

Chapter Report 5: Implementation

City of Stirling Coastal Hazard Risk Management and Adaptation Plan

CW1195500

Prepared for
City of Stirling

23 June 2023



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1 Introduction

1.1 Overview

The City of Stirling (herein referred to as ‘the City’) is located approximately 6 km north-west of Perth’s Central Business District (**Figure 1-2**). The City contains approximately 7 km of Indian Ocean coastline, including iconic beaches, such as Scarborough, Trigg and Mettams Pool. The adjacent foreshore reserves support a variety of recreation, conservation and commercial land uses, including substantial built infrastructure situated in close proximity to the shoreline.

The City is undertaking a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) to provide strategic guidance for coordinated, integrated and sustainable land use planning and management along its coastline. The CHRMAP will inform the City’s future decision-making with respect to areas and assets identified as being at risk from coastal hazards.

1.2 Background

Globally, mean sea level (MSL) has risen since the nineteenth century and is predicted to continue to rise, at an increasing rate, through the twenty first century (Intergovernmental Panel on Climate Change [IPCC], 2021), bringing changes to the Western Australian (WA) coastline over the coming decades. To prepare for sea level rise (SLR) induced coastal hazards, such as coastal erosion and inundation, all levels of government are putting processes in place to ensure that communities understand the risks to values and assets on the coast, and to plan to adapt over time.

Changes to MSL over the past century have been observed for the coastline adjacent to the Perth Metropolitan Area (CSIRO, BoM, 2015). *Sea Level Change in Western Australia – Application to Coastal Planning* (Department of Transport [DoT], 2010) reviewed information relating to SLR at a local scale and recommended an allowance for SLR be adopted for planning purposes. Recommendations were based on the upper bound of the global average SLR projections from *IPCC’s Fourth Assessment Report [AR4]* (IPCC, 2007). In the intervening years, following release of the DoT document, advances in climate change science have been reflected in revisions to SLR projections, such as those documented in *IPCC’s Sixth Assessment Report [AR6]* (IPCC, 2021). Current guidance on global SLR projections is derived from Shared Socioeconomic Pathways (SSP), characterising the trajectory of global society, demographics and economics over the coming century. Analogous to that used in DoT’s recommendation is SSP5, which forecasts an average SLR of 0.94m between 2020 and 2120 (**Figure 1-1**).

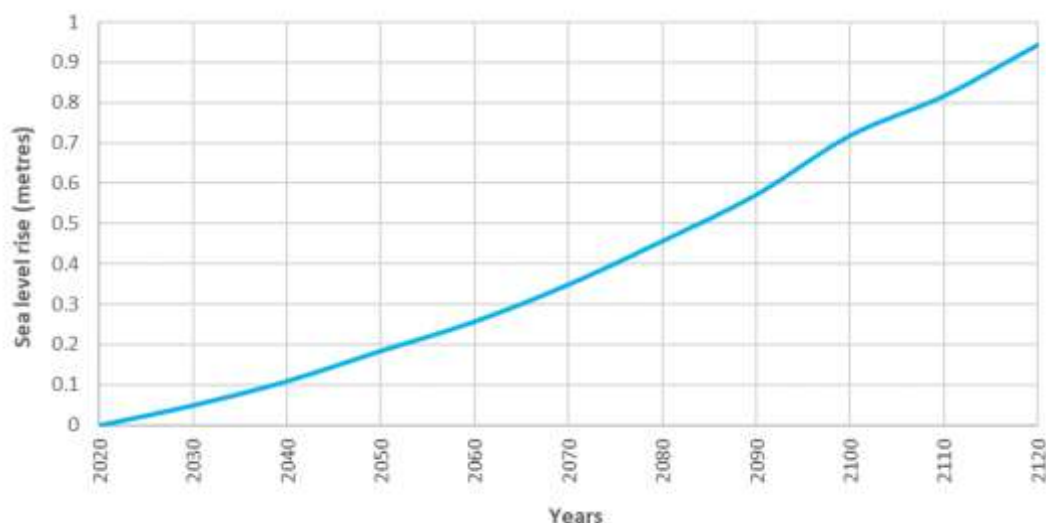


Figure 1-1 Sea level rise for planning purposes in Western Australia (adapted from DoT, 2010 & IPCC, 2021).



The City's coastline to the south of Trigg Island is sandy, featuring coastal dunes, nearshore reefs and seagrass meadows. For sandy coastlines, increases in local MSL generally result in shoreline recession, with a "rule of thumb" often applied, that a 1 cm rise in MSL will result in 1 m of landward recession of the shoreline. It should be noted that this is based on the "Bruun Rule" which is generally considered a conservative (and simplified) approach (Rosati et al, 2013; Cooper & Pilkey, 2004).

North of Trigg Island, the coastline features pocket perched beaches, with nearshore reef platforms, visible rocky cliffs and subsurface rock formations. In these areas' special consideration of the height and integrity of the rock formations is required to ascertain the level of erosion protection that the rocky features will afford adjacent areas.

1.3 Overview of the CHRMAP Process

The key policy governing coastal planning in WA is the *State Planning Policy No. 2.6: State Coastal Planning Policy* (Western Australian Planning Commission [WAPC], 2013) (SPP2.6). SPP2.6 recommends that management authorities develop a CHRMAP, using a risk mitigation approach to planning, that identifies the hazards associated with existing and future development in the coastal zone. SPP2.6 and the *State Coastal Planning Policy Guidelines* (WAPC, 2020) contain prescriptive details, for example in relation to scales of assessment, storm event types and SLR allowances.

The WAPC (2019) has also developed the *Coastal hazard risk management and adaptation planning guidelines* (CHRMAP Guidelines) which are less prescriptive in terms of technical assessment of coastal processes but is aimed to ensure that planning is carried out using a risk-based approach. This includes paying due regard to stakeholder engagement, community consultation and education, and requires that a full range of applicable adaptation options are considered. An overview of the typical CHRMAP process is shown in **Figure 1-3**.

Coastal planning in accordance with SPP2.6 also needs to take into consideration the requirements of other planning policies, including *Statement of Planning Policy No. 2: Environment and Natural Resources Policy* (WAPC, 2003) (SPP2), *State Planning Policy No. 2.8: Bushland policy for the Perth Metropolitan Region* (WAPC, 2010) (SPP2.8), *Statement of Planning Policy No. 3: Urban Growth and Settlement* (WAPC, 2006a) (SPP3.0) and *State Planning Policy No. 3.4: Natural Hazards and Disasters* (WAPC, 2006b) (SPP3.4).

1.4 Success Criteria

Success criteria have been defined for the project, based on the outcomes of the Coastal Values Survey, and are used to guide consequence ratings in the vulnerability analysis. These are:

- > SC1: Preserve the function and opportunity for recreation activities along the coastline (such as walking/running, swimming and surfing).
- > SC2: Preserve the existing hospitality venues along the coastline and access to them.
- > SC3: Ensure the natural environment is protected and sustained in its current condition or an improved condition (concerning the dunes and flora and fauna).
- > SC4: Develop solutions to coastal processes that are sustainable (financially, socially and built form) and locally responsive.
- > SC5: Revisit regularly with community and key stakeholders their values in relation to development adjacent the coastline.
- > SC6: Maintain services that maximise community benefit for all.
- > SC7: Ensure the coastline is safe and accessible to all.
- > SC8: Achieve a balance between access needs and environmental sensitivities.

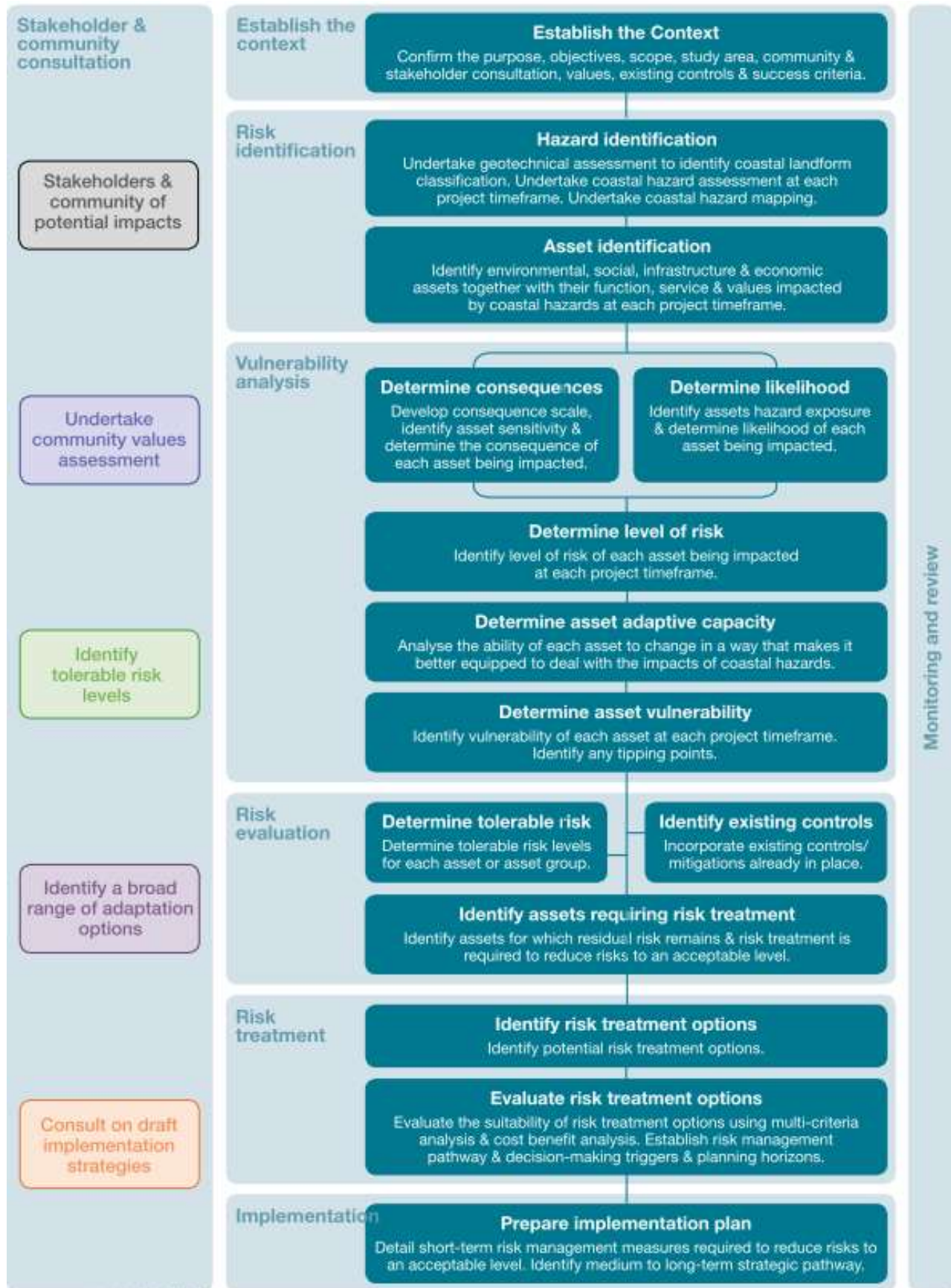


Figure 1-3 Risk management steps forming the CHRMAP process (WAPC, 2019)

