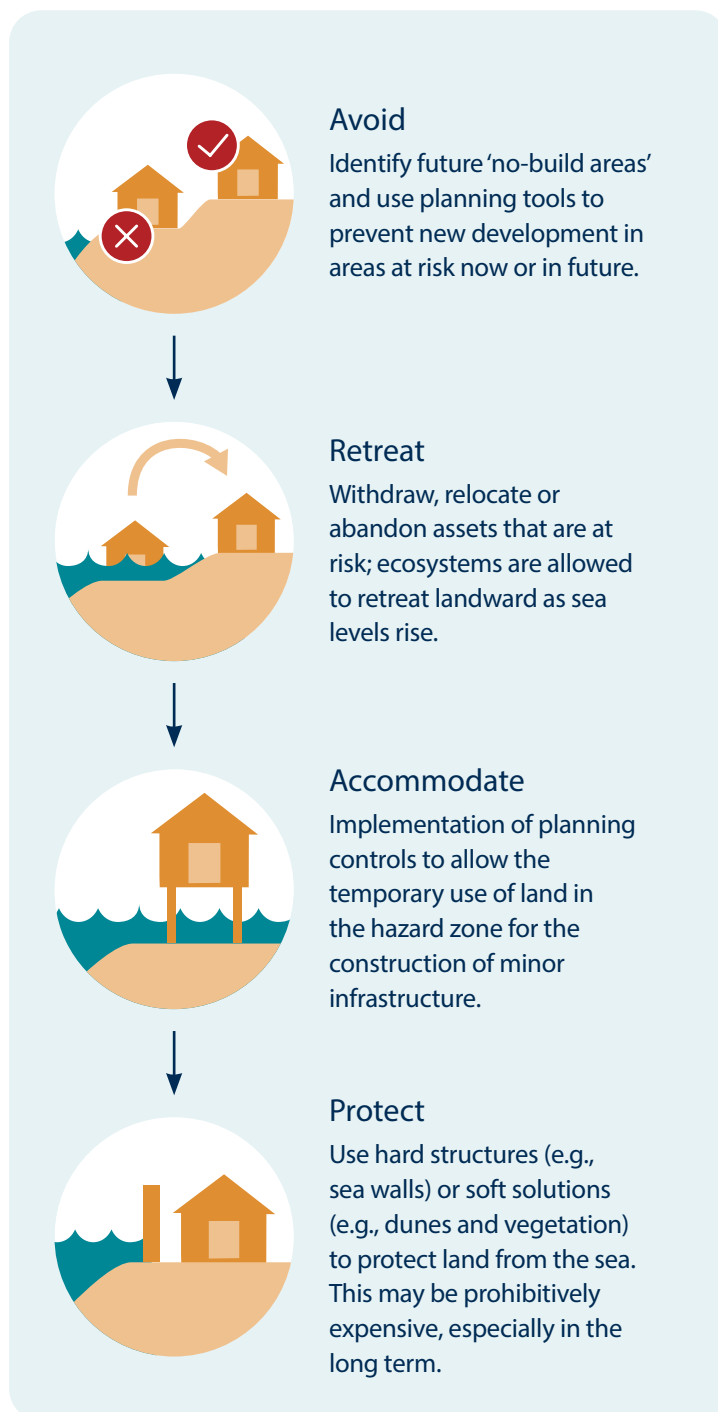
Effective adaptation planning involves the identification and evaluation of options suitable to manage the risk of coastal hazards. Potential options have been identified under the risk management hierarchy of 'avoid', 'managed retreat', 'accommodate' and 'protect' in accordance with SPP2.6 and the CHRMAP guidelines (WAPC, 2019). Protection is the least preferred management option.

- **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.
- **Managed retreat** is a preferred long-term strategy for areas of existing development at risk. This option aims to remove assets from the risk of coastal hazards and is generally the economically responsible approach over the long term, although it may involve significant expenditure during implementation. Appropriate statutory and financial planning is required to prepare for implementation of this option.
- **Accommodate** options aim to redesign 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.
- **Protect** options range from temporary 'soft' protection, such as sand nourishment, to semi-permanent 'hard' protection options, such as groynes and seawalls. It should be noted that no protection option is considered permanent (hence their description as 'interim' protection), and all have associated expenses to implement, maintain and remove. These expenses 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 preferential planning 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.

SPP2.6 clause (5.5 (iii)) states that when “sufficient justification can be provided for not avoiding the use or development of land that is at risk from coastal hazards, and accommodation measures alone cannot adequately address the risks from coastal hazards, then coastal protection works may be proposed for areas where there is a need to preserve the foreshore reserve, public access and public safety, property and infrastructure that is not expendable”.

Although protection measures are the least-favoured option, particularly as a long-term mitigation measure, they remain a commonly employed coastal risk mitigation strategy globally. For further information, see pages 14 and 15 of the WA Coastal Zone Strategy (WAPC, 2017).



Management options

Option category	Option name	Option code	Description
Avoid	Avoid development	AV	Avoidance of inappropriate (for example, significant/permanent) development within coastal hazard areas.
Planned/managed retreat	Leave unprotected/repair	PMR1	Assets are left unprotected and loss or damage is accepted following hazard event. Assets are then repaired or removed.
	Remove/relocate	PMR2	Assets located in the hazard zone are permanently removed or relocated prior to impact.
	Planning controls to prepare for managed retreat	PMR3	Use of planning controls to allow continued use of the current infrastructure until such time that impacts arise, but restrict the development of further infrastructure (densification) as the area/asset is known to be vulnerable.
Accommodate	Planning controls to accommodate/identify risk	AC1	Indicates to current and future landholders/stakeholders that an asset is at risk from coastal hazards over the planning timeframe. Helps stakeholders to make informed decisions about the level of risk they are/may be willing to accept and that risk management and adaptation is likely to be required at some stage.
	Emergency plans and procedures	AC2	Implement plans for assets/areas that are at risk of coastal hazards. Have procedures in place for before, during and after the events for safety, for example, signage/barriers to prevent access.
	Redesign to withstand impact	AC3	Maintain asset in existing location but redesign and upgrade to be resilient to coastal hazard impacts.
Protect	Dune care /sand management	PR1	Development of an ongoing program for revegetation and rehabilitation of the dune system. Sand fencing to manage wind-blown erosion also falls under this category.
	Beach nourishment (see Figure 6)	PR2	Addition of sand to the beach, dune and/or nearshore area to replace lost material and/or create additional buffer. This option is often a temporary measure and can be more effective in association with hard protection options, such as groynes. The sand may be from an external source or from a nearby part of that coastal area (though outside of the local sediment cell - use of sediment within the cell is considered sand management – PR1).
	Groynes/headland enhancement (see Figure 7)	PR3	Construct groynes/headland enhancement along the beach to restrict longshore sediment movement and stabilise sections of shoreline. This option is often accompanied by beach nourishment. Hard protection generally diverts/creates erosion issues elsewhere, such as to the down-drift side of a structure.

Option category	Option name	Option code	Description
Protect (continued)	Nearshore reefs /breakwaters (see Figures 8 and 9)	PR4	Construct offshore reef(s)/breakwater(s) or raise existing natural nearshore reef structure to increase protection from wave energy as sea level rises, lowering cross-shore sediment transport. Hard protection generally diverts erosion issues elsewhere, such as to beaches either side of the nearshore structures.
	Revetments/ seawalls (see Figure 10)	PR5	Construct seawall in front of assets or along length of coastline to protect them from coastal hazards. Hard protection generally diverts erosion issues elsewhere, such as to beaches either side of and directly in front of, a seawall.
Do nothing	Do nothing	DN	Take no action. No limitations on development or implementation of adaptation planning. Accept risk.