1.5 Purpose of this Report

The City's CHRMAP has been developed through a staged approach, with the various stages documented in dedicated chapter reports. The chapter reports have been summarised and used to underpin the overall CHRMAP document. The purpose of the chapter reporting is to capture key technical detail, while the overall CHRMAP presents a more accessible and community-friendly document. The chapter reports prepared as part of the City's CHRMAP include:

- > Chapter 1 – Establish the Context (Stage 1) (Cardno, 2023a);
- > Chapter 2 – Risk Identification (Stage 2) (Cardno, 2023b);
- > Chapter 3 – Vulnerability Assessment and Risk Evaluation (Stages 3 and 4) (Cardno, 2023c);
- > Chapter 4 – Risk Treatment (Stage 5) (Cardno, 2023d); and
- > **Chapter 5 – Implementation (Stage 6).**

This report presents the *Implementation* stage, which recommends 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 to 50 year (medium term) and 50 to 100 year (long term) timeframes is also provided. *Monitoring and Review* is also captured by this report, which details the monitoring to be undertaken to understand ongoing coastal hazard risk and inform the triggering of reactive management measures. These triggers have been detailed in the *Risk Treatment* chapter report (Cardno, 2023d).

2 Short-term Implementation

2.1 Overview

A range of options for managing and adapting to the effects of coastal hazards on the coastal zone, over the next century, have been outlined in the *Risk Treatment Report* (Cardno, 2023d). 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. This section first discusses the issues around funding and equity, looks at planning mechanisms that should be incorporated, then discusses physical management priorities for the City. 'Short-term' refers to the planning period less than 25 years into the future (up to 2045).

The CHRMAP process recognises the difficult decisions that will need to be made in the near future and the CHRMAP is intended to be updated at least every 10 years, or as new information becomes available that may significantly alter the extent of hazards, such as new SLR predictions.

2.2 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 accelerating SLR and 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 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 Government, 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, update and or/establish funding sources for ongoing and future coastal management. Appropriate investigations should be carried out to ensure this 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. Further investigation, beyond this CHRMAP, will be required to inform the most fair and equitable approach to managing the City's coastline. Key recommendations to investigate equity and establish funding sources are detailed below.

R1: Engage the community to present the results of this CHRMAP and formally assess their willingness to contribute to funding.

Critical to the CHRMAP process is ongoing community engagement. The City plans to present the results of the CHRMAP to the community to ensure transparency, educate them on coastal processes and the hazards associated with SLR, and seek further feedback on the acceptability of the range of adaptation measures presented. It will be important to highlight protection and managed retreat as two distinct management approaches and provide an informed account of the advantages and disadvantages of each. It should be emphasised that managed retreat is the preferred approach over the long term. Engagement activities should see to educate stakeholders and the community around the 'beneficiary pays principle', particularly with respect circumstances where private landholders may benefit from coastal protection. The engagement activities should be used to assess the community's and beneficiary's willingness to contribute to the management of the coast, through a variety of methods including council rates, taxes, access/use fees etc.

Increased signage at coastal locations, highlighting coastal assets with environmental, heritage and built value, identified through the CHRMAP, is recommended for installation. This will help build community awareness and buy in to the CHRMAP process.

R2: Investigate and establish a fund for ongoing coastal adaptation and management and allocate funding sources.

Following a detailed economic assessment (**Section 3.2.4**) and the adoption and refinement of long-term management pathways, the City should look to establish a dedicated fund for management of coastal hazards into the future. It should be noted that the City already allocates some funding for coastal management. The first step should be an assessment of the existing fund with respect to potential ongoing and future costs, outlined in this CHRMAP.

For areas where coastal protection works are considered the appropriate course of action, a Benefit Distribution Analysis should be undertaken to help apportion the costs of construction and ongoing maintenance. This is particularly the case where private landholders will benefit from the protection works.

A portion of council rates could be a key funding source, and the use of specified area rates should be considered. Specified area rates will help apportion funding contributions, aligning them with the level of benefit that certain rate payers will receive as a result of coastal management.

The requirement for developer contributions should also be considered if applicable. Such contributions would be required where a development is set to benefit from its proximity to the coast and, therefore, the management of the coast in the area.

Sourcing funding from beach and foreshore users could also be considered. This might be in the form of coastal car parking fees. Sourcing funding in this way would need to be carefully approached, given that the intent of the CHRMAP is to ensure the beach and coastal foreshore reserve is a public asset that should be available to all members of the community.

Future sources of State and Federal Government funding are unpredictable and somewhat beyond the control of Local Governments. The City should, however, demonstrate its preparedness and liaise closely with these levels of government to secure funding where available.

R3: Establish or join a strategic partnership with other Local Government Areas (LGAs) to coordinate coastal management activities

As the effects of sea level rise intensify, protective coastal management activities are likely to be considered in multiple areas along the Perth coastline. These management activities can have 'up/downstream' effects beyond the implementing LGA's jurisdiction, raising issues of equity between LGAs. It is recommended that the City establish or join a strategic partnership with other LGAs in the same primary sediment cell (i.e. City of Fremantle to City of Joondalup) to help facilitate the coordination and equitable implementation of any ongoing and future coastal management. Such partnerships already exist along the WA coastline, with the Peron-Naturaliste Partnership (PNP) being one example. The PNP was established to promote the sharing of knowledge and data, as well as to help coordinate projects and grant applications across nine LGAs in WA's south-west.

2.3 Exterior Funding Options

The primary State Government funding options (grants) available to the City, via application, are:

- > Coastal Adaptation and Protection (CAP) Grants: The Coastal Adaptation and Protection Grants are administered by the DoT to support projects that identify and manage coastal hazards. The program seeks to preserve and enhance coastal assets for the general public, build partnerships with local coastal managers, and help them understand and adapt to coastal hazards;
- > Hotspot Coastal Adaptation and Protection (H-CAP) Major Project Fund (DoT): The Hotspot Coastal Adaptation and Protection (H-CAP) Major Project Fund, administered by DoT, supports projects which design and implement coastal adaptation works at WA's coastal erosion hotspots as identified in *Assessment of Coastal Erosion Hotspots in Western Australia* (Seashore, 2019);
- > Coastal Management Plan Assistance Program (CMPAP): CMPAP grants support SPP2.6, which guides land use and development along WA's coast. CMPAP assists coastal land managers to prepare and

implement strategies and management plans for coastal areas that are, or predicted to become, under pressure from a range of challenges. The DoPLH administers CMPAP on behalf of the WAPC; and

- > Coastwest Grants: Coastwest provides opportunities for Western Australians to learn about, conserve and protect our coast. The DoPLH administers the Coastwest Program on behalf of the Western Australian Planning Commission.

2.4 Planning Controls

A range of planning mechanisms and considerations were presented in the *Risk Treatment Report* (Element, 2022d). The City should look to implement appropriate planning controls in accordance with the Implementation Plan in **Table 5.2**. These controls will help limit risk and liability for the City in the future. The following key recommendations are made with respect to planning controls.

R4: If future revisions of the CHRMAP, which incorporate additional geotechnical information and planned coastal controls, find that private properties are intersected by future coastal hazard extents, the City should explore the addition of a Special Control Area over this land, to control development that is inappropriate with respect to the timeframe of the hazard extent.

Such a Special Control Area (SCA) would apply to affected land zoned 'Urban', located on the seaward side of the coastal erosion hazard line, to trigger normally exempt development to require planning approval. Implementation of a SCA is further detailed in **Appendix A**.

R5: If future revisions of the CHRMAP, which incorporate additional geotechnical information and planned coastal controls, find that private properties are intersected by future coastal hazard extents, affected landholders should be notified directly and by the application of notification on Certificates of Title, where practicable.

It is important that the City notify the community and potentially affected landholders and stakeholders of the results of the CHRMAP and the extents of potential coastal hazards. Should future revisions of the CHRMAP, which incorporate additional geotechnical information and planned coastal controls, find that private properties are intersected by future coastal hazard extents, it is recommended that the City notify holders of land lying within the 100-year erosion extents directly, via mail or email. For further detail, refer **Appendix A**.

R6: Proposed structure plans should be reviewed to ensure they adhere to SPP2.6 and account for the risks identified in this CHRMAP.

All structure planning should account for the hazards identified in this CHRMAP and the requirements of SPP2.6. The primary mechanism for achieving this through structure planning, will be the allocation of a suitable portion of land as coastal foreshore reserve. This foreshore reserve should be of adequate width to account for the 2122 coastal erosion hazard line, and also ensure a functional foreshore area will remain should this hazard extent be realised in the future. In due course and as structure plans are implemented, it is expected that the zones and reserves they include will be reflected in relevant Local Planning Schemes via scheme amendments. For further detail, refer to **Appendix A**.