Triggers to respond

Management triggers have been developed so that management and adaptation actions respond to actual future climate change conditions and ongoing risk levels, rather than forecasts that may not be realised (that is, unnecessary expenditure). Triggers are in place to initiate both management action and preparation for such action. Triggers are generally associated with the measurement of risk - specifically, when intolerable risk is encountered.

The following are examples of management triggers.

- The horizontal shoreline datum shifts to within the S1 distance of an asset's most seaward extent

- Asset is damaged, becomes unsafe or inaccessible
- A coastal management technique is deemed no longer effective
- Community or financial support for a previously implemented option is no longer available.

Refer to Chapter Report 4: Risk Treatment for further detail.



Figure 6: Beach nourishment at Mettams Pool



Figure 7: City Beach Groyne

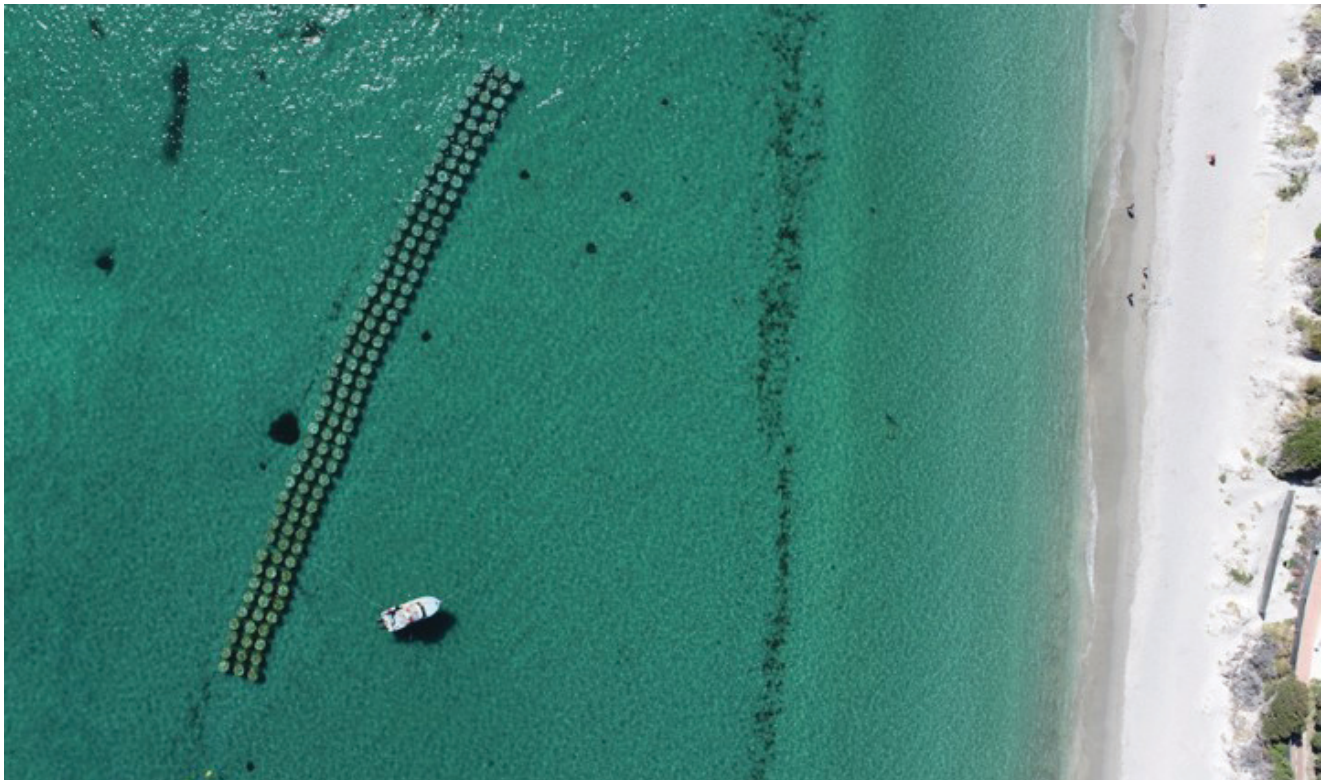


Figure 8: CY O'Connor offshore reef



Figure 9: Kwinana offshore breakwater



Figure 10: Seawall at Watermans Bay

How to best manage the City of Stirling coastline

Community and stakeholder preferences

Following the collection of coastal values from the community and stakeholders earlier in the project, the next stage of the engagement was to understand the community's preferences for managing the coastline and impacted assets. Due to COVID-19, two workshops were held online, with a webinar and online feedback form open from March to April 2022.

Feedback from participants is summarised below.

- Coastal zones with more built assets of economic value and environmental assets were deemed to have a 'catastrophic' consequence if they were to be impacted by coastal hazards. Examples of built assets noted by the community were West Coast Highway, the Scarborough foreshore and infrastructure services running along West Coast Highway. Examples of environmental assets noted by the community were the dune system, vegetation, the reef and usable sandy beach.
- For these assets, protect or accommodate were the preferred adaptation strategies.
- For some social assets (such as surf life saving clubs) it was noted that a planned or managed retreat would be an appropriate adaptation strategy.
- Where possible, limited development should be allowed on the foreshore reserve along the whole coastline.

Multi-criteria assessment

As recommended by the CHRMAP Guidelines (WAPC, 2019), a multi-criteria analysis (MCA) has been applied as a preliminary step to identify potentially suitable adaptation options for sections of coastline, as well as to discard unviable options. The analysis uses a broad range of criteria and a simple 'traffic light' rating system to evaluate the acceptability of each option across each of the six management units.

The following are the general outcomes of the MCA assessment.

- Avoidance of presently undeveloped land within the coastal foreshore reserve is recommended
- Minor public infrastructure may be left unprotected
- Future planning controls for managed retreat are recommended for commercial and private properties
- Dune care and sand management are recommended for all management units
- Protective options such as groynes/headland enhancement, offshore breakwaters, seawalls and nourishment require further assessment.

For full MCA tables and rating system, please see Appendix C.

Cost-benefit analysis

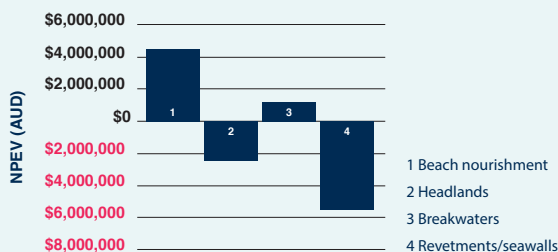
A cost-benefit analysis (CBA) is a systematic method for determining if the overall costs match the net benefits of a project. A CBA was undertaken to inform selection of preferred risk treatment options, based on a 50 year management time frame (to 2073), for each management unit that was recommended by the MCA as warranting further assessment. The costs and benefits of risk treatments have been forecast over their expected lifetimes. Costs were subtracted from benefits to determine the net present economic value (NPEV) of each option.

NPEV is a measure which allows a simple comparison of the net benefit to society of risk treatment options. It is important to note that this refers to economic benefit only, and this does not always reflect societal acceptance of options.

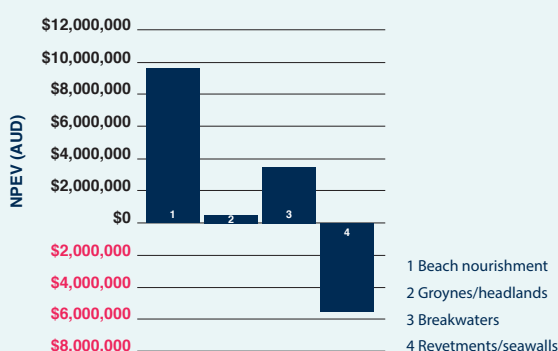
The CBA modelled five options, for a number of risk treatment options for each management unit. Refer to the Risk Treatment chapter report for more detail of modelled risk treatment options. The individual NPEV of each option is shown in the following.