R7: After the introduction of an SCA, undertake development of a coastal Local Planning Policy to guide future management of the City's coastal reserves and areas.

A coastal Local Planning Policy should consider development provisions to better accommodate and respond to the risk of coastal erosion for new development on properties located within the SCA. For further detail, refer **Appendix A**.

2.5 Management Priorities

2.5.1 Ongoing protection

R8: Maintain implementation of soft protection measures such as dune planting and restoration.

Ongoing dune maintenance and revegetation activities should continue along the City's coastline. Sand fencing, to capture wind-blown sand movement should also be considered. 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 (e.g. reinstatement of dune followed by revegetation). The activities also promote ownership and understanding of the natural coastline among the community.

R9: Initiate targeted beach nourishment of existing vulnerable areas.

In the short term, beach nourishment should be continued/employed to manage coastal erosion hazards along the City's coastline. With predicted SLR, the volume of sand required is likely to increase and it will be important to allocate nourishment effort as effectively as possible. There is risk associated with assessing (and committing to) nourishment options into the future, given uncertainty around availability of suitable source material. Further investigations are required to identify potential sources, the suitability and volume of material they hold and the cost of sourcing sand from them. The recommendation to undertake a detailed sand sourcing study is outlined in **Section 3.2.2**.

The City should review nourishment activities along the Perth Metropolitan coastline and plan future activities in light of the results of hazard modelling undertaken as part of the CHRMAP. Nourishment should target areas with the highest overall risk and vulnerability and also consider where the most value can be added through the activity. Effective beach nourishment programs should consider the various components that increase the activity's success and the longevity of protection. These include:

- > Selecting the appropriate location for placement;
- > Using the most effective placement volume, footprint and profile;
- > Selecting appropriate sand in terms of grain size and colour; and
- > Timing nourishment for best efficacy.

2.5.2 Implement Coastal Protection

R10: Implement interim (25 years) coastal protection for Watermans Bay and Mettams Pool.

Based on the outcomes of the options assessment described in **Section 3.2.1**, the preferred option should be implemented to afford protection of Watermans Bay and Mettams Pool for a period of at least 25 years.

2.5.3 Hazard Response

R11: Update the City's coastal asset inventory and emergency/damage response plan to include specific risk from and response to potential coastal impacts.

With a changing climate and projected SLR, there is a greater likelihood of experiencing coastal hazard events that are more severe than those encountered in the past. Because of this, there may be a lack of preparation for severe coastal hazard (and other extreme weather) events. The City should use the hazard extents derived through the CHRMAP, specifically those for the present day (2022), 2030 and 2045 planning timeframes, to create an inventory of assets that could be impacted. If applicable, the City's existing asset management system could be updated to include these assets.

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

3 Monitoring and Further Investigations

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

3.1 Monitoring

3.1.1 Ongoing coastal monitoring (S2, S3)

R12: Continue/expand the City's long-term coastal monitoring program, incorporating ad hoc storm and metocean monitoring, and coastal asset condition assessments.

Long term estimates of recession are typically derived using historic high resolution aerial imagery. This can provide a useful indication of how the shoreline has moved in the past. Due to the difficulties in defining average shoreline positions from aerial imagery, it is common practice to use the vegetation line as an indicator of shoreline movement. Whilst this is a useful analysis to estimate historic long-term trends, it is emphasised that the vegetation line does not necessarily move at the same rate as the shoreline or represent progressive erosion (net loss of beach volume/sediment). For instance, the vegetation could be smothered in sand due to high winds, could have been disturbed due to human interference (especially at high-use beaches like those in the City), or recent storm activity may have occurred where the beach is recovering faster than the vegetation.

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

To inform future revisions of the CHRMAP and to monitor the position of the HSD on an ongoing basis, it is recommended that the City implement regular coastal monitoring, in addition to analysis of aerial imagery that is routinely collected by others. The City's program should include:

- > Regular analysis of aerial images, vegetation lines, and creation of GIS layers to describe them. I.e., digital tracing of vegetation lines and shorelines (at least in key vulnerable areas) in a GIS format, to allow analysis and comparison over time;
- > 6-monthly beach profile monitoring at set transect locations, spaced at 100 metre intervals, depending on the change in orientation of the shoreline (i.e., long straight beaches can have surveys wider apart). The surveying should prioritise areas with the highest vulnerability at present or where the efficacy of coastal management needs to be monitored. These should be timed to occur in the intervals between the Perth seasonal summer and winter (approximately April and October/November, respectively);
- > Sediment sampling at beach profile locations (6 monthly). Ideally, samples would be analysed for particle size distribution by a laboratory. Lab analysis can be expensive and other options are available, such as analysing with sediment sizing cards, and/or the collection and storage of sediment samples for future analysis if/when required;
- > Installation of remote imagery cameras - As well as providing ongoing information on the state of beaches, cameras also capture a range of other data, including storm effects, beach visitation, coastal inundation extents and seasonal variations that could be missed by beach profile surveys;
- > Storm monitoring and metocean data collection as described below (**Section 3.1.2**); and
- > Regular analysis of collected data (every 5 years or as required) alongside wind data collected by the BoM, and water level and wave data collected by the DoT.

It is noted that the City's current coastal monitoring program incorporates a number of these initiatives at specific sites.

3.1.2 Storm and metocean monitoring (S1)

The collection of data around storm events will be valuable in refining estimates of how vulnerable beaches within the City are to storm-based erosion. The collected data can be used to qualify and validate modelled S1 erosion extents. These extents are critical to adaptation planning because they are used as a trigger distance to initiate a change in the management pathway, such as triggering removal or managed retreat of assets. Considerable uncertainty exists around the application of storm erosion modelling techniques (Ranasinghe et al, 2013), such as the SBEACH modelling commonly used in the CHRMAP process. Additionally, the lack of data available to confidently quantify what a 1 in 100-year erosion storm event is, for a particular area, means that estimated storm erosion is generally conservative, and potentially unrealistic.

The City should incorporate *ad hoc* storm monitoring in key vulnerable areas into the long-term coastal monitoring program. The key components of the program would be shoreline profiling and sediment sampling, targeting vulnerable sections of coastline before and after storm events. Sampling should target the most severe storm events, or those with the greatest potential to lead to shoreline impact. Predicting the duration and intensity of forecast storms is difficult and, furthermore, predicting their ability to impact the shoreline is impossible. Notwithstanding this, there are several key factors that should be assessed when selecting a storm to monitor. These are as follows:

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

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

Profiling is critical for assessing changes in the shoreline and estimating changes in volume of sand on the beach. It is important to note that the shoreline is constantly changing, and profiling provides a 'snapshot' in time of the beach cross-section. The dynamic nature of the shoreline means it is important to profile as close to before and after a storm as possible, to avoid detecting changes that might be associated with other processes. Profiling protocols for storm monitoring should be consistent with those outlined in **Section 3.1.1**, and the same profile locations as the overall monitoring program should be used where possible.

Sediment sampling is important to assess the change in composition of beach sand, associated with storm impact. Generally smaller grain sizes are taken away more easily, leaving large sand particles after a storm event. Sediment data will be useful for informing renourishment and shoreline protection activities, where the characteristics of imported sand are critical (see **Section 3.2.2**). Sediment sampling protocols for storm monitoring should be consistent with those outlined in **Section 3.1.1**, and the same sample locations as the overall monitoring program should be used where possible.

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

3.1.3 Coastal Asset Condition Assessment

Some built assets necessarily reside within coastal hazard areas because of their purpose. These assets include seawalls, surf lifesaving clubs and access infrastructure, like carparks and access ways. Such assets are often designed to be sufficiently strong to withstand coastal hazards or are accompanied by protection against coastal hazards. As SLR has already been occurring and climate change is expected to bring further changes to water levels and storm intensity, it is possible that existing coastal assets have been under designed for present and/or future coastal conditions. Assets such as seawalls can also lose functionality as conditions change and the shoreline is altered. This is always a challenge when placing fixed infrastructure at a dynamic shoreline.

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

3.1.4 Geological Risk Monitoring

As the rate of sea level rise intensifies, limestone formations along the north of the City's coastline will become increasingly exposed to coastal processes. Erosion of rock does not only occur incrementally, wave action will often undercut a rock formation causing the structure to collapse, presenting a risk to human health. As rock along the City's coastline is of variable strength and is often deeply incised and undercut (BMT 2015), it is important that the associated geological risks are assessed periodically and appropriate safety precautions implemented if an area is deemed unsafe for public access.

Geological risk monitoring can also better inform erosion (or accretion) rates along the City's coastline which can be fed into future iterations of the CHRMAP. The City should incorporate geological risk monitoring into its coastal monitoring program for their overall coastline. This should involve the development of a monitoring manual, which also includes instruction around storm monitoring (see above).

3.2 Further Investigations

3.2.1 Detailed Coastal Processes and Options Assessment(s)

R13: Undertake a detailed options assessment to determine the optimal coastal protection technique(s) at Watermans Bay Beach and Mettams Pool Beach.

Identified as state Coastal Erosion Hotspots, both Watermans Bay Beach and Mettams Pool Beach are currently at 'high' risk of being impacted by coastal erosion with built assets at Mettams Pool moving to 'high' risk in 2030 (Saunders Street carpark) and 2045 (Mettams Pool public toilets). Preliminary multi-criteria and economic assessment of options has indicated that the construction of nearshore reef(s) may be the most cost-effective and acceptable interim coastal hard protection measure to treat the risk at Watermans Bay and Mettams Pool Beaches. The City should confirm this by undertaking a detailed options assessment for these two sections of coastline, assessing 'short-listed' coastal engineering techniques to protect natural and built assets. The detailed options assessment should include the following:

- > Development of validated long-term shoreline evolution and storm response models for the coastline section;
- > Assessment of the effectiveness of options such as groynes/headland enhancement, nearshore breakwaters/reef enhancement and nourishment (combined with coastal structures and in isolation), based on concept designs;
- > Cost-benefit and multi-criteria assessment of each selected technique, based on concept designs;
- > Assessment of subsequent impacts outside of the target management area and the implications/acceptability of these;

- > Selection and refinement of a preferred technique or combination of techniques (e.g. structures and ongoing minor nourishment);
- > Detailed design of engineered structures and/or nourishment; and
- > Description of appropriate approvals pathways (environmental, development etc.).

The options assessments should thoroughly review and incorporate previous optioneering and community/stakeholder feedback regarding management and infrastructure planning for these coastal areas. Substantial recent options assessment and community engagement in 2019 regarding protection and access infrastructure upgrades for the Mettams Pool foreshore should be incorporated. Consideration of previous engagement is important to maintain trust of the community, as well as to reduce unnecessary rework in this regard.

R14: Undertake a detailed options assessment to determine the optimal coastal protection technique(s) at Scarborough Beach.

Scarborough Beach has significant portions of its public foreshore reserve at risk of being impacted by coastal erosion in early planning timeframes, an area of the coastline which stakeholders have expressed a desire to protect. Preliminary multi-criteria and economic assessment of options has indicated that the construction of groynes may be the most cost-effective interim coastal hard protection measure to treat the risk at Scarborough Beach. The City should investigate this by undertaking a detailed options assessment for the stretch of coastline, assessing 'short-listed' coastal engineering techniques to protect natural and built assets. The detailed options assessment should include the following:

- > Development of validated long-term shoreline evolution and storm response models for the coastline section;
- > Assessment of the effectiveness of options such as groynes/headland enhancement, nearshore breakwaters/reef enhancement and nourishment (combined with coastal structures and in isolation), based on concept designs;
- > Cost-benefit and multi-criteria assessment of each selected technique, based on concept designs;
- > Assessment of subsequent impacts outside of the target management area and the implications/acceptability of these;
- > Selection and refinement of a preferred technique or combination of techniques (e.g. structures and ongoing minor nourishment);
- > Detailed design of engineered structures and/or nourishment; and
- > Description of appropriate approvals pathways (environmental, development etc.).

3.2.2 Nourishment Sand Source Investigation

R15: Undertake an investigation to identify suitable sediment sources and determine available volumes for use in ongoing beach nourishment.

A preferred management technique for vulnerable areas in the short term is to continue/begin a beach nourishment program to maintain the present-day shoreline along the City's coastline. This management technique provides temporary protection, generally improves beach amenity and maintains a flexible adaptation pathway for the future. As sea levels rise, the volume of sand needed to be added to beaches will increase. In anticipation of the increased nourishment volumes, it will be prudent to identify suitable sediment sources for use in the future. This could include identification of sources such as:

- > Stripping sand from the City's beaches where accretion is occurring such as south of Trigg Point or in areas not considered to be vulnerable at present;
- > Sourcing sand from neighbouring councils such as Joondalup who have accretion points along their coastline;

- > Sourcing sand from developments close to the coast where excavation in good quality sand (for example basement excavation) is proposed;
- > Sourcing sand from local quarries; and
- > Identification of nearshore/offshore sand sources that could be sourced using dredging operations.

3.2.3 Foreshore Management Plans

R16: Undertake development of Foreshore Management Plan(s) to guide future management of the City's coastal areas.

The City should prepare a foreshore management plan for its coastline to provide guidance for the ongoing management of the foreshore reserves, monitoring of assets and the triggers for the managed retreat of assets and infrastructure at risk of erosion. Foreshore management plans are typically prepared for a particular stretch of coastline similar in spatial scale to management units used in this CHRMAP, however may be combined into one study.

Foreshore management plans can provide a strategy to deliver the recommendations of the CHRMAP for particular foreshore reserves throughout the City. Foreshore management plans can be a key tool for communication and engagement with the community as they include more detailed planning for community places and facilities.

3.2.4 Detailed Economic Analysis

R17: Undertake economic data collection and analysis to accurately quantify the value of the City's natural assets.

Given that future decision-making will involve trade-offs between maintaining natural assets, such as beaches and dunes, and built coastal assets, it is important that the City has an accurate understanding of the value of its natural assets. A detailed economic analysis, which will likely need to be informed by data collection, should be undertaken to quantify the inherent and ongoing economic value associated with natural coastal assets. Data collection may take the form of coastal area use and user feedback, which may also be derived from remote coastal imagery (see **Section 3.1.1**). The economic analysis will be critical to informing detailed assessment of coastal management options (see **Section 3.2.1**)

3.2.5 CHRMAP Revision

R18: Undertake a full revision of the City's CHRMAP, identifying and incorporating relevant new information.

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

"...risks arising from coastal hazards rarely remain static, especially as the understanding of coastal processes improves and given the long timeframes associated with some types of coastal processes and land use and development. Monitoring and reviewing the CHRMAP ensures that risk management measures, consequences and likelihood, and the risk management priorities, remain suitable, effective, timely and cost appropriate. Where practical, principles of risk management should be applied which involve changes based on regular monitoring and revision of plans based on the best information available at the time."

The key changes to any future revisions of the CHRMAP could include updated hazard estimates using more recent information, changes to projected SLR and climate change effects, any changes to the use of foreshore areas, changes to relevant legislation and changes to SPP2.6 and associated guidelines.

4 Medium- and Long-term Implementation

4.1 Future Sea Level Rise Predictions

The Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) is a scientific body set up by the World Meteorological Organisation and the United Nations Environment Programme in 1988. The IPCC was established to provide decision-makers and others interested in climate change with an objective source of information about climate change. IPCC assessments provide a major source of SLR information, with each successive assessment providing improved understanding of the contributions to past sea-level change, future projections and their associated uncertainties.

The IPCC have prepared sea-level rise projections, showing the variable predictions of different emissions scenarios and climate models. The four main emissions scenarios, described as Representative Concentration Pathways (RCPs) used by the IPCC in recent reports are:

- > RCP2.6 – The most ambitious scenario, requiring that carbon dioxide emissions start declining by 2020 and go to zero by 2100. RCP 2.6 also requires declines in methane and sulphur dioxide emissions and is likely to keep global temperature rise below 2 degrees Celsius by 2100;
- > RCP4.5 – An intermediate scenario requiring that carbon dioxide emissions start declining by approximately 2045 to reach roughly half of the levels of 2050 by 2100. RCP 4.5 also requires declines in methane and sulphur dioxide emissions and is likely to keep global temperature rise below 3 degrees Celsius by 2100;
- > RCP6.0 – An intermediate scenario requiring that carbon dioxide emissions start declining by approximately 2080. RCP 6.0 also requires declines in methane and sulphur dioxide emissions and is likely to keep global temperature rise below 3 degrees Celsius by 2100; and
- > RCP8.5 – A high emissions scenario where carbon dioxide, methane and sulphur dioxide emissions continue to rise until 2100. RCP8.5 is likely to result in global temperature rise of up to 5 degrees Celsius by 2100.

IPCC's *Fifth Assessment Report* (IPCC, 2014) and *Sixth Assessment Report* (IPCC, 2021) provide the most up to date and complete assessment on the scientific, technical and socio-economic aspects of climate change. A number of supplementary reports have also been released by IPCC, including the *Special Report on Ocean and Cryosphere in a Changing Climate* (IPCC, 2019). Current IPCC projections for SLR are provided in **Table 4-1** below. **Appendix B** has been included for further information regarding RCPs, for the interest of the reader.

Table 4-1 IPCC sea level rise scenarios referenced from 2020

Scenario	2020	2045	2070	2120
RCP2.6 (AR6)	0.00	0.13	0.22	0.44
RCP4.5 (AR6)	0.00	0.15	0.26	0.57
RCP6.0 (AR5)	0.00	0.14	0.25	NA*
RCP8.5 (AR6)	0.00	0.18	0.34	0.92

*SLR predictions beyond 2100 not provided in Fifth Assessment Report (AR5)

Figure 4-1 depicts the global mean SLR curves associated with each RCP, as well as the bands of uncertainty associated with the modelling. The figure demonstrates increasing uncertainty as predictions move into the future.

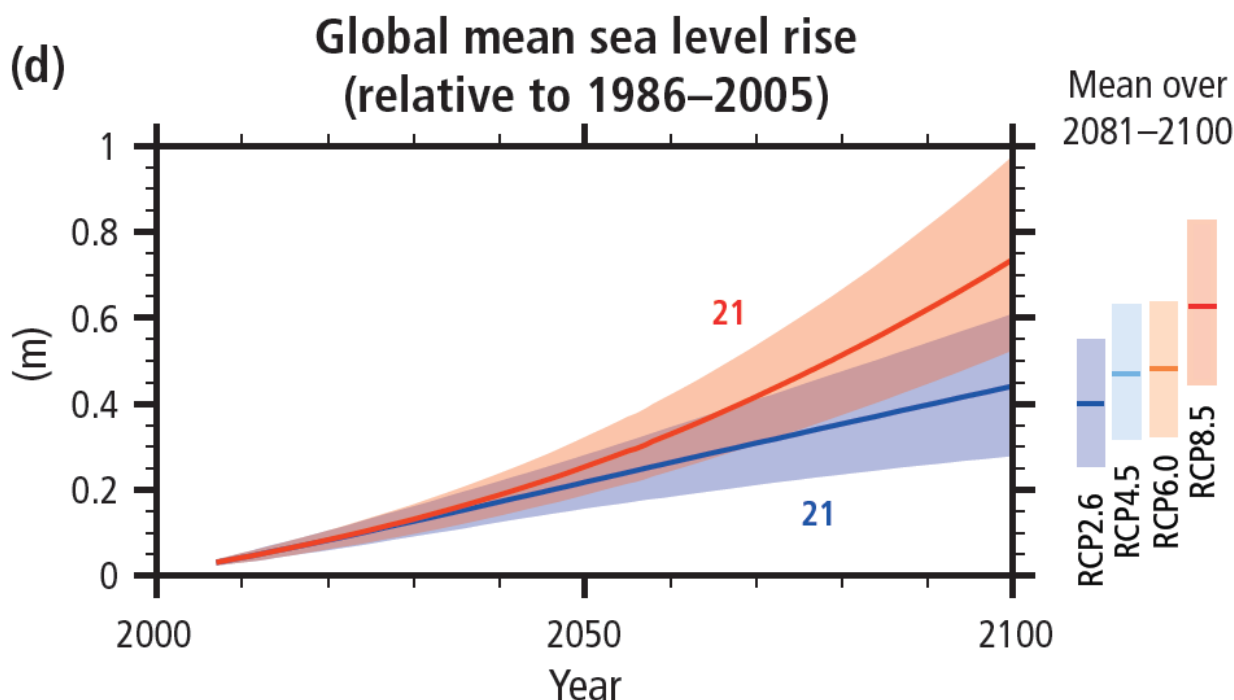


Figure 4-1 Change in global MSL (IPCC, 2014)