Note for MU2 (North Beach), beach nourishment was the only option tested, returning an NPEV of \$150,730.

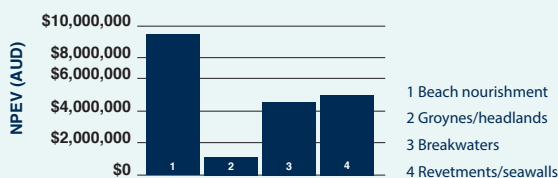
MU1 – Watermans Bay



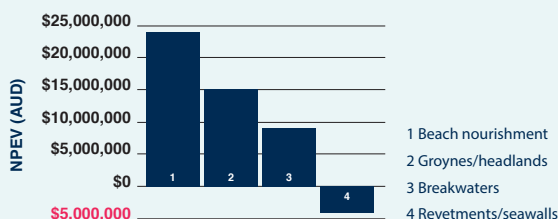
MU3 – Mettams Pool



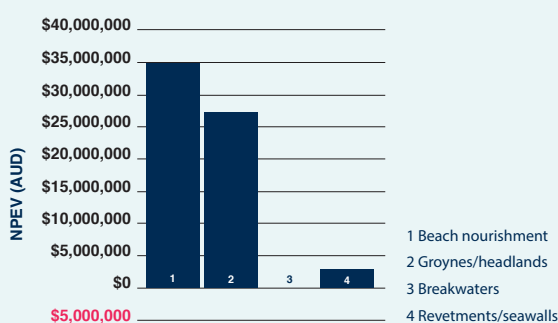
MU4 – Trigg Beach North



MU5 – Trigg Beach South



MU6 – Scarborough Beach



Adaptation pathways

Adaptation pathways have been established to guide the City's management activities/approach, so that tolerable risk levels for assets are maintained across planning timeframes. Pathways have been developed based on the MCA and stakeholder preferences, with the financial viability of favoured options tested in the CBA.

It is important to reiterate that several assumptions have been used to approximate risk levels at each timeframe. The levels of (intolerable) risk may be arrived at sooner or later than predicted. Because of this, adaptation should be in response to the associated trigger(s) being reached, rather than the timeframe-based predictions. Once one or more

triggers are met, the relevant adaptation pathway should be followed. This approach prevents unnecessary expense on adaptation prior to risk being present, as well as triggering a response if risk levels become intolerable sooner than anticipated.

Separate pathways are provided for each MU of the City's coastline. Pathways include preferred management/adaptation options, triggers for management action and indications of timeframes where they are likely to be required. Further discussion of pathways for each asset category is provided in the following sub-sections.

Refer to Chapter Report 4: Risk Treatment for further detail.



MU1 – Watermans Bay Beach

The general approaches recommended to adapt to the risk of coastal erosion at Watermans Bay include:

- Avoiding further permanent development on land which has been identified as prone to erosion over the next 100 years
- Accommodating coastal hazard risk through implementation of planning controls to allow for the continued use of current infrastructure, until such time that risk levels require transition to a managed retreat pathway
- Protecting infrastructure at Watermans Bay in the short term, through beach nourishment and potentially through the construction of coastal engineering protection in the short to medium term (subject to more detailed assessment)
- Planning for the eventual managed retreat of existing assets in the foreshore reserve as risk becomes intolerable.

Assets – undeveloped land				
Planning timeframe	2025-30	2030-45	2045-70	2070 and beyond
Pathway	Avoid (AV)			
Trigger(s)	T12: Undeveloped land lying within the hazard extent			
Assets – developed land				
Planning timeframe	2025-30	2030-45	2045-70	2070 and beyond
Pathway	Planned/managed retreat (PMR3)			
Trigger(s)	T4: Asset lying within 100-year coastal hazard extent			
Pathway	Accommodate (AC1)			
Trigger(s)	T4: Asset lying within 100-year coastal hazard extent			
Pathway	Soft protect (PR2)	Protect (TBC) and (PR2)		Planned/managed retreat (PMR2)
Trigger(s)	T1: HSD is within S1 distance of an asset T5: Asset damaged, destroyed or unsafe T6: Asset to move to high or extreme risk in next planning timeframe	T1: HSD is within S1 distance of an asset T5: Asset damaged, destroyed or unsafe T6: Asset to move to high or extreme risk in next planning timeframe T7: Majority of stakeholders no longer supportive T8: Technique no longer economically or physically feasible		T2: Access to property lost T3: Services to asset decommissioned T6: Asset to move to high or extreme risk in next planning timeframe T7: Majority of stakeholders no longer supportive T8: Technique no longer economically or physically feasible T9: The beach/coastal foreshore reserve is significantly diminished
Assets – beach and dunes				
Planning timeframe	2025-30	2030-45	2045-70	2070 and beyond
Pathway	Soft protect (PR1)			
Trigger(s)	T10: Localised erosion of beach and dune systems			

MU2 – North Beach

The general approaches recommended to adapt to the risk of coastal erosion at North Beach include:

- Avoiding further permanent development on land which has been identified as prone to erosion over the next 100 years
- Accommodating coastal hazard risk through implementation of planning controls to allow for the continued use of current infrastructure until such time that risk levels require transition to a managed retreat pathway
- Protecting infrastructure at North Beach in the short term, through beach nourishment
- Planning for the eventual managed retreat of assets at North Beach.

Assets – undeveloped land				
Planning timeframe	2025-30	2030-45	2045-70	2070 and beyond
Pathway	Avoid (AV)			
Trigger(s)	T12: Undeveloped land lying within the hazard extent			
Assets – developed land				
Planning timeframe	2025-30	2030-45	2045-70	2070 and beyond
Pathway	Planned/managed retreat (PMR3)			
Trigger(s)	T4: Asset lying within 100-year coastal hazard extent			
Pathway	Accommodate (AC1)			
Trigger(s)	T4: Asset lying within 100-year coastal hazard extent			
Pathways	Soft protect (PR2)		Planned/managed retreat (PMR2)	
Trigger(s)	T11: Community support for current shoreline position to be maintained		T2: Access to property lost T3: Services to asset decommissioned T6: Asset to move to high or extreme risk in next planning timeframe. T7: Majority of stakeholders no longer supportive. T8: Technique no longer economically or physically feasible. T9: The beach/coastal foreshore reserve is significantly diminished.	
Assets – beach and dunes				
Planning timeframe	2025-30	2030-45	2045-70	2070 and beyond
Pathway	Soft protect (PR1)			
Trigger(s)	T10: Localised erosion of beach and dune systems			

MU3 – Mettams Pool

The general approaches recommended to adapt to the risk of coastal erosion at Mettams Pool include:

- Avoiding further permanent development on land which has been identified as prone to erosion over the next 100 years
- Accommodating coastal hazard risk through implementation of planning controls to allow for the continued use of current infrastructure, until such time that risk levels require transition to a managed retreat pathway
- Protecting infrastructure at Mettams Pool in the short term, through beach nourishment in the short term and potentially through the construction of coastal engineering protection in the short to medium term (subject to more detailed assessment)
- Planning for the eventual managed retreat of existing assets in the foreshore reserve as risk becomes intolerable.