CSIRO Climate Change Assessments

The *State of the Climate 2020* report (CSIRO and BoM, 2020) draws on the latest climate research, encompassing observations, analyses and projections to describe year-to-year variability and longer-term changes in Australia's climate. The Report provides a review of climate change in Australia and provides a number of projections for future climate change in Australia, including the following that are particularly relevant to this CHRMAP:

- > Ongoing sea level rise. Recent research on potential ice loss from the Antarctic ice sheet suggests that the upper end of projected global mean sea level rise could be higher than previously assessed (as high as 0.61 to 1.10 m global average by the end of the century for a high emissions pathway, although these projected levels vary by location); and
- > More frequent extreme sea level events. For most of the Australian coast, extreme sea levels that had a probability of occurring once in a hundred years are projected to become an annual event by the end of this century with lower emissions pathways, and by mid-century for higher emissions pathways.

The *Climate Change in Australia* report (CSIRO and BoM, 2015) provides a comprehensive assessment of climate change effects specific to Australia, underpinned by IPCC studies. For example, the effects on SLR for Australia (**Figure 4-2**).

The report provides a more quantitative assessment of regional climate change projections for Fremantle, using long-term, continuous water level records available. Relevant predictions and projections include:

- > Mean SLR projections for Fremantle;
- > Extreme SLR projections for Fremantle arising from a combination of factors including astronomical tides, storm surges and wind waves;
- > Projected changes to large scale wind circulation patterns, influenced by the seasonal movement of the subtropical ridge. While there is relatively high confidence in the projected changes to large-scale circulation patterns, it should be noted that there is large uncertainty in projected changes to extreme near surface winds. This is due to the inability of global climate change models to resolve small scale meteorological systems; and

- > Projected increases in the temperature differential between the land and sea during the summer months, resulting in increased onshore wind speeds during summer.

Projections for regional SLR at Fremantle suggest that the region is tracking, on average, consistently with broader global predictions.

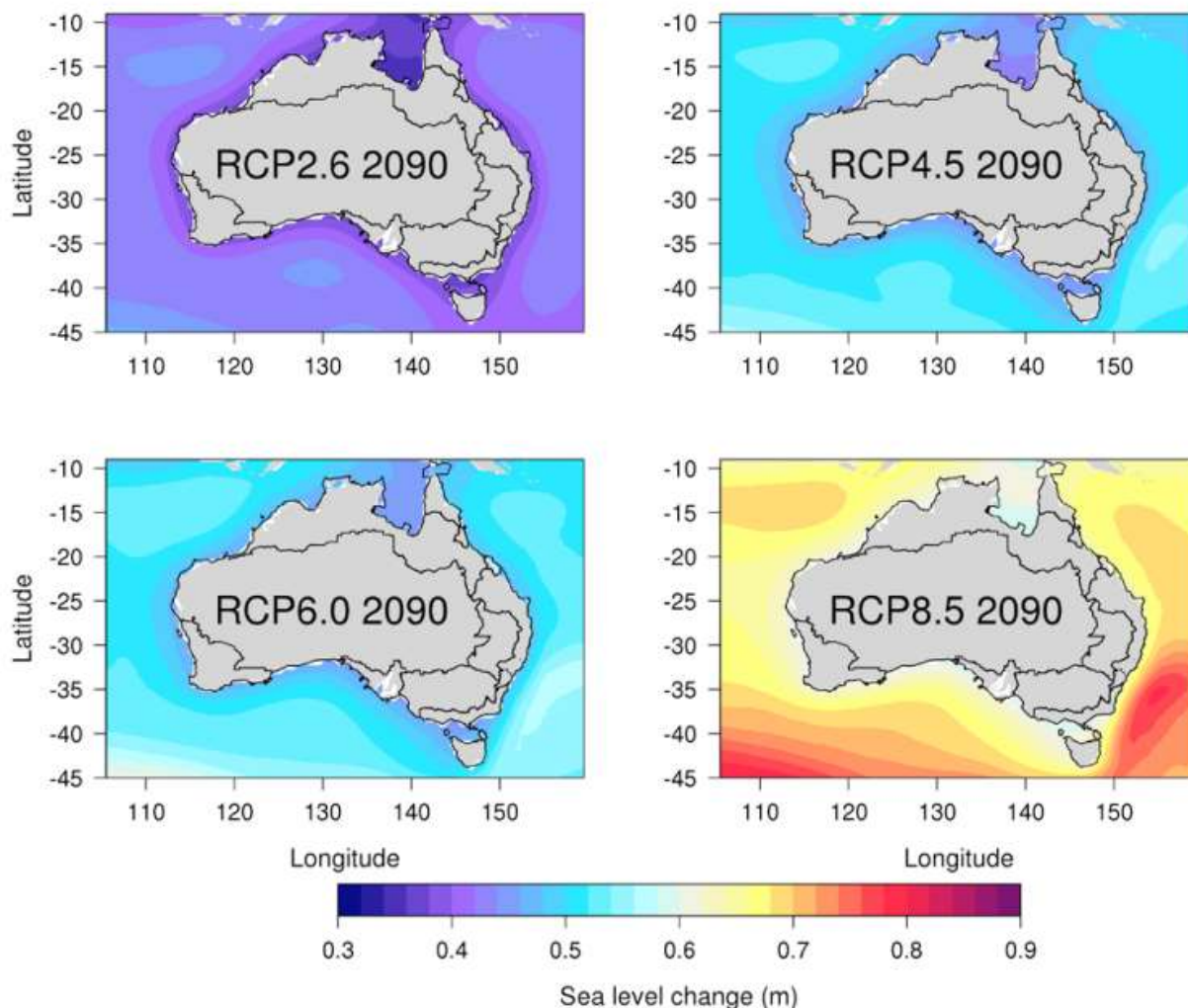


Figure 4-2 Distribution and variability of mean sea level change projections around Australia for 2090 (CSIRO and BoM, 2015)

4.2 Medium-term Implementation (25 to 50 years)

The 2045 to 2070 timeframe is expected to exhibit an accelerating SLR trend, with coastal storm events that are currently rare becoming more frequent. This is expected to result in a receded average shoreline position and greater inland reach for acute erosion events, particularly for sandy coastlines such as that to the south of Trigg Island. If implemented, coastal protection structures at Watermans Bay and/or Mettams Pool will be nearing the end of their functional life, losing effectiveness in mitigating ongoing erosion. The risk to multiple high-value public built (e.g. West Coast Drive, buildings, accessways and carparks) and natural (beaches and dunes) assets during this timeframe is predicted to become intolerable for the City.

Coastal monitoring data collected over the preceding 25 years, as well as the specialist investigations undertaken, will be used to inform decision making for the medium-term timeframe. Foreshore management planning should also have been undertaken to allocate areas of land for specific use and purpose within the coastal foreshore reserve. Future funding should have been set aside to fund the required adaptation. Likely actions to be implemented will include:

- > Making the critical decision to either prolong and maintain the coastal protection techniques along the City's coastline, or to discontinue funding 'protection' and adjust to a 'managed retreat' approach. It is likely that

the approach will be to refurbish/maintain coastal protection structures to be safe across the timeframe, but to accept their lower effectiveness and discontinue protection actions requiring ongoing cost, such as nourishment;

- > During the timeframe, managed retreat of built assets is more likely to be required to maintain valuable natural assets (at particular beaches), than due to direct risk of damage of the structures. Several existing built assets are likely to be reaching the end of their design life during this timeframe. Poor public perception of decreasing beach width is also likely to increase. It is anticipated that several buildings and carparks will require demolition, with their footprints replaced by the reestablishment of beach, natural dune barrier or public recreation areas;
- > Critical decisions will need to be made in this timeframe regarding the maintenance of a useable coastal foreshore reserve for future generations. The ongoing and predicted shoreline retreat will reduce the available foreshore space seaward of major public assets, such as West Coast Drive and Scarborough Foreshore Development. Natural beach and foreshore to the north of any protective structures is also likely to be diminishing at a more rapid rate (sacrificed), due to the focus on maintaining the shoreline position adjacent built assets. Ongoing community and stakeholder consultation prior to the timeframe should have educated the public that managed retreat may be triggered for built assets that are not immediately threatened (e.g. by coastal erosion) but to maintain sufficient space for a coastal foreshore reserve for use by the broader public. This will be contentious as some of the highest value private infrastructure will be the first to be threatened; and
- > Strong collaboration should be established during this timeframe between levels of government (State and Federal), as well as among local government authority. Adaptation approaches to be implemented should be wholistic for the City's coastline. They should also be wholistic along the Perth Metropolitan coastline, with acknowledgement of the connectedness of sediment transport processes across jurisdictional boundaries.