Assets – undeveloped land				
Planning timeframe	2025-30	2030-45	2045-70	2070 and beyond
Pathway	Avoid (AV)			
Trigger(s)	T12: Undeveloped land lying within the hazard extent.			
Assets – developed land				
Planning timeframe	2025-30	2030-45	2045-70	2070 and beyond
Pathway	Planned/managed retreat (PMR3)			
Trigger(s)	T4: Asset lying within 100-year coastal hazard extent			
Pathway	Accommodate (AC1)			
Trigger(s)	T4: Asset lying within 100-year coastal hazard extent			
Pathway	Soft protect (PR2)	Protect (TBC) and (PR2)		Planned/managed retreat (PMR2)
Trigger(s)	T1: HSD is within S1 distance of an asset T5: Asset damaged, destroyed or unsafe T6: Asset to move to high or extreme risk in next planning timeframe	T1: HSD is within S1 distance of an asset T5: Asset damaged, destroyed or unsafe T6: Asset to move to high or extreme risk in next planning timeframe T7: Majority of stakeholders no longer supportive T8: Technique no longer economically or physically feasible		T2: Access to property lost T3: Services to asset decommissioned T6: Asset to move to high or extreme risk in next planning timeframe T7: Majority of stakeholders no longer supportive T8: Technique no longer economically or physically feasible T9: The beach/coastal foreshore reserve is significantly diminished
Assets – beach and dunes				
Planning timeframe	2025-30	2030-45	2045-70	2070 and beyond
Pathway	Soft protect (PR1)			
Trigger(s)	T10: Localised erosion of beach and dune systems			

MU4 – Trigg Beach North

The general approaches recommended to adapt to the risk of coastal erosion at Trigg Beach North include:

- Avoiding further permanent development on land which has been identified as prone to erosion over the next 100 years
- Accommodating coastal hazard risk through implementation of planning controls to allow for the continued use of current infrastructure, until such time that risk levels require transition to a managed retreat pathway
- Protecting infrastructure at Trigg Beach North in the short term, through beach nourishment and potentially through the construction of coastal engineering protection in the short to medium term (subject to more detailed assessment); and
- Planning for the eventual managed retreat of existing assets in the foreshore reserve as risk becomes intolerable.

Assets – undeveloped land				
Planning timeframe	2025-30	2030-45	2045-70	2070 and beyond
Pathway	Avoid (AV)			
Trigger(s)	T12: Undeveloped land lying within the hazard extent			
Assets – developed land				
Planning timeframe	2025-30	2030-45	2045-70	2070 and beyond
Pathway	Planned/managed retreat (PMR3)			
Trigger(s)	T4: Asset lying within 100-year coastal hazard extent			
Pathway	Accommodate (AC1)			
Trigger(s)	T4: Asset lying within 100-year coastal hazard extent			
Pathway	Soft protect (PR2)	Protect (TBC) and (PR2)		Planned/managed retreat (PMR2)
Trigger(s)	T1: HSD is within S1 distance of an asset T5: Asset damaged, destroyed or unsafe T6: Asset to move to high or extreme risk in next planning timeframe	T1: HSD is within S1 distance of an asset T5: Asset damaged, destroyed or unsafe T6: Asset to move to high or extreme risk in next planning timeframe T7: Majority of stakeholders no longer supportive T8: Technique no longer economically or physically feasible		T2: Access to property lost T3: Services to asset decommissioned T6: Asset to move to high or extreme risk in next planning timeframe T7: Majority of stakeholders no longer supportive T8: Technique no longer economically or physically feasible T9: The beach/coastal foreshore reserve is significantly diminished
Assets – beach and dunes				
Planning timeframe	2025-30	2030-45	2045-70	2070 and beyond
Pathway	Soft protect (PR1)			
Trigger(s)	T10: Localised erosion of beach and dune systems			

MU5 – Trigg Beach South

The general approaches recommended to adapt to the risk of coastal erosion at Trigg Beach South include:

- Avoiding further permanent development on land which has been identified as prone to erosion over the next 100 years
- Accommodating coastal hazard risk through implementation of planning controls to allow for the continued use of current infrastructure, until such time that risk levels require transition to a managed retreat pathway
- Protecting infrastructure at Trigg Beach South in the short term, through beach nourishment and potentially through the construction of coastal engineering protection in the short to medium term (subject to more detailed assessment)
- Planning for the eventual managed retreat of existing assets in the foreshore reserve as risk becomes intolerable.

Assets – undeveloped land				
Planning timeframe	2025-2030	2030-2045	2045-2070	2070 and beyond
Pathway	Avoid (AV)			
Trigger(s)	T12: Undeveloped land lying within the hazard extent			
Assets – developed land				
Planning timeframe	2025-30	2030-45	2045-70	2070 and beyond
Pathway	Planned/managed retreat (PMR3)			
Trigger(s)	T4: Asset lying within 100-year coastal hazard extent			
Pathway	Accommodate (AC1)			
Trigger(s)	T4: Asset lying within 100-year coastal hazard extent			
Pathway	Soft protect (PR2)	Protect (TBC) and (PR2)		Planned/managed retreat (PMR2)
Trigger(s)	T1: HSD is within S1 distance of an asset T5: Asset damaged, destroyed or unsafe T6: Asset to move to high or extreme risk in next planning timeframe	T1: HSD is within S1 distance of an asset T5: Asset damaged, destroyed or unsafe T6: Asset to move to high or extreme risk in next planning timeframe T7: Majority of stakeholders no longer supportive T8: Technique no longer economically or physically feasible		T2: Access to property lost T3: Services to asset decommissioned T6: Asset to move to high or extreme risk in next planning timeframe T7: Majority of stakeholders no longer supportive T8: Technique no longer economically or physically feasible T9: The beach/coastal foreshore reserve is significantly diminished
Assets – beach and dunes				
Planning timeframe	2025-30	2030-45	2045-2070	2070 and beyond
Pathway	Soft protect (PR1)			
Trigger(s)	T10: Localised erosion of beach and dune systems.			

MU6 – Scarborough Beach

The general approaches recommended to adapt to the risk of coastal erosion at Scarborough Beach include:

- Avoiding further permanent development on land which has been identified as prone to erosion over the next 100 years;
- Accommodating coastal hazard risk through implementation of planning controls to allow for the continued use of current infrastructure, until such time that risk levels require transition to a managed retreat pathway
- Protecting infrastructure at Scarborough Beach in the short term, through beach nourishment and potentially through the construction of coastal engineering protection in the short to medium term (subject to more detailed assessment); and
- Planning for the eventual managed retreat of existing assets in the foreshore reserve as risk becomes intolerable.

Assets – undeveloped land				
Planning timeframe	2025-30	2030-45	2045-70	2070 and beyond
Pathway	Avoid (AV)			
Trigger(s)	T12: Undeveloped land lying within the hazard extent.			
Assets – developed land				
Planning timeframe	2025-2030	2030-2045	2045-2070	2070 and beyond
Pathway	Planned/managed retreat (PMR3)			
Trigger(s)	T4: Asset lying within 100-year coastal hazard extent.			
Pathway	Accommodate (AC1)			
Trigger(s)	T4: Asset lying within 100-year coastal hazard extent.			
Pathway	Soft Protect (PR2)	Protect (TBC) and (PR2)		Planned/managed retreat (PMR2)
Trigger(s)	T1: HSD is with S1 distance of an asset. T5: Asset damaged, destroyed or unsafe. T6: Asset to move to high or extreme risk in next planning timeframe.	T1: HSD is with S1 distance of an asset. T5: Asset damaged, destroyed or unsafe. T6: Asset to move to high or extreme risk in next planning timeframe. T7: Majority of stakeholders no longer supportive. T8: Technique no longer economically or physically feasible.		T2: Access to property lost. T3: Services to asset decommissioned. T6: Asset to move to high or extreme risk in next planning timeframe. T7: Majority of stakeholders no longer supportive. T8: Technique no longer economically or physically feasible. T9: The beach/coastal foreshore reserve is significantly diminished.
Assets – beach and dunes				
Planning timeframe	2025-2030	2030-2045	2045-70	2070 and beyond
Pathway	Soft protect (PR1)			
Trigger(s)	T10: Localised erosion of beach and dune systems			

Refer to Chapter Report 4: Risk Treatment for further detail.



Implementing the CHRMAP and gaining a better understanding of coastal hazard risk

Short-term implementation (next 25 years)

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 cost of maintaining current features is likely to become prohibitively expensive at some point in the future. The interim nature of protection options needs to be recognised across the community and adaptation options developed and solutions optimised for social, environmental and economic (affordability) drivers.