4.3 Long-term Implementation (50 to 100 years)

The 2070 to 2122 timeframe is expected to exhibit a more rapid rate of SLR than is currently observed and is expected to be observed over the next 50 years. The peak water levels and coastal storm surge events observed are anticipated to be unprecedented with respect to recorded history. Maintenance of the average shoreline position that is present at the start of this timeframe, even for short sections of sandy coastline, is expected to become financially unviable unless the sacrifice of valuable natural assets is accepted (e.g. seawalls are installed and beaches are lost).

The period is likely to require the implementation of substantial managed retreat, including major public assets such as West Coast Drive and assets at the Scarborough Foreshore, in order to maintain a useable and functional coastline for the broader public. Overarching strategies and funding (State and Federal) are expected to be in place for adaptation across this timeframe, as multiple, developed coastal areas will be experiencing the same impacts.

The significant uncertainty with respect to both emissions scenarios (human behaviour related) and resulting sea level rise (due to sea level response and modelling uncertainty) must be acknowledged when considering implementation within this timeframe.

5 Key Recommendations

Key CHRMAP recommendations are collated and summarised in **Table 5-1**. These recommendations generally focus on actions that will or may require implementation prior to 2045. Recommendations for management actions beyond 2045 will be better informed by investigations undertaken and information collected over the next decade, which will be highlighted in the next review of the CHRMAP.

Table 5-1 Key CHRMAP recommendations

ID	Recommendation
R1	<i>Engage the community to present the results of this CHRMAP and formally assess their willingness to contribute to funding.</i>
R2	<i>Investigate and establish a fund for ongoing coastal adaptation and management, and allocate funding sources.</i>
R3	<i>Establish or join a strategic partnership with other Local Government Areas (LGAs) to coordinate coastal management activities</i>
R4	<i>If future revisions of the CHRMAP, which incorporate additional geotechnical information and planned coastal controls, find that private properties are intersected by future coastal hazard extents, the City should explore the addition of a Special Control Area over this land, to control development that is inappropriate with respect to the timeframe of the hazard extent.</i>
R5	<i>If future revisions of the CHRMAP, which incorporate additional geotechnical information and planned coastal controls, find that private properties are intersected by future coastal hazard extents, affected landholders should be notified directly and by the application of notification on Certificates of Title, where practicable.</i>
R6	<i>Proposed structure plans should be reviewed to ensure they adhere to SPP2.6 and account for the risks identified in this CHRMAP.</i>
R7	<i>After the introduction of an SCA, undertake development of a coastal Local Planning Policy to guide future management of the City's coastal reserves and areas.</i>
R8	<i>Maintain implementation of soft protection measures such as dune restoration and sand-fencing.</i>
R9	<i>Initiate targeted beach nourishment of existing vulnerable areas.</i>
R10	<i>Implement interim coastal protection for Watermans Bay and Mettams Pool.</i>
R11	<i>Update the City's coastal asset inventory and emergency/damage response plan to include specific risk from and response to potential coastal impacts.</i>
R12	<i>Initiate a long-term coastal monitoring program, incorporating ad hoc storm and metocean monitoring, coastal asset condition assessments and geological risk monitoring.</i>
R13	<i>Undertake a detailed options assessment to determine the optimal coastal protection technique(s) at Watermans Bay Beach and Mettams Pool Beach.</i>
R14	<i>Undertake a detailed options assessment to determine the optimal coastal protection technique(s) at Scarborough Beach.</i>

R15	<i>Undertake an investigation to identify suitable sediment sources and determine available volumes for use in ongoing beach nourishment.</i>
R16	<i>Undertake development of Foreshore Management Plan(s) to guide future management of the City's coastal areas.</i>
R17	<i>Undertake economic data collection and analysis to accurately quantify the value of the City's natural assets.</i>
R18	<i>Undertake a full revision of the City's CHRMAP, identifying and incorporating relevant new information.</i>

5.2 Short-term Implementation Plan

A short-term implementation plan is presented in **Table 5-2**. The table describes actions recommended for implementation by 2045, their estimated costs and suggestions for timing. The cost estimates provided are based on commercial rates and do not assume work will be carried out by the City to complete the actions. Realistically, a significant portion of the proposed works will be undertaken by City staff. The City should assess how it wishes to resource the proposed works, before estimating costs for the purpose of budgeting.

The table includes potential funding sources for the recommended actions, including external funding sources (grants) described in **Section 2.3**. It must be noted that funding from these sources is subject to a competitive application process. There are limits on the total funding available from these grant programs, as well as the amount available for an individual project. There are also certain co-contribution requirements for some of the grant programs. Furthermore, continuity of these funding programs into the future is not assured.

Table 5-2 Short-term implementation plan to 2045

Component	Annual cost estimate	Total cost estimate (to 2045)	Timing	Funding options
<u>Operational</u>				
Investigate & establish coastal adaption fund (R2)	-	-	From 2023	Internal
Introduction of SCA (R4)	-	-	TBC (following R18)	CMPAP Grant / Internal
Establish strategic partnership with other LGAs (R3)	-	-	From 2025	CMPAP Grant / Internal
Notify landholders (R5)	-	-	TBC (following R18)	Internal
Apply notifications to title (R5)	-	-	TBC (following R18)	Internal
Review of structure plans (if applicable)	-	-	When submitted	Internal
Develop Coastal Local Planning Policy (R7)	-	-	TBC (following R18)	CMPAP Grant / Internal
	<u>Sub-total</u>	<u>TBD</u>		
<u>Monitoring</u>				
Shoreline monitoring program establishment (R12)	-	\$30,000	2023 - 2024	CAP Grant / Internal
Ongoing aerial imagery analysis (R12)	\$12,000	\$252,000	From 2024	CAP Grant / Internal
Ongoing shoreline monitoring (R12)	\$25,000	\$525,000	From 2024	CAP Grant / Internal
Storm monitoring (R12)	\$12,000	\$252,000	From 2024	CAP Grant / Internal
Coastal asset condition assessments (5-yearly) (R12)	\$1,000	\$25,000	From 2025	CAP Grant / Internal
Metoccean data collection (R12)	-	\$125,000	From 2024	CAP Grant / Internal
Geological risk monitoring (R12)	\$10,000	\$105,000	From 2024	CAP Grant / Internal
	<u>Sub-total</u>	<u>\$1,315,000</u>		
<u>Implementation/ Management</u>				
CHRMAP results community engagement (R1)	-	\$20,000	2022 - 2023	Internal
Ongoing community engagement (R1)	\$10,000	\$220,000	From 2023	Internal

Ongoing dune restoration (R8)	\$10,000	\$220,000	From 2023	Coastwest Grant / Internal
Ongoing beach nourishment* (R9)	\$270,000	\$5,940,000	From 2023	CAP Grant / Internal
Coastal asset inventory update (R11)	-	\$10,000	2023 - 2024	Internal
Asset management plan update (R11)	-	\$10,000	2023 - 2024	CMPAP Grant / Internal
Hazard response preparation (R11)	-	\$15,000	From 2024	Internal
Installation of protection – Watermans and Mettams (R10)	-	\$6,000,000	Between 2025 and 2030	H-CAP Grant / Internal
	<u>Sub-total</u>	<u>\$12,435,000</u>		
<u>Special Investigations</u>				
Detailed options assessment for Watermans and Mettams (R13)	-	\$300,000	By 2025	CAP Grant / Internal
Detailed options assessment for Scarborough (R14)		\$200,000	By 2025	CAP Grant / CMPAP Grant / Internal
Nourishment sand source investigation (R15)	-	\$30,000	By 2024	CAP Grant / Internal
Detailed foreshore management plan(s) (R16)		\$200,000	By 2025	CMPAP Grant / Internal
Detailed economic analysis (R17)		\$50,000	By 2025	CMPAP Grant / Internal
Hazard line and CHRMAP revision 1 (R18)	-	\$100,000	2030	CMPAP Grant / Internal
Hazard line and CHRMAP revision 2 (R18)	-	\$100,000	2040	CMPAP Grant / Internal
	<u>Sub-total</u>	<u>\$980,000</u>		
	<u>Grand Total</u>	<u>\$14,730,000</u>		

* Does not account for installation of protective options, which should reduce nourishment need.

Figure 5-1: City of Stirling CHRMAP - Short-term Implementation Plan

Commencing:

Jan-23

[illegible]

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APPENDIX

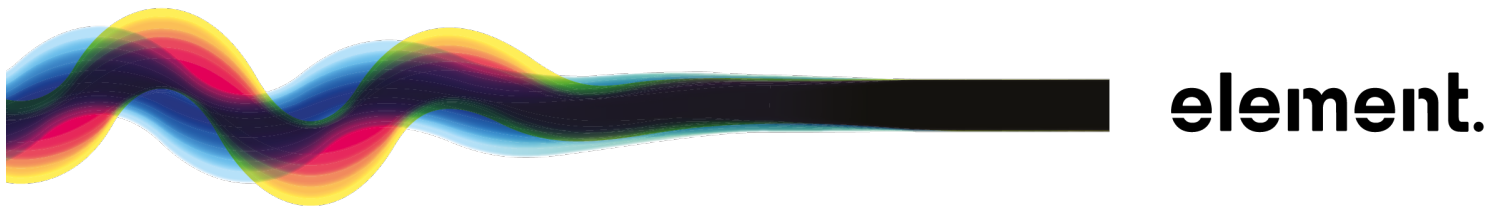
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STATUTORY PLANNING RECOMMENDATIONS



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City of Stirling CHRMAP

Risk Treatment & Implementation

30 May 2023

Document ID: 21-338

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			Name	Name
1	14 June 2022	Draft 1	Dylan Wray	Matt Raymond
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3	19 October 2022	FINAL 1	Dylan Wray	Matt Raymond
4	30 May 2023	FINAL 2	Dylan Wray	Matt Raymond

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Risk Treatment

Statutory Planning Controls

Chapter 1: Establish the Context reviewed the existing planning framework relevant to the study area, including the identification of planning controls that can be implemented by the City to respond to coastal erosion and inundation.