Funding and equity

The cost to manage changes to the City's coastline in the future is predicted to be considerably greater than current expenditure on coastal management, due to an increasing number of assets becoming vulnerable. Significant expenditure may be directed towards a combination of interim protection, to maintain the shoreline position as best as is practicable, and implementation of managed retreat of high-value assets to accommodate eventual shoreline recession. Although part-funding may be available from the State and Federal Governments, the City should prepare to take on a significant portion of the cost and take responsibility for ensuring the most responsible financial decisions are made.

The City should identify funding sources for ongoing and future management. Appropriate investigations, such as a benefit distribution analysis, which determines who is affected, both positively and negatively, from a particular management measure, should be carried out to ensure funding is derived from the main beneficiaries of the management measures. Those parties that would be disadvantaged by any management activities, if any, should also be identified and appropriately compensated.

Funding sources to be investigated include:

- Council rates, including specified area rates that can draw more funding from those receiving greater benefit
- Developer contributions for coastal developments
- Beach and foreshore access and use fees, such as parking fees.

It is recommended that the City establish or join a strategic partnership with other local government areas (LGAs) in the same primary sediment cell to help facilitate the coordination and equity of management measures across LGAs. Such partnerships already exist along the WA coastline, with the Peron-Naturaliste Partnership established to promote the sharing of knowledge and data as well as helping coordinate projects and grant applications across nine LGAs in WA's south-west.

Planning controls

A range of planning mechanisms and considerations were presented in the Risk Treatment Report (Cardno, 2023). The City should look to implement appropriate planning controls when properties have been identified as being subject to coastal hazards through further iterations of this CHRMAP. Planning controls will help limit risk and liability for the City in the future.

Planning controls recommended include:

- Introduction of a special control area (SCA) in the future, a planning zone where special consideration is required for proposed development, given the risk from coastal hazards over the next 100 years
- Review existing and future structure plans to ensure that they properly account for the outcomes of this CHRMAP
- Develop a coastal Local Planning Policy to formally guide future development proposals within the coastal zone.



Management priorities

Ongoing dune maintenance and revegetation activities, as well as restorative sand fencing, should continue along the City's coastline. These activities enhance or prevent degradation of natural erosion barriers (dunes). They are also likely to improve the longevity of nourishment when applied and any planned nourishment should be coordinated with these activities (for example, reinstatement of dunes followed by revegetation). The activities also promote ownership and understanding of the natural coastline among the community.

In the immediate term, where required, beach nourishment should be employed to manage coastal erosion hazards along the City's coastline. The City should review nourishment activities along the Perth metropolitan coastline and plan future activities considering the results of hazard modelling undertaken as part of the CHRMAP. Nourishment should target areas with the highest overall risk and vulnerability and consider where the most value can be added through the activity, such as by improving beach amenity at Watermans Bay and Mettams Pool.

The risk assessment found Watermans Bay and Mettams Pool Beaches are currently at high risk of being impacted by coastal erosion. Preliminary multi-criteria and economic assessment of options has indicated that the construction of nearshore reef(s) is likely to be the most cost-effective and acceptable interim coastal protection measure to treat the risk at both locations. The City should confirm this by undertaking a detailed options assessment for each section of coastline, assessing 'short-listed' coastal engineering techniques to protect infrastructure at both locations. The preferred option should then be implemented to afford protection to the two beaches for at least 25 years.

Portions of the Scarborough Beach foreshore are also at risk of being impacted by coastal erosion in early planning timeframes. As this section of coastline is relatively exposed, the effectiveness of nourishment is likely to be low and an interim hard protection measure would be required to treat risk at Scarborough. Preliminary multi-criteria and economic assessment of options has indicated that groynes are likely to be the most cost-effective and acceptable interim coastal protection measure. The City should confirm this by undertaking a detailed options assessment for the section of coastline, assessing 'short-listed' coastal engineering techniques to protect infrastructure at both locations. The preferred option should then be implemented to afford protection to Scarborough for at least 25 years.

Monitoring and further investigation

It has been recommended that a dedicated coastal monitoring program is continued and expanded for the City's coastline. The dataset obtained from the monitoring program will be critical to informing adaptation at future planning timeframes and understanding ongoing risk levels, so any reactive management can be triggered. This will include:

- Ongoing assessment of aerial imagery
- Shoreline profiling
- Remote shoreline imagery collection
- Sediment sampling
- Before and after storm monitoring
- Geological risk monitoring
- Ad hoc metocean data collection.

The key further investigations recommended to be undertaken in the short term include:

- A sediment source investigation to inform proposed nourishment of the City's shorelines going forward
- A detailed options assessment to select the optimal interim coastal protection solution for Watermans Bay, Mettams Pool and Scarborough Beaches
- Development of Foreshore Management Plan(s) for vulnerable areas of the City's coastline, such as Watermans Bay and Mettams Pool
- A detailed economic assessment to properly quantify the value of natural assets along the City's coastline
- Revisions of the CHRMAP and hazard extents at 10-yearly intervals or to coincide with significant changes to strategic plans, local planning strategies and schemes, release of IPCC assessment reports or policy and guideline changes.

Medium and long-term implementation

Recent global sea level rise predictions released by the Intergovernmental Panel for Climate Change have been interpreted at a local level by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Bureau of Meteorology (BoM) (2015 & 2020). Projections for regional SLR at Fremantle suggest that the region is tracking, on average, consistently with broader global predictions. The predictions demonstrate significant uncertainty with respect to both emissions scenarios (human behaviour-related) and resulting sea level rise (due to sea level response and modelling uncertainty) as they move into future timeframes.

The medium-term timeframe (25-50 years) is expected to require the implementation of key decisions that are well informed by collected data and investigations undertaken across the preceding 25 years. The timeframe is likely to require a shift from the typical protect approach for built-up coastal areas towards a managed retreat approach.

In the long term (50-100 years), accelerated sea level rise and associated erosion is likely to make maintenance of the shoreline and adjacent foreshore reserve (in its present state) infeasible, even for short stretches of coastline. The need for managed retreat will begin to impact on major landward assets such as roads and private property, given that an adequate coastal foreshore reserve must be maintained. An overarching strategy (for example, guided at state and federal levels) to implement such adaptation is expected to be in place to inform the City's decision making.

Refer to Chapter Report 5: Implementation for further detail.

Key recommendations

- ✔ Engage the community to present the results of this CHRMAP and formally assess their willingness to contribute to funding.
- ✔ Investigate and establish a fund for ongoing coastal adaptation and management, and allocate funding sources.
- ✔ Establish or join a strategic partnership with other local government areas to coordinate coastal management activities.
- ✔ Explore the possibility of introducing a special control area over land affected by coastal hazards following future CHRMAP revisions, if private property is found to be at risk.
- ✔ If future CHRMAP revisions show private land to be affected by coastal hazards by 2122, land holders should be notified directly and by the application of notification on certificates of title, where practicable.
- ✔ Existing and proposed structure plans should be reviewed to ensure they adhere to SPP2.6 and account for the risks identified in this CHRMAP.
- ✔ After introducing a special control area, undertake development of a coastal Local Planning Policy to guide future management of the City's coastal reserves and areas.
- ✔ Maintain implementation of soft protection measures such as dune restoration and sand fencing.
- ✔ Initiate targeted beach nourishment of existing vulnerable areas.
- ✔ Implement interim coastal protection for Watermans Bay and Mettams Pool.
- ✔ Update the City's coastal asset inventory and emergency/damage response plan to include specific risk from and response to potential coastal impacts.
- ✔ Initiate a long-term coastal monitoring program, incorporating ad hoc storm and metocean monitoring, coastal asset condition assessments and geological risk monitoring.
- ✔ Undertake a detailed options assessment to determine the optimal coastal protection technique(s) at Watermans Bay Beach and Mettams Pool Beach.
- ✔ Undertake a detailed options assessment to determine the optimal coastal protection technique(s) at Scarborough Beach.
- ✔ Undertake an investigation to identify suitable sediment sources and determine available volumes for use in ongoing beach nourishment.
- ✔ Undertake development of foreshore management plan(s) to guide future management of the City's coastal areas.
- ✔ Undertake economic data collection and analysis to accurately quantify the value of the City's natural assets.
- ✔ Undertake a full revision of the City's CHRMAP, identifying and incorporating relevant new information.