The current hazard modelling indicates that only one zoned property under LPS 3 may be impacted by erosion or inundation within the 2120 planning timeframe. As such, there is no immediate need for the City to implement the recommendations outlined below. However, the recommendations provide a foundation for future revisions of the CHRMAP, including implementation triggers once there is more certainty around the impacts of coastal erosion and inundation through updated hazard estimates.

Current Recommended Planning Controls

There is no immediate need for the City to implement additional planning controls given the 2120 modelled hazard lines only impact a small area of one zoned property. While no immediate planning controls are required, the City must be proactive and commence long term planning for coastal hazards which will become more prevalent through future iterations of this CHRMAP.

Possible Future Planning Controls

The following recommendations provide the foundation for sustainable coastal planning in the City, in accordance with SPP 2.6. These recommendations shall be implemented once the impacts of erosion and/or inundation are more certain, as identified through future revisions of the CHRMAP.

Although these planning controls are recommended to be implemented, they are based on possible future scenarios. As such, development within impacted areas will be assessed on a case-by-case basis and may in fact not be permitted.

Local Planning Strategy

The CHRMAP will inform the City's Local Planning Strategy to guide land use planning and development in areas prone to erosion or inundation. Areas of risk identified through revisions of the CHRMAP should not be identified for further development, intensification or rezoning.

Subsequent revisions of the Local Planning Strategy shall include a provision for all SPP 2.6 requirements to be met at the earliest stage possible, including the requirements for the ongoing provision of a coastal foreshore reserve.

The Local Planning Strategy must assess the hazard risks identified in this CHRMAP alongside other relevant planning matters including environmental, economic and social considerations to holistically inform and shape future expansion, as a precursor to future amendments to the City's Local Planning Scheme.

Structure Planning

Structure planning is considered the most effective mechanism where some degree of comprehensive redevelopment of land remains an option. While a structure plan is unlikely to be prepared by the City, it must be considered given the interim arrangements for the normalisation of the Scarborough Redevelopment Area.

The agreed approach to transfer the planning framework back to the City is to rezone the Scarborough Redevelopment Area from 'No Zone' to 'Development' zone under LPS3. The City does not intend to prepare a structure plan for this area. However, the 'Development' zone does enable the private sector to prepare and submit a structure plan to the City for consideration.

In the event a structure plan is prepared for land subject to erosion or inundation as identified through future revisions of the CHRMAP, the City shall require the proponent to accommodate coastal risks by including provisions for all SPP 2.6 requirements to be met at the earliest stage of subdivision and development.

Local Planning Scheme Amendment

The City will be required to initiate an amendment to the Local Planning Scheme when future revisions of the CHRMAP, which incorporate additional geotechnical information and planned coastal controls, identify the coastal hazard extents as intersecting private properties. The scheme amendments shall include:

- Insert CHRMAP Special Control Area (SCA) under Part 6; and
- Update Scheme Maps to include CHRMAP SCA over all zoned land impacted by erosion or inundation.

The City shall determine the most appropriate time to amend the Local Planning Scheme following updates to the hazard estimates through revisions of the CHRMAP.

Special Control Area

The introduction of an SCA over zoned land affected by erosion or inundation in the 100-year planning timeframe will provide the most effective response to coastal hazards. The SCA will stipulate provisions to respond to the risks identified in the CHRMAP, including the trigger for normally exempt development to require development approval.

It is noted that some forms of development cannot be controlled by the SCA, such as works carried out by the State Government under the *Public Works Act 1902*. The City should liaise with the State regarding such development to ensure it is not incompatible with the long-term pathway set out for the area.

The following SCA shall be introduced into the Local Planning Scheme when future revisions of the CHRMAP, which incorporate additional geotechnical information and planned coastal controls, identify the coastal hazard extents as intersecting private properties.

Table 1: CHRMAP Special Control Area

CHRMAP Special Control Area	
<u>Objectives:</u>	
a)	To ensure land in the coastal zone is continuously available for coastal foreshore management, public access, recreation and conservation.
b)	To ensure public safety and reduce risk associated with erosion and inundation.
c)	To avoid inappropriate land use and development of land at risk of erosion and inundation.
d)	To ensure land use and development does not accelerate erosion or inundation risk; or have a detrimental impact on the functions of public reserves.
e)	To protect new development from the impacts of erosion and inundation.
f)	To provide for implementation of the City of Stirling Coastal Hazard and Risk Management Adaptation Plan.
<u>Special Control Area</u>	
a)	The CHRMAP Special Control Area is shown on the Scheme Maps and delineated as such.
<u>Approval</u>	
a)	Notwithstanding any other provision of the Scheme, all proposed development within the CHRMAP Special Control Area requires the approval of the local government, inclusive of any development which may otherwise be exempt under the Planning and Development (Local Planning Schemes) Regulations 2015.

<p><u>Structure Plans</u></p> <p>a) Structure Plans shall be consistent with –</p> <ol style="list-style-type: none"> I. The City of Stirling Coastal Hazard and Risk Management Adaptation Plan. II. The provisions of State Planning Policy 2.6 – State Coastal Planning Policy. III. Coastal Local Planning Policy. IV. Relevant local planning policies.
<p><u>Subdivision and Development</u></p> <p>a) The subdivision and development of land within the CHRMAP Special Control Area shall have due regard to –</p> <ol style="list-style-type: none"> I. The City of Stirling Coastal Hazard and Risk Management Adaptation Plan. II. The provisions of State Planning Policy 2.6 – State Coastal Planning Policy. III. Coastal Local Planning Policy. IV. Relevant local planning policies.
<p><u>Notifications</u></p> <p>a) Where subdivision applications are received within the CHRMAP SCA, a notification pursuant to Section 165A of the Planning and Development Act 2005 is to be placed on the Certificate(s) of Title of the subject land, at the cost of the landowner advising that the lot is located in an area likely to be subject to erosion and/or inundation over the next 100 years.</p> <p>b) Where development applications are received within the CHRMAP SCA, the local government shall require a notification pursuant to section 70A of the Transfer of Land Act 1983 to be placed on the Certificate(s) of Title of the subject land, at the cost of the landowner, advising that the lot is located in an area likely to be subject to erosion and/or inundation over the next 100 years.</p>
<p><u>Referrals</u></p> <p>a) In certain instances, there may be a requirement to refer the application to the Department of Transport, the Western Australian Planning Commission and any other relevant authority for advice and comment on the risk of erosion and inundation.</p>

Coastal Local Planning Policy

Development on properties located within the SCA will be required to give due regard to additional development provisions to better accommodate and respond to the risk of erosion and inundation.

Following the introduction of the SCA into the Local Planning Scheme, the City shall prepare and adopt a Coastal Local Planning Policy in accordance with Schedule 2 of the *Planning and Development (Local Planning Schemes) Regulations 2015*. It is recommended that the Coastal Local Planning Policy includes the following provisions, as deemed appropriate by the City.

Application for Development Approval:

- All development within the CHRMAP SCA requires development approval prior to the commencement of construction, unless specifically exempted by this Policy.
- Applicants will need to clearly demonstrate that their proposal meets the objectives and requirements of this policy and the City of Stirling CHRMAP.

Application for Subdivision Approval:

- As previously stated, there is a general presumption against further intensification of properties within the CHRMAP SCA. However, the City may consider subdivision if it can be demonstrated that adequate protection measures are provided, at the cost of the landowner and to the satisfaction of the City.
- Subdivision of land within the CHRMAP SCA will only be supported by the City where the applicant can demonstrate a reduction in the identified hazard risks through site specific studies, in accordance with State Planning Policy 2.6 Coastal Planning Policy and the CHRMAP Guidelines.
- A notification pursuant to Section 165A of the *Planning and Development Act 2005* is to be placed on the Certificate(s) of Title of the subject land, at the cost of the landowner. The notification shall be required as a condition of subdivision approval, advising that the lots are located in an area likely to be subject to erosion and/or inundation over the next 100 years.

Erosion Requirements:

- No permanent development is to be located seaward of the 100-year erosion hazard line, as defined in the CHRMAP, unless expressly exempt under this policy.
- Development that is not permanent can be located seaward of the erosion hazard lines provided the applicant demonstrates that the design life is suitable for its location with regard to the coastal hazard lines contained within the CHRMAP.
- Development proposed seaward of the 100-year erosion hazard line shall only be considered where the applicant demonstrates that the development can be relocated or removed. The below conditions and advice notes shall be applied to development approvals pertaining to properties at risk of erosion, to the discretion of the City.
- Properties without access to reticulated sewerage shall provide an aerobic treatment unit system, to the satisfaction of the City's Environmental Health Officer.
- Exemptions for minor development on properties seaward of the 100-year erosion hazard line may be considered where they do not substantially alter the development footprint. Exemptions could include additions and alterations, incidental land uses, or development and land uses that are not considered an intensification of development.

Inundation Requirements:

- Habitable rooms for residential buildings and net lettable areas for commercial, retail or community buildings require minimum finished floor level of at least 0.5m above the modelled inundation level.
- Where the filling of land is proposed to achieve minimum finished floor levels, the design and location of retaining walls shall not create an adverse impact of inundation levels on adjoining properties.
- All essential services, including electricity, water, sewerage and communications infrastructure shall be elevated and / or designed to be protected from the impact of inundation. The City may require information to demonstrate how this will be achieved or apply conditions to this effect.
- Buildings designed to withstand structural loads associated with inundation, including water resistant building materials and construction methods. The City may require information to demonstrate how this will be achieved or apply conditions to this effect.
- Effluent disposal systems shall be designed to withstand inundation events. Properties without access to reticulated sewerage shall provide an aerobic treatment unit system, to the satisfaction of the City's Environmental Health Officer.
- Lower levels of buildings at risk of inundation may be used for non-habitable rooms or spaces. These rooms and uses are to be clearly labelled on the plans submitted for development approval.
- Exemptions for minor development which could include additions and alterations that do not increase the development footprint by more than 50m² in habitable or net lettable area, or is not considered an intensification of development or land use.
- Development applications for vulnerable land uses shall be accompanied by a site-specific emergency evacuation plan. Vulnerable land uses include the occupation of people who are less physically or mentally able to respond in an emergency and include the elderly, children under 18 years of age and the sick or injured.

Management Requirements

Model Conditions List

The following list of conditions and advice notes shall be applied to development approvals within the CHRMAP SCA, at the discretion of the City.

Conditions:

1. The development approval shall cease to have effect and the development removed when:
 - a. The most landward part of the Horizontal Shoreline Datum is within the S1 distance of the most seaward part of the habitable buildings; or
 - b. A public road is no longer available or able to provide legal access to the property; or
 - c. Water, sewerage or electricity to the lot is no longer available due to coastal hazards.
2. Any development approval granted in respect to Condition 1 shall require the land to be rehabilitated to its pre-development condition, once the development has been removed. The land shall be rehabilitated to the specifications and satisfaction of the Local Government, at the landowners cost.
3. A notification, pursuant to Section 70A of the Transfer of Land Act 1893 is to be placed on the Certificate of Title of the proposed development lot advising of the existence of a hazard. The notification is to state as follows:

'Vulnerable coastal area - This lot is located in an area likely to be subject to coastal erosion and/or inundation over the next 100 years and is subject to conditions of development approval which requires removal and/or rehabilitation of development to pre-development conditions if the time limit specified on the development approval is reached or any one of the following events occurs:

- a) the most landward part of the Horizontal Shoreline Datum being within (insert number) meters of the most seaward part of the habitable building;*
- b) a public road no longer being available or able to provide legal access to the property;*
- c) when water, sewerage or electricity to the lot is no longer available as they have been removed/decommissioned by the relevant authority due to coastal hazards.'*

Advice Notes:

1. The applicant is advised that the Horizontal Shoreline Datum means the active limit of the shoreline under storm activity, as defined in State Planning Policy 2.6 – State Coastal Planning Policy (2013).
2. The applicant is advised that the distance between the Horizontal Shoreline Datum and the most seaward part of the habitable building is the S1 value, as defined for each coastal management zone in the CHRMAP.

The City shall also recommend conditions and advice notes to a similar effect to the WAPC for any development proposed within the foreshore reserve.

Planned or Managed Retreat Policy

There is no immediate need for the City to prepare a Planned or Managed Retreat Policy given the erosion hazard lines are not expected to impact assets on private properties within the 100-year planning timeframe. The City should however acknowledge that a Planned or Managed Retreat Policy may need to be prepared when there is more certainty around the risk of erosion on private properties.

In view of this, a recommendation for a Managed Retreat Policy is not included in this version of the CHRMAP. The City should review the need and timing for such policy in conjunction with future revisions of the CHRMAP which may include further guidance on the content and direction of a Managed Retreat Policy.

The City should also work with the State Government to determine an appropriate response to the managed retreat of at risk assets within the existing foreshore reserve. These assets would be best managed by a Foreshore Management Plan, prepared and implemented by the City.

Any development within the foreshore reserve should give due regard to the recommendations of the CHRMAP. The City shall collaborate with the State Government to determine the most appropriate response for the ongoing use of existing and proposed public assets.

Foreshore Management Plans

Foreshore management plans can provide a strategy to deliver the recommendations of the CHRMAP for particular foreshore reserves throughout the City. Foreshore management plans can be a key tool for communication and engagement with the community as they include detailed planning for community places and facilities.

The City should prepare a foreshore management plan for its coastlines to provide guidance for the ongoing management of foreshore reserves, monitoring of assets and the triggers for the managed retreat of assets and infrastructure at risk of erosion.

Publicly Available Information

It is recommended that the City introduces the erosion and inundation hazard data into the publicly available mapping system. This will ensure staff and the community have access to information on any affected land and can be made aware of the presence of the coastal hazards.

Information on relevant coastal hazards and the implications for property, now and into the future, should also be made available to potential buyers upon making a land purchase enquiry.

Emergency Response and Evacuation

In accordance with the *Emergency Management Act 2005*, the City is responsible for assisting the community in preparing, preventing, responding and recovering from various emergencies. The City's Local Emergency Management Committee (LEMC) has prepared a Local Emergency Management Arrangements (LEMA) which includes useful information in relation to emergency preparation and response.

The LEMA should be reviewed in conjunction with this CHRMAP to ensure areas identified as being at risk of inundation events have arrangements in place to assist with emergency response and recovery.

Implementation

Short Term Planning Controls

The following planning and management controls presented in Chapter 5: Risk Treatment should be implemented by the City over the next 25 years in response to the coastal hazards identified in the CHRMAP. There is no immediate need to update the City's planning framework based on the current hazard modelling. However, the controls in Table 2 should be implemented once there is greater certainty around the impact of coastal processes on zoned land. This will be established through periodic reviews of the CHRMAP which will require revised hazard modelling.

Table 2 – Short Term Implementation (next 25 years)

Planning Controls	Description	Implementation Triggers
Structure Plans	Require proponents to include coastal adaptation and management provisions into structure plans.	The submission of a structure plan containing lots being affected by coastal hazards.
Scheme Amendment	Introduce SCA into the City's local planning scheme.	When future revisions of the CHRMAP identify the coastal hazard extents as intersecting private properties.
Coastal Local Planning Policy	Adoption of a local planning policy to guide future development within the SCA.	Following the introduction of the SCA into the City's local planning scheme.
Model Conditions List	Update model conditions list to include conditions relating to notifications on title and managed retreat.	Following the introduction of the SCA into the City's local planning scheme.
Publicly Available Information	Update IntraMaps to include coastal hazard data.	Upon completion of the CHRMAP.

Medium to Long Term Planning Controls

The following planning and management controls presented in Chapter 5: Risk Treatment should be implemented by the City at a time when the risk of coastal process is more certain through periodic reviews of the CHRMAP.

Table 3 – Medium to Long Term Implementation (25 - 100 years)

Planning Controls	Description	Implementation Triggers
Planned or Managed Retreat Policy	Adoption of a policy for the retreat of assets and acquisition of at-risk land.	Once it has been determined that the land can no longer be used for its intended purpose.
MRS Amendment	Rezone acquired land to 'Parks and Recreation' reserve under the MRS.	Once land has been acquired in accordance with the adopted Planned or Managed Retreat Policy.
Emergency Response and Evacuation	Review LEMA alongside the inundation mapping identified in the CHRMAP.	Once it has been determined that habitable buildings will be subject to inundation events.

Further Investigations

Foreshore Management Plan

The City shall undertake the development of Foreshore Management Plan(s) to guide future management of the City's coastal areas and assets. The City shall determine the most appropriate time to prepare a Foreshore Management Plan however should prioritise high use areas with at-risk public assets, including Scarborough Beach, Trigg, Watermans Bay and Mettams Pool.

CHRMAP Revisions

As noted in the CHRMAP Guidelines, the CHRMAP should be a living document and undergo regular revisions alongside periodic reviews of the City's Local Planning Strategy and Local Planning Scheme.

The key considerations for future revisions of the CHRMAP should include any changes to community values and expectations, revised hazard mapping based on current data, changes to the use of foreshore reserves and changes to relevant legislation.

APPENDIX

B

IPCC RCPS



now



What are the RCPs?

RCP stands for 'Representative Concentration Pathway'. To understand how our climate may change in future, we need to predict how we will behave.

For example, will we continue to burn fossil fuels at an ever-increasing rate, or will we shift towards renewable energy?

Current emissions are tracking close to the RCP8.5 pathway

The RCPs try to capture these future trends. They make predictions of how concentrations of greenhouse gases in the atmosphere will change in future as a result of human activities.

The four RCPs range from very high (RCP8.5) through to very low (RCP2.6) future concentrations. The numerical values of the RCPs (2.6, 4.5, 6.0 and 8.5) refer to the concentrations in 2100.

2°C

increase in temperature
is recognised as the threshold at which climate change becomes **dangerous**.

Effort to curb emissions	Energy generation	New technology	Transport		Temperature 2081–2100 (average increase relative to 1986–2005)	Sea level 2081–2100 (average rise relative to 1986–2005)	Extreme weather 2081–2100	Adaptation required
Low	Coal-fired power		Cars, trucks	RCP 8.5	3.7 °C	0.63 m	Large increase	High level at high cost
Medium	Mix		Mix	RCP 6.0	2.2 °C	0.48 m	Moderate increase	Medium level at medium cost
Medium	Renewable		Mix	RCP 4.5	1.8 °C	0.47 m	Moderate increase	Medium level at medium cost
High	Renewable	Emissions capture	Bicycles, public transport	RCP 2.6	1.0 °C	0.4 m	Small increase	Low level at low cost

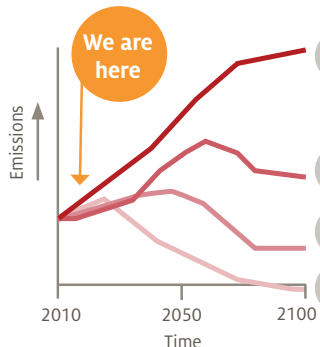
Where do the RCPs come from?

The RCPs were used in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) in 2014 as a basis for the report's findings.

Previous IPCC assessment reports used a set of scenarios known as SRES (Special Report on Emissions Scenarios), which start with socioeconomic circumstances from which emissions trajectories and climate impacts are projected. In contrast, RCPs fix the emissions trajectory and resultant radiative forcing rather than the socioeconomic circumstances.

We can use the RCPs to plan for the future

Scientists use the RCPs to model climate change and build scenarios about the impacts. You can use these scenarios to plan for the future.



If we follow the RCP 8.5 pathway, **more adaptation** will be needed.

If we follow the RCP 2.6 pathway, **less adaptation** is needed.

RCP 8.5 leads to much greater temperature increases, and this means greater impacts and greater costs. To adapt to these changes will also cost more. A balance must be struck between the cost of impacts and the cost of adaptation.