Reference list

- BMT JFA Consultants (2015) Strategic Coastal Processes Study. Prepared for City of Stirling, December 2015.
- Cardno (2023). Coastal Hazard Risk Management and Adaptation Plan - Technical Assessment Chapter Reports (1 to 5), Prepared for the City of Stirling.
- CSIRO and BoM (2020) The State of the Climate 2020 report. ISBN 978-1-4863-1509-3.
- CSIRO and BoM (2015) Annual Climate Report 2015. ISSN 1837-8854.
- GBGMAPS (2018) Geophysical Investigation to Determine Rock Profile at Trigg Beach, West Coast Drive in North Beach and Watermans Bay, WA. Prepared by GBGMAPS for the City of Stirling. Report 70428 June 2018.
- IPCC (2021) Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press.
- Jones, T., Middelmann, M. & Corby, N. (2005), Natural Hazard Risk in Perth, Western Australia, Geosciences Australia, Bureau of Meteorology.
- 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, Volume 66, Issue 9, 01 September 2016, Pages 763–773
- Seashore Engineering Pty Ltd (2019) Assessment of Coastal Erosion Hotspots In Western Australia. Prepared for the DoT and DoPLH. 18 March 2019.
- Standards Australia (2013) Climate change adaptation for settlements and infrastructure - A risk based approach [AS 5334-2013]. Published 05-06-2013.
- Stul T, Gozzard JR, Eliot IG and Eliot MJ (2015) Coastal Sediment Cells for the Vlamingh Region between Cape Naturaliste and Moore River, Western Australia. Report prepared by Seashore Engineering Pty Ltd and Geological Survey of Western Australia for the Western Australian Department of Transport, Fremantle
- WAPC (2013) State Planning Policy No. 2.6: State Coastal Planning Policy. Published by the Western Australian Planning Commission, Perth, Western Australia.
- WAPC (2017) WA Coastal Zone Strategy. 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: Asset classification list

Classification	Asset ID	Assets at risk	Management unit
Natural	MU1-01	Watermans Bay Beach	MU1 - Watermans Bay
Natural	MU1-02	Watermans Bay dog beach	
Natural	MU1-03	Watermans Bay vegetated dunes	
Built	MU1-04	Watermans Bay GSC revetment	
Built	MU1-05	West Coast Drive, footpath and services (Beach Road to Mary Street)	
Built	MU1-06	Lookout and amenities, Watermans Bay	
Built	MU1-07	Car park and lookout, Margaret Street	
Built	MU1-08	Watermans Bay access, amenity and minor infrastructure	
Natural	MU2-01	North Beach dog beach	MU2 - North Beach
Natural	MU2-02	North Beach (north)	
Natural	MU2-03	North Beach (south)	
Built	MU2-04	North Beach access, amenity and minor infrastructure	
Natural	MU2-05	North Beach vegetated dunes	
Built	MU2-06	West Coast Drive, footpath and services (Malcolm Street to James Street)	
Built	MU2-07	North Beach revetment and jetty	
Built	MU2-08	West Coast Drive, footpath and services (Sorrento Street to Hamersley Street)	
Natural	MU3-01	Mettams Pool Beach	MU3 - Mettams Pool
Built	MU3-02	Parking Area, Saunders Street	
Built	MU3-03	Mettams Pool public toilets	
Built	MU3-04	West Coast Drive, footpath and services (Sholl Avenue to Bailey Street)	
Natural	MU3-05	Mettams Pool vegetated dunes	
Built	MU3-06	Mettams Pool access, amenity and minor infrastructure	
Natural	MU4-01	Bennion Beach	MU4 - Trigg Beach North
Natural	MU4-02	Trigg Beach dog beach	
Natural	MU4-03	Trigg Beach North	
Natural	MU4-04	Trigg Beach North vegetated dunes	
Built	MU4-05	West Coast Drive, footpath and services (near Kathleen Street)	
Built	MU4-06	Car park between Bennion and Bailey Streets	
Built	MU4-07	Parking area, Trigg Place	
Built	MU4-08	Trigg Beach North access, amenity and minor infrastructure	

Classification	Asset ID	Assets at risk	Management unit
Natural	MU5-01	Trigg Beach	MU5 - Trigg Beach South
Natural	MU5-02	Trigg Beach South	
Natural	MU5-03	Trigg Beach South vegetated dunes (Bush Forever Site 308)	
Built	MU5-04	Trigg surf lookout	
Built	MU5-05	Parking area, Trigg Beach North	
Built	MU5-06	Trigg Beach SLSC building 1	
Built	MU5-07	Trigg Beach SLSC building 2	
Built	MU5-08	Trigg Beach Café	
Built	MU5-09	Parking area, Trigg Beach central	
Built	MU5-10	Trigg Beach South access, amenity and minor infrastructure	
Built	MU5-11	Surfing WA headquarters	
Built	MU5-12	Trigg Beach carpark	
Natural	MU6-01	Scarborough Beach North	MU6 - Scarborough Beach
Natural	MU6-02	Scarborough Beach	
Natural	MU6-03	Brighton Beach	
Natural	MU6-04	Peasholm Beach	
Natural	MU6-05	Scarborough vegetated dunes (Bush Forever Site 308)	
Built	MU6-06	Scarborough Beach carpark	
Built	MU6-07	Scarborough Amphitheatre	
Built	MU6-08	Scarboro SLSC	
Built	MU6-09	Scarborough Beach Pool	
Built	MU6-10	Scarborough Beach Restaurant	
Built	MU6-11	Scarborough Playground and Skate Park	
Built	MU6-12	Scarborough Beach carpark south	
Built	MU6-13	Brighton Beach carpark	
Built	MU6-14	Scarborough Beach access, amenity and minor infrastructure	

Appendix B: Erosion risk assessment outcomes

Erosion risk – MU1 Watermans Bay					
Timeframes	2022	2030	2045	2070	2122
Asset	Risk ratings				
Watermans Bay Beach	High	High	Extreme	Extreme	Extreme
Watermans Bay dog beach	Medium	High	High	Extreme	Extreme
Watermans Bay vegetated dunes	Medium	Medium	High	Extreme	Extreme
Watermans Bay GSC revetment	Medium	Medium	High	High	High
West Coast Drive, footpath and services (Beach Road to Mary Street)	Very low	Very low	Very low	Medium	High
Lookout and amenities, Watermans Bay	Low	Low	Medium	High	High
Car park and lookout, Margaret Street	Medium	Medium	Medium	High	High
Watermans Bay access, amenity and minor infrastructure	Medium	Medium	Medium	High	High

Erosion risk – MU2 North Beach					
Timeframes	2022	2030	2045	2070	2122
Asset	Risk ratings				
North Beach dog beach	Medium	High	High	Extreme	Extreme
North Beach (north)	Medium	High	High	Extreme	Extreme
North Beach (south)	Medium	High	High	Extreme	Extreme
North Beach access, amenity and minor infrastructure	Medium	Medium	Medium	High	High
North Beach vegetated dunes	Medium	Medium	High	Extreme	Extreme
West Coast Drive, footpath and services (Malcolm Street to James Street)	Medium	Medium	High	Extreme	Extreme
North Beach revetment and jetty	Medium	Medium	High	High	High

Erosion risk – MU3 Mettams Pool					
Timeframes	2022	2030	2045	2070	2122
Asset	Risk ratings				
Mettams Pool Beach	High	High	Extreme	Extreme	Extreme
Parking area, Saunders Street	Medium	High	High	Extreme	Extreme
Mettams Pool public toilets	Medium	Medium	High	Extreme	Extreme
West Coast Drive, footpath and services (Sholl Avenue to Bailey Avenue)	Very low	Very low	Medium	High	Extreme
Mettams Pool vegetated dunes	Medium	Medium	High	Extreme	Extreme
Mettams Pool access, amenity and minor infrastructure	Medium	Medium	Medium	High	High

Erosion risk – MU4 Trigg Beach North					
Timeframes	2022	2030	2045	2070	2122
Asset	Risk ratings				
Bennion Beach	Medium	High	High	Extreme	Extreme
Trigg Beach dog beach	Medium	High	High	Extreme	Extreme
Trigg Beach North	Medium	High	High	Extreme	Extreme
Trigg Beach North vegetated dunes	Medium	Medium	High	Extreme	Extreme
West Coast Drive, footpath and services (near Kathleen Street)	Very low	Very low	Medium	High	Extreme
Car park between Bennion and Bailey Streets	Very low	Very low	Medium	High	High
Parking area, Trigg Place	Very low	Very low	Medium	High	High
Trigg North access, amenity and minor infrastructure	Medium	Medium	Medium	High	High

Erosion risk – MU5 Trigg Beach South					
Timeframes	2022	2030	2045	2070	2122
Asset	Risk ratings				
Trigg Beach	Medium	High	High	Extreme	Extreme
Trigg Beach South	Medium	High	High	Extreme	Extreme
Trigg South vegetated dunes	Medium	Medium	High	Extreme	Extreme
Trigg Surf Lookout	Low	Low	Medium	High	High
Parking area, Trigg Beach North	Very low	Very low	Medium	High	High
Trigg Beach SLSC building 1	Very low	Very low	Very low	Medium	High
Trigg Beach SLSC building 2	Very low	Very low	Very low	Medium	High
Trigg Beach Café	Very low	Very low	Medium	High	Extreme
Parking area, Trigg Beach central	Very low	Very low	Very low	Medium	High
Trigg Beach south access, amenity and minor infrastructure	Very low	Medium	High	High	Extreme
Surfing WA headquarters	Very low	Very low	Very low	Medium	High
Trigg Beach carpark	Very low	Very low	Very low	Medium	High

Erosion risk – MU6 Scarborough Beach					
Timeframes	2022	2030	2045	2070	2122
Asset	Risk ratings				
Scarborough Beach North	Medium	High	High	Extreme	Extreme
Scarborough Beach	Medium	High	High	Extreme	Extreme
Brighton Beach	Medium	High	High	Extreme	Extreme
Peasholm Beach	Medium	High	High	Extreme	Extreme
Scarborough vegetated dunes	Medium	High	High	Extreme	Extreme
Scarborough Beach carpark	Very low	Very low	Very low	Medium	High
Scarborough Amphitheatre	Medium	Medium	Medium	High	High
Scarboro SLSC	Medium	Medium	Medium	High	High
Scarborough Beach Pool	Very low	Very low	Medium	High	Extreme
Scarborough Beach Restaurant	Very low	Very low	Medium	High	Extreme
Scarborough Playground and Skate Park	Very low	Very low	Medium	High	High
Scarborough Beach carpark south	Very low	Very low	Very low	Medium	High
Brighton Beach carpark	Very low	Very low	Very low	Medium	High
Scarborough Beach access, amenity and minor infrastructure	Very low	Medium	High	High	Extreme



Appendix C: Multi-criteria analysis

The ratings are described as follows:

Red light: Options will not be recommended, i.e., it is likely to be fatally flawed based on that criteria | **Yellow light:** Requires further assessment or is neutral for the criteria | **Green light:** Likely to be positive for the respective criteria.

MU1 – Watermans Bay

Option Category	Option Code	Option Name	Applicable Assets / Areas	Preliminary Feasibility			Preliminary Acceptability		Preliminary Financial Implication			Recommendation
				Effectiveness	Legal / Approval Risk	Reversibility / Adaptability	Environmental / Social Impact	Community Acceptability	Economic gain / Avoidance of Cost	Capital Cost	Ongoing Cost	
Avoid	AV	Avoid development	Presently undeveloped land within the coastal foreshore reserve.									Recommend
Planned / Managed Retreat	PMR1	Leave unprotected/repair	Minor public infrastructure - e.g. benches, paths, amenities.									Recommend
			Major public infrastructure - e.g. buildings, roads, carparks.									Do not recommend
			Residential and commercial property.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	PMR2	Remove/relocate	Minor public infrastructure - e.g. benches, paths, amenities.									Recommend
			Major public infrastructure - e.g. buildings, roads, carparks.									Further assessment
			Residential and commercial property.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	PMR3	Planning controls for managed retreat	Residential and commercial property.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Accommodate	AC1	Planning controls to identify/accommodate risk	Residential and commercial property.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	AC2	Emergency plans and controls	All areas.			N/A						Recommend
	AC3	Re-design to withstand impact	Built assets.									Do not recommend
Protect	PR1	Dune care/sand management	Beach and dunes - protective buffer to landward assets.									Recommend
	PR2	Beach Nourishment	Beach and dunes - protective buffer to landward assets.									Further assessment
	PR3	Groyne(s)/Headland enhancement	Beach and dunes - protective buffer to landward assets.									Further assessment
	PR4	Nearshore Reef(s)/Breakwater(s)	Beach and dunes - protective buffer to landward assets.									Further assessment
	PR5	Revetment(s)/Seawall(s)	Protective buffer to landward assets.									Further assessment
Do Nothing	DN	Do nothing	All areas.									Do not recommend

MU2 – North Beach

Option Category	Option Code	Option Name	Applicable Assets / Areas	Preliminary Feasibility			Preliminary Acceptability		Preliminary Financial Implication			Recommendation
				Effectiveness	Legal / Approval Risk	Reversibility / Adaptability	Environmental / Social Impact	Community Acceptability	Economic gain / Avoidance of Cost	Capital Cost	Ongoing Cost	
Avoid	AV	Avoid development	Presently undeveloped land within the coastal foreshore reserve.									Recommend
Planned / Managed Retreat	PMR1	Leave unprotected/repair	Minor public infrastructure - e.g. benches, paths, amenities.									Recommend
			Major public infrastructure - e.g. buildings, roads, carparks.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
			Residential and commercial property.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	PMR2	Remove/relocate	Minor public infrastructure - e.g. benches, paths, amenities.									Recommend
			Major public infrastructure - e.g. buildings, roads, carparks.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
			Residential and commercial property.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	PMR3	Planning controls for managed retreat	Residential and commercial property.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Accommodate	AC1	Planning controls to identify/accommodate risk	Residential and commercial property.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	AC2	Emergency plans and controls	All areas.			N/A						Recommend
	AC3	Re-design to withstand impact	Built assets.									Do not recommend
Protect	PR1	Dune care/sand management	Beach and dunes - protective buffer to landward assets.									Recommend
	PR2	Beach Nourishment	Beach and dunes - protective buffer to landward assets.									Further assessment
	PR3	Groyne(s)/Headland enhancement	Beach and dunes - protective buffer to landward assets.									Do not recommend
	PR4	Nearshore Reef(s)/Breakwater(s)	Beach and dunes - protective buffer to landward assets.									Do not recommend
	PR5	Revetment(s)/Seawall(s)	Protective buffer to landward assets.									Do not recommend
Do Nothing	DN	Do Nothing	All areas.									Do not recommend

MU3 – Mettams Pool

Option Category	Option Code	Option Name	Applicable Assets / Areas	Preliminary Feasibility			Preliminary Acceptability		Preliminary Financial Implication			Recommendation
				Effectiveness	Legal / Approval Risk	Reversibility / Adaptability	Environmental / Social Impact	Community Acceptability	Economic gain / Avoidance of Cost	Capital Cost	Ongoing Cost	
Avoid	AV	Avoid development	Presently undeveloped land within the coastal foreshore reserve.									Recommend
Planned / Managed Retreat	PMR1	Leave unprotected/repair	Minor public infrastructure - e.g. benches, paths, amenities.									Recommend
			Major public infrastructure - e.g. buildings, roads, carparks.									Do not recommend
			Residential and commercial property.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	PMR2	Remove/relocate	Minor public infrastructure - e.g. benches, paths, amenities.									Recommend
			Major public infrastructure - e.g. buildings, roads, carparks.									Further assessment
			Residential and commercial property.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	PMR3	Planning controls for managed retreat	Residential and commercial property.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Accommodate	AC1	Planning controls to identify/accommodate risk	Residential and commercial property.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	AC2	Emergency plans and controls	All areas.			N/A						Recommend
	AC3	Re-design to withstand impact	Built assets.									Do not recommend
Protect	PR1	Dune care/sand management	Beach and dunes - protective buffer to landward assets.									Recommend
	PR2	Beach Nourishment	Beach and dunes - protective buffer to landward assets.									Further assessment
	PR3	Groyne(s)/Headland enhancement	Beach and dunes - protective buffer to landward assets.									Further assessment
	PR4	Nearshore Reef(s)/Breakwater(s)	Beach and dunes - protective buffer to landward assets.									Further assessment
	PR5	Revetment(s)/Seawall(s)	Protective buffer to landward assets.									Further assessment
Do Nothing	DN	Do Nothing	All areas.									Do not recommend

MU4 – Trigg Beach North

Option Category	Option Code	Option Name	Applicable Assets / Areas	Preliminary Feasibility			Preliminary Acceptability		Preliminary Financial Implication			Recommendation
				Effectiveness	Legal / Approval Risk	Reversibility / Adaptability	Environmental / Social Impact	Community Acceptability	Economic gain / Avoidance of Cost	Capital Cost	Ongoing Cost	
Avoid	AV	Avoid development	Presently undeveloped land within the coastal foreshore reserve.									Recommend
Planned / Managed Retreat	PMR1	Leave unprotected/repair	Minor public infrastructure - e.g. benches, paths, amenities.									Recommend
			Major public infrastructure - e.g. buildings, roads, carparks.									Do not recommend
			Residential and commercial property.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	PMR2	Remove/relocate	Minor public infrastructure - e.g. benches, paths, amenities.									Recommend
			Major public infrastructure - e.g. buildings, roads, carparks.									Further assessment
			Residential and commercial property.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	PMR3	Planning controls for managed retreat	Residential and commercial property.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Accommodate	AC1	Planning controls to identify/accommodate risk	Residential and commercial property.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	AC2	Emergency plans and controls	All areas.			N/A						Recommend
	AC3	Re-design to withstand impact	Built assets.									Do not recommend
Protect	PR1	Dune care/sand management	Beach and dunes - protective buffer to landward assets.									Recommend
	PR2	Beach Nourishment	Beach and dunes - protective buffer to landward assets.									Further assessment
	PR3	Groyne(s)/Headland enhancement	Beach and dunes - protective buffer to landward assets.									Further assessment
	PR4	Nearshore Reef(s)/Breakwater(s)	Beach and dunes - protective buffer to landward assets.									Further assessment
	PR5	Revetment(s)/Seawall(s)	Protective buffer to landward assets.									Further assessment
Do Nothing	DN	Do Nothing	All areas.									Do not recommend

MU5 – Trigg Beach South

Option Category	Option Code	Option Name	Applicable Assets / Areas	Preliminary Feasibility			Preliminary Acceptability		Preliminary Financial Implication			Recommendation
				Effectiveness	Legal / Approval Risk	Reversibility / Adaptability	Environmental / Social Impact	Community Acceptability	Economic gain / Avoidance of Cost	Capital Cost	Ongoing Cost	
Avoid	AV	Avoid development	Presently undeveloped land within the coastal foreshore reserve.									Recommend
Planned / Managed Retreat	PMR1	Leave unprotected/repair	Minor public infrastructure - e.g. benches, paths, amenities.									Recommend
			Major public infrastructure - e.g. buildings, roads, carparks.									Do not recommend
			Residential and commercial property.									Do not recommend
	PMR2	Remove/relocate	Minor public infrastructure - e.g. benches, paths, amenities.									Recommend
			Major public infrastructure - e.g. buildings, roads, carparks.									Do not recommend
			Residential and commercial property.									Further assessment
	PMR3	Planning controls for managed retreat	Residential and commercial property.									Recommend
Accommodate	AC1	Planning controls to identify/accommodate risk	Residential and commercial property.									Recommend
	AC2	Emergency plans and controls	All areas.			N/A						Recommend
	AC3	Re-design to withstand impact	Built assets.									Do not recommend
Protect	PR1	Dune care/sand management	Beach and dunes - protective buffer to landward assets.									Recommend
	PR2	Beach Nourishment	Beach and dunes - protective buffer to landward assets.									Further assessment
	PR3	Groyne(s)/Headland enhancement	Beach and dunes - protective buffer to landward assets.									Further assessment
	PR4	Nearshore Reef(s)/Breakwater(s)	Beach and dunes - protective buffer to landward assets.									Further assessment
	PR5	Revetment(s)/Seawall(s)	Protective buffer to landward assets.									Further assessment
Do Nothing	DN	Do Nothing	All areas.									Do not recommend

MU6 – Scarborough Beach

Option Category	Option Code	Option Name	Applicable Assets / Areas	Preliminary Feasibility			Preliminary Acceptability		Preliminary Financial Implication			Recommendation
				Effectiveness	Legal / Approval Risk	Reversibility / Adaptability	Environmental / Social Impact	Community Acceptability	Economic gain / Avoidance of Cost	Capital Cost	Ongoing Cost	
Avoid	AV	Avoid development	Presently undeveloped land within the coastal foreshore reserve.									Recommend
Planned / Managed Retreat	PMR1	Leave unprotected/repair	Minor public infrastructure - e.g. benches, paths, amenities.									Recommend
			Major public infrastructure - e.g. buildings, roads, carparks.									Do not recommend
			Residential and commercial property.									Do not recommend
	PMR2	Remove/relocate	Minor public infrastructure - e.g. benches, paths, amenities.									Recommend
			Major public infrastructure - e.g. buildings, roads, carparks.									Do not recommend
			Residential and commercial property.									Further assessment
	PMR3	Planning controls for managed retreat	Residential and commercial property.									Recommend
Accommodate	AC1	Planning controls to identify/accommodate risk	Residential and commercial property.									Recommend
	AC2	Emergency plans and controls	All areas.			N/A						Recommend
	AC3	Re-design to withstand impact	Built assets.									Do not recommend
Protect	PR1	Dune care/sand management	Beach and dunes - protective buffer to landward assets.									Recommend
	PR2	Beach Nourishment	Beach and dunes - protective buffer to landward assets.									Further assessment
	PR3	Groyne(s)/Headland enhancement	Beach and dunes - protective buffer to landward assets.									Further assessment
	PR4	Nearshore Reef(s)/Breakwater(s)	Beach and dunes - protective buffer to landward assets.									Further assessment
	PR5	Revetment(s)/Seawall(s)	Protective buffer to landward assets.									Further assessment
Do Nothing	DN	Do Nothing	All areas.									Do not recommend



Administration Centre 25 Cedric Street Stirling WA 6021

Telephone (08) 9205 8555 | Enquiries www.stirling.wa.gov.au/enquiries | Web www.stirling.wa.gov.au |    /citystirlingwa

This information is available in alternative formats on request. Please contact the Customer Contact Centre on (08) 9205 8555